Budapest University of Technology and Economics

Bulletin

2019-2020

Study in the European Union

Study at BME

Your future career begins at the Budapest University of Technology and Economics

BULLETIN

Budapest University of Technology and Economics

2019–2020

An ECTS Guide

MŰEGYETEM 1782

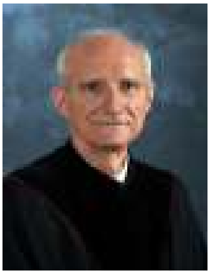
Programs in English
www.future.bme.hu
admission@mail.bme.hu

Bulletin of the Budapest University of Technology and Economics
Engineering Programs in English

Managing Editor: Valéria Balogh
Design & Layout: Tamás Rumi
Photos: János Philip, József Tóth, István Oravecz, György Ádám Horváth

This Catalogue provides information on the programs and services of the Budapest University of Technology and Economics. Curricula, courses, degree requirements, fees and policies are subjects to revision. Specific details may vary from the statements printed here without further notice.
The manuscript was closed on 11 January 2019.

HU ISSN 1786-5352



Dear Student,

You are reading the Bulletin of the Budapest University of Technology and Economics. Its direct predecessor, the Institutum Geometricum, was established in 1782 by Emperor Joseph II, as part of the Faculty of Liberal Arts at the University of Buda. During the past 237 years the professors of the university have striven to provide an outstanding quality of education. This has earned the university an international reputation, attracting students and also professors from all over the world.

Our university has eight faculties. They are, in order of foundation: Civil Engineering, Mechanical Engineering, Architecture, Chemical Technology and Biotechnology, Electrical Engineering and Informatics, Transportation Engineering and Vehicle Engineering, Natural Sciences, Economic and Social Sciences.

"Education is the most powerful weapon which you can use to change the world."
This is the quotation from Nelson Mandela. It is unquestionably true and especially applicable for engineers who have the power to make a better world:
Sustainable energy, clean water, safe transport on roads and on bridges, producing less pollution, buildings for comfortable living and working, machines and robots for work and for amusement, fast and reliable communications, medical equipment that assure a good quality of life for the individual and can be financed by society, and healthy food for us all. All of these goals need engineering solutions to make the world a safer, better and more exciting place to be. **This is also your responsibility.** You can acquire the necessary knowledge and skills to make your own contribution. As a graduate you will certainly do your best for your colleagues, company and society.

Two components are decisive for a good diploma: good teachers and a good student. I can say our university provides you with excellent teachers – **you must be good students!** I am sure it is worth being so.
Besides, you will love it: the university years will be your best memory, the engineering profession will provide you the joy of creation.
Hungary is a member of the European Union. As a student in Budapest you will find general European as well as particular Hungarian cultural customs: food, fashion, folk art, music and dance.

Use this bulletin to help you consider our programs. Come to visit our campus. Better yet, come to study with us for one or two semesters or for an entire degree program. Should you decide to stay for only one semester, this bulletin will also help you choose from among the different semester programs.

The Budapest University of Technology and Economics extends a special welcome to students from abroad.

Károly Veszprémi
vice-rector for education

Avaliable study programmes for 2019/2020 academic year

BSc programmes	Faculty
Chemical Engineering	Faculty of Chemical Technology and Biotechnology
Civil Engineering	Faculty of Civil Engineering
Computer Engineer	Faculty of Electrical Engineering and Informatics
Electrical Engineering	
Mathematics	Faculty of Natural Sciences
Mechanical Engineering	Faculty of Mechanical Engineering

MSc/MA* programmes	Faculty
Applied Mathematics	Faculty of Natural Sciences
Architecture (Five-year Integrated Master Program and Master in Architecture Program)	Faculty of Architecture
Chemical Engineering	Faculty of Chemical Technology and Biotechnology
Computer Engineer	Faculty of Electrical Engineering and Informatics
Electrical Engineering	
Environmental Engineering	Faculty of Chemical Technology and Biotechnology
Finance*	Faculty of Economic and Social Sciences
Management and Leadership*	
Regional and Environmental Economic Studies*	
Mechanical Engineering Modelling	Faculty of Mechanical Engineering
Physics	Faculty of Natural Sciences
Structural Engineering	Faculty of Civil Engineering
Autonomous Vehicle Control Engineering	Faculty of Transportation Engineering and Vehicle Engineering
Transportation Engineering	
Vehicle Engineering	
Logistics Engineering	

PhD programmes	Faculty
Architecture Engineering	Faculty of Architecture
Architecture (DLA program)	
Business and Management	Faculty of Economic and Social Sciences
Chemistry	Faculty of Chemical Technology and Biotechnology
Chemical- Bio- and Environmental Engineering	
Civil Engineering Sciences and Earth Sciences	Faculty of Civil Engineering
Computer Engineer	Faculty of Electrical Engineering and Informatics
Electrical Engineering	
Mathematics and Computer Science	Faculty of Natural Sciences
Physical Sciences	
Mechanical Engineering Science	Faculty of Mechanical Engineering
Autonomous Vehicle Control Engineering	Faculty of Transportation Engineering and Vehicle Engineering
Transportation Engineering	
Vehicle Engineering	
Logistics Engineering	

Tuition Fees for 2019/2020 academic year

Course	Semesters	For EU citizens	For non-EU citizens
Preparatory Course and General Course in Architecture	2	EUR 3,200 / semester	EUR 3,200 / semester
Undergraduate Tuition Fees, leading to B.Sc. degree	6 or 7	EUR 2,250 / semester	EUR 3,200 / semester
Undergraduate Tuition Fees, leading to B.Sc. degree in Civil Engineering	8	EUR 3,200 / semester	EUR 3,200 / semester
Graduate Tuition Fees, leading to M.Sc. degree for graduates of external higher education institutions	4	EUR 3,200 / semester	EUR 3,500 / semester
Graduate Tuition Fees, leading to M.Sc. degree for graduates of BME	4	EUR 2,850 / semester	EUR 3,200 / semester
Graduate Tuition Fees, leading to M.Sc. degree in Structural Engineering	3	EUR 3,800 / semester	EUR 3,800 / semester
Graduate Tuition Fees, leading to M.Sc. degree in Architecture	10	EUR 2,850 / semester	EUR 3,200 / semester
Postgraduate Tuition Fees, leading to Ph.D. or DLA degree (Depending on the character of the research and course programs)	8	EUR 4,500 / semester	EUR 4,500 / semester
Tuition Fees for special students (courses leading to no degree)		EUR 110/credits (min. 12 lessons/week)	EUR 110/credits (min. 12 lessons/week)
Tuition Fees for special students (courses leading to no degree) in Civil Engineering		EUR 2,000 / semester minimum	EUR 2,000 / semester minimum

Agencies and representatives in the target countries

Azerbaijan

CELT Colleges
Anar Gurbanzade Study Abroad Coordinator
Mammad Afandiyev 6, Flat 12,
AZ 1001, Baku, Azerbaijan
+994 12 4926853; +994 55 6447280
admissions@celt.az; www.celt.az

Cameroon

GIC INTERNATIONAL CONSULTING
KAMDEM SAMUEL Manager
AV AMADA AIDJA FACE KTIOS,
BP 5202 Yaoundé Cameroun
phone number: 00237 675607870 / 00237 696776324
Face Ktios imm UNICS 2 etage Porte 201
Tel 2:00237 242 10 77 57
Facebook: interconsultingcameroun
Skype: inter.consulting
E-mail: interconsulting77@yahoo.fr
http://www.gicinterconsulting.com

China

Shenyang EU-SINO Education Information Consulting Co., Ltd.
Mr. Chen Qilin Director
Room 1407, Ouya Lianying Business Building, No.1 Jia, Nanjingnan Str., Heping Dist., Shenyang City, Liaoning Province, China.110001
Tel: 86-24-23286616/ 400-006-7997
Web: www.studyinhungary.org
E-mail: eusino_edu@hotmail.com

Mohar Global Services (MGS)
Abu Bakar Ejaz Managing Director
Achter de Grote Kerk 15
8911 GD Leeuwarden
The Netherlands
Tel.: 0031 – 616 – 563 – 733, 0031 – 616 – 941 – 160, 0097-143-050-614
Fax: 0031 – 588 – 434 – 932
www.letsgostudyabroad.com
Email: abu.bakar.ejaz@letsgostudyabroad.com

Jifulang Consultation Services Ltd
CEO: **Ms. YE Li**
Physical address: Chongqing city, Yubei district, Baihua Rd.6, Wanke Tixiangjun 11-1-7-15, Zip: 401121, China
Postal address: Chongqing city, Yubei district, Yunshan Nan Rd.10, Shewai Shangwuqu Bldg.4, 23-1-2, Zip: 401121, China
Contact: Fülöp Ferenc, fulop@inbox.com , +8613206017976 (+36302121210)

Cyprus

L.S. Moussoulos Co Ltd. (Studies Dept.)
Mr. Sofocles Moussoulos President
1: P.O.Box 21454, Nicosia 1509, Cyprus
2: Moussoulos Building, Corner of Ay. Pavlos and I. Kadmos str.,
Ayios Andreas, 1105 Nicosia, Cyprus
Telephone: 02-781644
Fax: 02-773111
mousoulos@cytanet.com.cy

Dubai

Gyanberry Education & Training
Pranali Labh (Chief Operating Officer
Dubai Knowledge Village Office G26, Block 13
pranali@gyanberry.com
+971 52 9092360

Gyanberry Training and Education FZ LLC
Ms Pranali Dhamankar- Labh
Address- Dubai Knowledge Park, Block 13, Office Nos G26, Dubai.
Phone Nos- 043689336, Nos- 0097143689336

Egypt and Middle East

Manufacturing Institute Group
Professor Dr. Mr. Ashraf Elsayed Mohamed Mohamed
BRNO University of Technology
SOUF SHAMAA-TALON-ST#1-O#28
ALEXANDRIA 21351 - EGYPT
Mobile: 00201147602039
E-mail: ashraf.mohamed@saudieng.org
E-mail: ashrafelsayedm@gmail.com
(Egypt, Oman, Qatar, Bahrain, Lybia, Arab Golf countries and Middlle east)

Georgia

PRIME STUDY Educational Consulting Agency
Davit Mikeladze
Mirotadze street 1, 8th floor, Tbilisi, 0179, Georgia
phone number: +995571120000
E-mail: info@primestudy.ge
www.primestudy.ge

Ghana

Honorary Consulate of Hungary
Amen D. Kpodo-Tay (Hon. Consul of Hungary)
55 Ring Road East Accra
phone number: +233-20 341 3550
mobile number: +233-20 341 3550
E-mail: ghanakonzul@gmail.com

India

Active synergy consultants.P. Ltd
Ram Sharan Dhakal
Bagbazar 31, 44600 Kathmandu, Nepal
phone number: 097714215496, 9779841356489
Email: info.activesynergy14@gmail.com
www.asc.com.np
(recruit students from India, Bangladesh, Srilanka and Nepal)

Angel Management Consultant (CEO)
Asif Syed director
Master Mind, V, No. 716, 717 Royal Palms, Aarey Milk Colony
Goregaon East, Mumbai 400065 India

Iran

Daneshpooyan Aria Institute
Dr. Alireza Habibi Director
Unit 2, No.18, 2nd Alley,
South Kaj St., Fatemi Ave.
Tehran 14147-63413, Iran
Tel: +98 21 8895 2288, 8895 4081, 8897 5337
Fax:+98 21 8898 1392
habibi@daneshpuyan.com

Open Iran Ltd
Anita Papp International Director
Address: 25, Arikeh Iranian Complex, Farahzadi Bulvar, Shahrake Gharb, Tehran, Iran
Tel: +98 21 2235 1161, +98 21 2235 1171
Fax: +98 21 2209 4856
Mobile: +98 912 707 20 83
E-mail: info@open-iran.com
www.open-iran.com

MATINIT Institute
Eng. Matin Hashem Manager
Address: Shemiran, Dezashib, Booali, Abbasi, Mehrnaz No. 2
Tehran 19349-35753, Iran
Phone: +9821 22201448
Fax: +9821 22211424
info@majarestan.com; www.majarestan.com

Daneshjooyan Educational and Publication Institute
Mr. Mehdi Dara
Tehran
Address: Apt. No. 5 , No. 10 , Shekarabi St., Shariati Ave., Upper Than Motahari Cross
postal code: 1567614668
phone number: 0098 21 88427100 (20 Line)
fax number: 0098 21 88419594
Email: info@study3000.com
Website: www.study3000.com

Avicenna International College
Dr. Shahrokh Mirzahosseini
Hungary
1089 Budapest, Orczy tér 3-5, Hungary.
phone number: +36703171424

Yekta Maktab Ibn Sina / Avicenna International School
Ms. Fatemeh Mirzahosseini
Iran
Kheradmand Shomali, No. 87, 3rd floor, No. 5, Tehran
phone number: +98-9125500012

BROrganization and Partners Kft.
Payam Abed Salimi
Hungary
1073 Budapest, Kertész street 22.
phone number: +36704397497

Israel

University International Studies
Mr. Roni Fried
Hazoran 1.
Entrance 10, Floor 2
Netanya, 42504 P.O. Box 8552, Israel
Fax: 972-9-8858287
Mobile: 972-57-4450445
info@uis.co.il; www.uis.co.il

Kazakhstan

Republican Social Association of "Kazakh Tili Kogamy" named after Konir Mandoki
Suleimenova Dana
Kulsarynskaya str. 33, 060100 Atyrau,
Republic of Kazakhstan
Tel: +7 707 333 7007
Email: sedupost@gmail.com

Kuwait

Kapico Travels and Tours
Pervin Mirza
Al Ghawali Complex
Sharq Kuwait
Tel.: +965 65777066
pervin.mirza@kapicotravels.com]

United Placement Services
Waleed Sheikh
address: Hawally, Block 2 , Othman street,
Mubarak complex, floor 3, office 15, Kuwait
phone number: 00965 22633136

Nepal

Oasis Abroad Study Services & Consultancy Pvt.
Mr. Ram Thapa
Bagbazar 31,
44600 Kathmandu, Nepal
phone number: +977-9851160282

Active synergy consultants. P. Ltd
Ram Sharan Dhakal
Bagbazar 31,
44600 Kathmandu, Nepal
phone number: 097714215496, 9779841356489
Email: info.activesynergy14@gmail.com
www.asc.com.np
(recruit students from India, Bangladesh, Srilanka and Nepal)

White rabbit educational consultancy
Mr Bikash Deuba
Putalisadak 31, 44600 Kathmandu
phone number: +977 014268102 / 9841463790

Tridev Education Service Pvt Ltd
Surendra Kharel
Dillibazar 32,
44600 Kathmandu, Nepal
Dillibazar Height (Opposite to Padma Kanya School)
phone number: 9861199325
Contact no: +977-9861199325 / +9779861199325
PO. Box: 11946

Nigeria

ALMERC
Dr. A.B.E. Nnuji Chairman
11, Calcutta Crescent, Apapa, Lagos
5th Avenue, 'G' Close House 16, Festac Town Lagos, Nigeria
Telephone: 234-(0)-1-7741243, 4342421, 234-803-3075781
E-mail: aloynnuji@yahoo.com

Chetzit Global
Mr. CELESTINE GANDU
address: 19 Buruku Road, Narayi, Kaduna
phone number: +2349097514222
mobile number: +36706368774
E-mail:info@chetzitglobal.com
Website: www.chetzitglobal.com
Facebook: https://www.facebook.com/chetzitglobal/

DREAM EDUCATION.HU
Ms. Linda Abia-Okon Managing Director
Tel.: +234 817 999 9909; +36702011 999
Office: 61, Jose Marti Crescent, Asokoro, ABUJA, Nigeria
E-mail: linda.abia.okon@dreameducationhungary.com; linda.abia.okon@gmail.com
www.dreameducationhungary.com

DAVAM CROWN DIAMOND NIGERIA LIMITED
Amadi Chukwudi David
No. 3 NGURU road barnawa kaduna,
80001 Kaduna state, Nigeria
phone number: +2349096065025

Y2GO Ltd
Richard Morgan Managing Director
World of Achievers Limited
Y2Go Limited
Mob UK: +44 77 10 763 474
Mob Nigeria: +234 7038 05 6665
Mob Ukraine: +38 0632 651 050
Skype: morgan.richard14
E-mail: morganrichard1164@yahoo.com.sg
richard@morganproperty.uk.com

Forintstud Agency
Jack Daboma Ibibo
address: 4 Ihunwo street, Woji Town, Port Harcourt, Nigeria
phone number: +2349052913518, +36703663000
Website: www.forintstud.com
Email: forintstud@gmail.com

Crown Continental Student and Travel Agency
Engineer **David Amadi**
address: No. 3 Nguru Road Barnawa Kaduna
phone number: 09096065025

AFRILIGHT EDUCATIONAL CONSULT
Dr. Ugo Onyeka-Fodor
Address: No. 98B City View Abuja. Nigeria
Phone number: +36304412882, +2348114405098
Email: alecteam@gmail.com

Pakistan

STUDYLINKER Student Consultancy (SSC)
(Foreign Student Admission & Advisory Services)
Asif Mahmood Managing Director
(MSc. Computer Science, Dipl. DCS, DHE, DWA)
Tel No. 0345-4149210, 0310-4149210
Email: info_studylinker@yahoo.com
LinkedIn: pk.linkedin.com/pub/asif-mahmood/45/652/87b/
FB: Security Check Required

Universal Education Consultant
Imran Ali
Resham Bazar 4th floor 406
75620 Karachi, Lahore, Pakistan
(Near Ned University, Karachi)
phone number: 00923312830497

World Consultants Pvt Ltd
Tamoor Aziz
address: Office No 32 1st Floor Beverly Centre Blue Area Islamabad Pakistan
phone number: +92 51 2814030--1

Saudi Arabia

Dr. M.H. Osman Taha Hungarian Business Consultant
P.O. Box 365812 Riyadh 11393 Saudi Arabia
Tel.: 00966 1 4654488 – 4643150
Fax. 00966 1 4658560
Mobile: 00966 50 3419791
E-mail: droszman@gmail.com
www.tu.com.sa

North America IEC Admissions
Masood Basha Lateef - Regional Director
city: Jeddah - Riyadh - Chennai
28 Zahran Tower 5th Floor North of Moraba Bridge - Al Madinah Road
phone number: 00966126821285
E-mail: na.admissions@iecabroad.com

Sri Lanka

Osthrove Ceylon Group (Pvt) Ltd.
J.A.C Asoka Silva
address: 198, Dambaduraya, Seeduwa, Sri Lanka.
phone number: +94 77 113 1599

Syria and Middle East

Eng. Ghassan Chanis
GCCE Director
E-mail: chanisg50@hotmail.com
Syria: Damascus-Abasia Sqr. 3
Hungary: Budapest, Kassák Lajos u 66.
Tel.: Damascus: +963114455786
Budapest: +36705483362

Turkey

MEDA STUDY ABROAD COUNSELLING
Ayse Ayan - Counsellor
MACARISTAN ve YURTDISI EGITIM DANISMANLIGI
Buyukdere Cad. No:182 D:16 Yeni Levent
Besiktas 34330 Istanbul - Turkey
Tlf: +90.212.270 64 19 (20) GSM: +90.532.690 33 39
Skype: ayse.ayan
E-mail: ayse.ayan@medaegitim.com, www.medaegitim.com

YEKS MEDA EGITIM DANISMANLIK TURIZM DANIS-MANLIK GIDA SAN DIS TIC LTD
Yelis ESTAS
Büyükdere Cad. No: 182 Kat 4 D 16, 34 330 Istanbul
phone number: 00 90 212 270 64 20

Can Akademi
Sayil Gunay
Istanbul & Kocaeli
Sahkulu Mh. Serdar-i Ekrem Sok. No:15/A, Galata | Istanbul
postal code: 34421
phone number: +905533130773

Hun Education Kft. (HUNEDU)
Ejder Yücel Manager
1204 Budapest Bethlen u. 17.
www.huneducation.com
infi@huneducation.com

Uganda

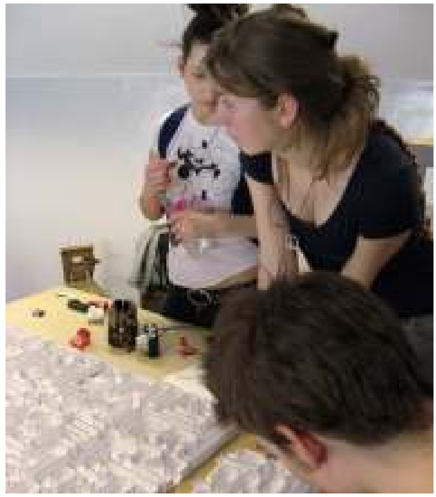
Overseas Educational Services
Solomon Edward Semanda
Plot 17 Mpanga Close off Luthuli Avenue Bugolobi
0256 Kampala
phone number: +256(0)752629482

United Arab Emirates

Blis Trading and Investment Co. Ltd.
Hassam El Tayeb Ali
P.O.Box 11662 Khartoum, Sudan
hassan_blais@yahoo.com

Univer360 FZ LLC
Mr. Ghassan El Rifai
Corniche Al Khan, Sondos Tower 3303
Sharjah 2207, United Arab Emirates
Phone number: +971 50 4810101; +971 50 2223564
Email: info@univer360.com; univer@emirates.net.ae

Faculty of Architecture



The Faculty of Architecture at the Budapest University of Technology and Economics focuses on training highly professional experts in architectural engineering who are aware of the social and cultural implications of their profession. Versatility is emphasised so that students will gain fundamental knowledge and abilities in every possible field of architecture and be able to find work in a highly competitive job market, and in any building- or design-related area of consulting, construction, and management. The Academic Programs of the Faculty of Architecture in English are as follows:

1. Integrated MSc Program, which is a five-year (10 semester) long training and leads directly to an MSc degree in Architecture and Architectural Engineering (Dipl. Ing. Arch.),
2. Masters' Program, which is a two-year (4 semester) long training and leads to an MSc in Architecture. Students who have earned BSc degrees in other schools of architecture can join the Master's Program.
3. PhD, DLA. The Faculty of Architecture offers graduate studies in its two graduate schools. The program of the Doctoral School of Architecture leads to the PhD-equivalent degree Doctor of Liberal Arts (DLA). The four year long curriculum strongly focuses on creative architectural design supported by project-based research. Studies in Csonka Pál Graduate School cover a wide range of scientific and engineering topics related to architecture and building such as history of architecture or applied mechanics. The focus of this school is independent research under personal supervision.

Graduates of the Faculty of Architecture are qualified for a broad spectrum of architectural occupations:

- Design, construction and maintenance of residential, public, industrial and agricultural buildings;
- Reconstruction and the preservation of historical monuments;
- Urban design and settlement planning; and
- Administration of all these activities.

The curricula were organised on Swiss and German models. The Faculty has maintained these traditions for the last 40 years but provides additional European and international dimensions through guest lecturers from abroad, topical short courses, workshop seminars and exchange programs.

The Academic Programs of the Faculty of Architecture taught in English are in full conformity with the Intergrated MSc and MSc programs provided in Hungarian, which after two years practice and experience are accepted for access to EUR-ING title.

General course – Preparatory Course

The year program in English, called the General Course precedes the Degree Program. It is designed to develop the skills of students from abroad so they will be at no disadvantage in meeting the Faculty's exacting educational standards. Students are introduced to various aspects of the profession they have selected, and they concentrate on studying English and basic technical subjects such as mathematics and freehand drawing. The whole, or partial fulfilment of the General Course doesn't replace the Placement Test. Only students who successfully pass the Placement Test can automatically (immediately) start the Integrated MSc program.

Academic Program of the Faculty of Architecture

- For integrated M.Sc degree (10 semesters) students have to accumulate min 300 credit points.
- For M.Sc degree (4 semesters) students have to accumulate min 120 credit points.

Both Programs require to accomplish obligatory subjects and elective subjects too.

Students, both International and Hungarian, who have a command of both languages can choose from either program. The participation of Hungarian students in the program given in English has obvious advantages. It eases the integration of international students into the society, which surrounds them during the years of their studies. It also attracts students from European, American and other universities worldwide to study in

Budapest within the framework of the International Student Exchange Program and other agreements.

Hungarian students likewise gain the opportunity to study at schools of architecture abroad. These exchanges will become a powerful factor in achieving real convertibility among educational system world-wise and, eventually, mutual international recognition of degrees.

Master's Program

Students who have earned BSc degrees in other schools of architecture can join the Master's Program. In the program, students can choose after the first semester from the following specialisations:

- Real-Estate Development and Facility Management
- Architectural and Interior Design
- Urban Design
- Structural Design

Note: The Faculty of Architecture reserves the right of changing the Curricula. Specialisations have a minimum required number of students to start.

Graduation

Graduation from the University is based on the successful completion of examinations in all subjects and on the successful defence of a diploma project in front of a Final Examination Board. The examinations are public and the Board consists of professors and eminent specialists in the profession. Diploma projects are prepared in the last semester under departmental guidance and can be submitted only by students with an "absolutorium" (university leaving certificate). The diploma project is expected to reflect its author's familiarity with technical and aesthetic knowledge fundamental to architectural practice, and his/her creativity in applying it. Currently, international agreements make it possible for certain Hungarian students to prepare and defend their diploma projects in the university of another country. Students from abroad can correspondingly prepare and defend their thesis projects under the guidance of the Faculty of Architecture at the Budapest University of Technology and Economics.

Departments

- Department of Architectural Geometry and Informatics
- Department of Construction Technology and Management
- Department of History of Architecture and Monument Preservation
- Department of Building Energetics and Building Service
- Department of Building Constructions
- Department of Industrial and Agricultural Building Design
- Department of Public Building Design
- Department of Residential Building Design
- Department of Graphics, Form, and Design
- Department of Mechanics, Materials and Structures
- Department of Urban Planning and Design
- Laboratory of Building Acoustics
- Laboratory of Thermal Physics

Budapest University of Technology and Economics
Faculty of Architecture
Faculty Office:
Building R, ground floor, room 001.
Mailing Address: Műegyetem rkp. 7-9.
H-1111 Budapest, Hungary
Phone: (+36-1) 463-3728
Fax: (+36-1) 463-2550

Dean of the Faculty: Dr. György Alföldi, DLA
Vice-Dean for International Education (Undergraduate Programs): István Bartók, DLA
Vice-Dean for Science (Postgraduate Programs): Dr. Péter Várkonyi PhD
Program Coordinators:
Ms. Karola Krajcsi, Ms. Gyöngyi Tamás

General (Preparatory) Courses in Architecture

Subject			hours/week		
Name	**Code**	**Credits**	**1**	**2**	**Requisities**
Basic Mathematics 1	BMETETOPB22	-	0/4/0p		
Computer Literacy 1	BMEEPAGG101	-	0/4/0p		
Engineering Sciences	BMETETOP117	-	0/4/0p		
Geometrical Construction 1	BMEEPAGG111	-	2/3/0p		
Freehand Drawing 1	BMEEPRAG101	-	0/6/0p		
Design Skills 1	BMEEPRAG111	-	0/2/0p		
Basic Mathematics 2	BMETETOPB23	-		0/5/0p	Basic Mathematics 1a
Computer Literacy 2	BMEEPAGG201	-		0/2/0p	Computer Literacy 1a
Geometrical Constructions 2	BMEEPAGG211	-		2/1/0p	Geometrical Constructions 1a
Freehand Drawing 2	BMEEPRAG201	-		0/6/0p	Freehand Drawing 1a
Fundamental of Structures	BMEEPSTG201	-		4/0/0p	
Basic Tools of Building Constructions	BMEEPESG201	-		0/2/0p	
Design Skills 2	BMEEPRAG211	-		0/2/0p	Freehand Drawing 1a
Fundamental of Architectural Design	BMEEPRAG221	-		0/2/0p	
English for Studies 1.	BMEGT630101	-	0/6/0p		
English for Studies 2.	BMEGT630102	-		0/6/0p	English for Studies 1.a

a) can be taken parallelly in the same semester. For students of BME Faculty of Architecture only criteria subjects (no credit points)

Curriculum of Integrated MSc Program
1-10. semester

Subject			lectures/practical lectures/laboratory					
Name	Code	Cre-dits	1	2	3	4	5	Requisities
Mathematics 1	BMETE90AX33	4	2/2/0e					-
Philosophy	BMEGT411099	2	2/0/0p					-
Descriptive Geometry 1	BMEEPAGA102	5	3/2/0e					-
Introduction to Building construction	BMEEPESA101	2	2/0/0p					-
History of Architecture I. (The Beginnings)	BMEEPETA101	3	2/1/0e					-
Introduction to Structural Design	BMEEPSTA101	2	2/0/0e					-
Drawing 1	BMEEPRAA101	5	0/5/0p					-
Introduction to Architecture	BMEEPUIA101	2	2/0/0p					-
Space Composition	BMEEPKOA101	5	0/5/0p					-
Mathematics 2	BMETE90AX34	2		0/2/0p				BMETE90AX33
Descriptive Geometry 2	BMEEPAGA202	5		3/2/0e				BMEEPAGA102
Building Constructions 1	BMEEPESA201	4		2/2/0e				BMEEPESA101, BMEEPSTA101s
Statics	BMEEPSTA201	4		2/2/0e				BMEEPSTA101
History of Architecture 2 (Antiquity)	BMEEPETA201	3		2/1/0p				-
Drawing 2	BMEEPRAA201	4		0/4/0p				BMEEPRAA101
Residential Building Design 1	BMEEPLAA201	2		2/0/0e				BMEEPUIA101
Basics of Architecture	BMEEPLAA202	6		0/6/0p				BMEEPUIA101, BMEEPRAA101, BMEEPKOA101
Building Materials I	BMEEOEMA301	3			2/1/0p			-
Architectural Informatics 1 - IT Applications	BMEEPAGA301	2			1/1/0p			-
Building Physics	BMEEPEGA301	2			2/0/0p			BMEEPESA101
Strength of Materials 1	BMEEPSTA301	4			2/2/0e			BMEEPSTA201, BMETE90AX33
History of Architecture 3 (Medieval)	BMEEPETA301	3			2/1/0e			BMEEPETA201
Drawing 3	BMEEPRAA301	4			0/4/0p			BMEEPRAA201
Public Building Design 1	BMEEPKOA301	2			2/0/0e			BMEEPLAA201, BMEEPLAA202
Residential Building Design 2	BMEEPLAA301	6			0/6/0p			BMEEPLAA201, BMEEPLAA202,
Building Constructions 2	BMEEPESA301	4			2/2/0e			BMEEPSTA101s, BMEEPAGA102, BMEEPESA101
Sociology for Architects	BMEGT43A044	2				2/0/0e		-
Architectural Inf. 2 - Digital Representation	BMEEPAGA401	3				1/2/0p		BMEEPAGA202,
Building Constructions 3	BMEEPESA401	4				2/2/0e		BMEEPESA201
Strength of Materials 2	BMEEPSTA401	6				4/2/0p		BMETE90AX34, BMEEPSTA301
Strength of Materials Global	BMEEPSTA499					global		BMEEPSTA401a
History of Architecture 4	BMEEPETA401	3				2/1/0e		BMEEPETA301
Drawing 4	BMEEPRAA401	2				0/2/0p		BMEEPRAA301
Design Methodology	BMEEPKOA402	2				2/0/0e		BMEEPLAA301, BMEEPKOA301
Architecture of Workplaces 1	BMEEPIPA401	2				2/0/0e		BMEEPLAA301, BMEEPK0A301
Public Building Design 2	BMEEPKOA401	6				0/6/0p		BMEEPLAA301, BMEEPK0A301
Architectural Inf. 3 - CAAD for Architects	BMEEPAGA501	3					1/2/0p	BMEEPAGA301, BMEEPAGA401, BMEEPLAA301, BMEEPESA301
CM1 - Basics of construction	BMEEPEKA501	2					2/0/0p	BMEEPESA301
Building Service Engineering 1	BMEEPEGA501	2					2/0/0p	-
Building Constructions 4	BMEEPESA501	4					2/2/0p	BMEEPESA301
Global of Building Constructions Basic	BMEEPESA599						global	BMEEPESA401, BMEEPESA501a
Design of Load-Bearing Structures	BMEEPSTA501	6					4/2/0e	BMEEPSTA499a, BMEPSTA401
History of Architecture 5 (19th century)	BMEEPETA501	3					2/1/0p	BMEEPETA401, BMEEPETA101
Drawing 5	BMEEPRAA501	2					0/2/0p	BMEEPRAA401
Urban Design 1	BMEEPUIA501	2					2/0/0e	BMEEPLAA201
Architecture of Workplaces 2	BMEEPIPA501	6					0/6/0p	BMEEPKOA401, BMEEPIPA401
Design Global Basic	BMEEPKOA599						global	BMEEPIPA501a, BMEEPRAA401, BMEEPKOA402

Curriculum of Integrated MSc Program
1-10. semester (contd.)

Subject			lectures/practical lectures/laboratory					
Name	Code	Credits	6	7	8	9	10	Requisities
Economics 1. (Microeconomics)	BMEGT301004	2	2/0/0p					-
CM3 - Planning of Construction Technology	BMEEPEKA701	4	2/2/0e					BMEEPEKA501
Building Service Engineering 2	BMEEPEGA601	2	2/0/0e					BMEEPEGA301
Building Constructions 5	BMEEPEST602	4	2/2/0p					BMEEPESA301, BMEEPESA401
History of Architecture 6	BMEEPETO601	3	2/1/0p					BMEEPETA401
Drawing 6	BMEEPRAA601	2	0/2/0p					BMEEPRAA501
Department's Design 1	BMEEPUIQ601	3	0/3/0p					BMEEPKOA599 or BMEEPESA599 or BMEEPSTA499
Urban Design 2	BMEEPUIA601	6	0/6/0p					BMEEPUIA501, BMEEPLAA301
Special Load-Bearing Structures	BMEEPSTT601	4	2/2/0e					BMEEPSTA501
History of Architecture Global (basic)	BMEEPETO699		global					BMEEPETA401
Economics 2. (Macroeconomics)	BMEGT301924	2		0/2/0/p				-
CM2 - Building Project Management	BMEEPEKK601	4		2/2/0e				BMEEPEKA501
Building Constructions 6	BMEEPESK702	4		2/2/0e				BMEEPESA599
History of Art	BMEEPETT721	2		2/0/0e				BMEEPKOA599
Drawing 7	BMEEPRAO702	2		0/2/0p				BMEEPRAA501, BMEEPKOA599
Department's Design 2	BMEEPRAT701	3		0/3/0p				BMEEPUIT601
Department's Design 3	BMEPExxT711	8		0/8/0p				BMEEPKOA599, BMEEPUIT601, BMEEPUIA601
Global In Structures	BMEEPSTT799			global				BMEEPSTT601a
Preservation of Historic Monuments	BMEEPETT611	2			2/0/0p			BMEEPKOA599, BMEEPETA501
Building and Architectural Economics	BMEEPEKA801	2			2/0/0p			BMEEPLAA301
Facility Management	BMEEPEK0633	2			2/0/0e			
History of Hungarian Architecture 1.	BMEEPETO801	2			2/0/0p			BMEEPKOA599, BMEEPETA501
Drawing 8	BMEEPRAO801	2			0/2/0p			BMEEPRAA501, BMEEPKOA599
Urbanism	BMEEPUI0805	2			2/0/0p			-
Contemporary Arch. Offices	BMEEPIP0893	2			0/2/0p			-
Res. Design and Cont. Competitions	BMEEPLA0897	2			2/0/0e			BMEEPLAA301
Complex Design 1	BMEEPxxT811	10			0/10/0p			BMEEPxxT711, BMEEPSTA501, BMEEPETO699
Building Construction Global	BMEEPEST899				global			BMEEPESA602, BMEEPEST702
Construction Law	BMEEPEKO901	2				2/0/0p		-
Design of Reinforced Concrete structures	BMEEPST0655	2				2/0/0e		-
Drawing 9	BMEEPRAT901	2				0/2/0p		BMEEPRAA501
Architectural Interiors	BMEEPKO0905	2				0/2/0p		BMEEPKOA401
The Form in Architecture	BMEEPRA0404	2				0/2/0p		-
History of Theory of Architecture 1	BMEEPET0407	2				2/0/0e		-
Complex Design 2	BMEEPxxT911	10				0/10/0p		BMEEPxxT811, BMEEPEKA701, BMEEPEGA601
Theory of Architecture Design	BMEEPETO921	2				2/0/0e		BMEEPKOA599
Contemporary Hungarian Architecture 2	BMEEPETO901	2				2/0/0p		BMEEPETA501, BMEEPETO601
History of Architecture Global	BMEEPETT999					global		BMEEPETO601, BMEEPETO801, BMEEPETO901a
Diploma Project Studio	BMEEPxxTD03	26					0/26/0p	Min. 270 credits all subjects and basic globals
Electives subjects		17		0/5/0e-p	0/4/0e-p	0/4/0e-p	0/4/0e-p	

a) can be taken parallelly in the same semester
s) signature only
Minimum number of credits for M. Sc. Degree: 300

Curriculum of Masters' Program
1-4. semester

Subject			lectures/practical lectures/laboratory				
Name	Code	Cre-dits	1	2	3	4	Requisities
Construction Management 2M - Building Project Management	BMEEPEKM101	4	2/2/0e				-
Building Constructions 6	BMEEPESM101	4	2/2/0e				-
Special Load-Bearing Structures	BMEEPSTM101	4	2/2/0p				-
CAAD & Architectural Informatics	BMEEPAGM102	3	0/2/0p				-
Drawing 7	BMEEPRAO702	2	0/2/0p				-
History of Architecture 6 (Contemporary)	BMEEPETM101	3	2/1/0p				-
Basics of Design Theory	BMEEPIPM101	3	3/0/0e				-
Department's Design 3	BMEEPxxM111	8	0/8/0p				-
Complex Design 1	BMEEPxxM1KX	10		0/10/0p			BMEEPxxM111
Complex Design 2	BMEEPxxM2KX	10			0/10/0p		BMEEPxxM1KX
Preservation of Historic Monu-ments	BMEEPETM2T1	2				2/0/0p	-
Diploma Project Studio	BMEEPxxMD01	26				0/26/0p	Milestone based on Compulsory subjects
Urbanism *,**,***	BMEEPUI0805	2		2/0/0p			-
Building and Architectural Economics *,**	BMEEPEKA801	2		2/0/0p			-
Urban Design 1 *,***	BMEEPUIM1V1	2		2/0/0e			-
Basics of Real-Estate Develop-ment *,***	BMEEPEKM1I1	4		2/2/0p			BMEEPEKM101
Real-estate Knowledge 1 *	BMEEPEKM1I2	4		2/2/0e			BMEEPEKM101
Supplemental Real-estate Knowl-edge to Complex Design 1 *	BMEEPEKM1I3	2		0/2/0p			BMEEPxxM1KXa
Computer aided construction management *	BMEEPEK5008	2		0/2/0e			-
Geodesy*,**	BMEEOAFM201	2			2/0/0p		-
Rehabilitation of Building Con-structions *	BMEEPESM1I1	4			2/2/0p		-
Real-estate Knowledge 2 *	BMEEPEKM2I2	4			2/2/0e		BMEEPEKM1I2
Supplemental Real-estate Knowl-edge to Complex Design 2 *	BMEEPEKM2I3	2			0/2/0p		BMEEPxxM2KXa
Mathematics 3 *,****	BMETE95AX21	2			0/2/0p		-
Construction Management 5 - Special Construction Projects *	BMEEPEKS901	2			2/0/0p		-
Real-estate development and building rehabilitation *	BMEEPEKM2I1	2			1/1/0p		BMEEPEKM101
Real-estate Global *	BMEEPEKM2I9				global		BMEEPEKM1I1, BMEEPEKM2I2a
Contemporary Arch. Offices **	BMEEPIP0893	2		0/2/0e			-
Department's Practice 1 **	BMEEPxxM1TG	6		0/6/0p			BMEEPxxM1KXa
Drawing 8 **	BMEEPRAM101	2		0/2/0p			-
Res. Design and Contemporary Competitions **	BMEEPLA0897	2		2/0/0e			-
Facility Management **	BMEEPEK0633	2		2/0/0e			-
Department's Practice 2 **	BMEEPxxM2TG	6			0/6/0p		BMEEPxxM2KXa
Cities of the World **,***	BMEEPUI0893	2			2/0/0p		-
Drawing 9 **	BMEEPRAT901	2			0/2/0p		-
History of Theory of Architecture 1 **	BMEEPET0407	2			2/0/0e		-
Design of Reinforced Concrete structures **,****	BMEEPST0655	2			2/0/0e		-
Theory of Architecture and Design global **	BMEEPIPM2T9				global		BMEEPIPM101, BMEEPIP0893, BMEEPKO0905a
Architectural Interiors **	BMEEPKO0905	2			0/2/0p		-
Environmental Design ***	BMEEPUIM1V2	4		2/2/0p			-
Urban Research ***	BMEEPUIM1V3	4		2/2/0p			-
Sociology for Architects***	BMEGT43A044	2		2/0/0e			-
Hungarian Cities ***	BMEEPUI0423	2			2/0/0e		-
Urban Design 2 ***	BMEEPUIM2V1	6			2/4/0p		BMEEPUIM1V1
Studies for Chief Architects ***	BMEEPUIM2V2	5			4/1/0e		BMEEPUI0805

Curriculum of Masters' Program
1-4. semester (contd.)

Subject			lectures/practical lectures/laboratory				
Name	Code	Cre-dits	1	2	3	4	Requisities
GIS systems ***	BMEEO	3			3/0/0p		-
Urban Design Global	BMEEPUIM2V9				global		BMEEPUIM1V1, BMEEPUIM2V1a
Building Materials****	BMEEOEMM101	3		2/0/1e			-
Reinforced Concrete Structures ****	BMEEPSTM201	4		2/2/0e			-
Timber Structures ****	BMEEPSTM202	4		2/2/0e			-
Design of Steel Structures ****	BMEEPST0650	2		2/0/0e			-
Building Dynamics and Design for Earthquake ****	BMEEPSTM0S1	4		2/2/0e			-
Steel Structures ****	BMEEPSTM301	4			2/2/0e		-
Soil Mechanics ****	BMEEOGMM101	3			2/1/0e		-
Mechanics - Finite Element Method 1 ****	BMEEPSTM1S1	4			2/2/0e		-
Global in Structures ****	BMEEPSTM2S9				global		BMEEPSTM101, BMEEPSTM201, BMEEPSTM202, BMEEPSTM301a
Argumentation, Negotiation and Persuasion ****	BMEGT41MS01	2			2/0/0p		-

**: For Real-estate Development and Facility Management*
***: For Architectural and Interior Design*
****: For Urban Design*
*****: For Structural Design*

a) can be taken paralelly in the same semester
s) signature only
Minimum number of credits for MSc degree: 120

Faculty of Chemical Technology and Biotechnology

The education of chemical engineers and chemists has a long-standing tradition in Hungary dating back to the 18th century. Chemical engineering curricula, separating from that of mechanical and civil engineers, reach back to the 1863/64 academic year. In the 1960s chemical engineering studies were extended to the master level and introduced the range of specialised studies already. A doctoral school having a pioneering PhD program has also been established which was developed to be one of the most successful one in Hungary. Studies in English at the Faculty of Chemical Technology and Biotechnology began in the 1985/86 academic year. Currently bachelor (BSc, 7 semesters), master (MSc, 4 semesters) and doctoral (PhD, 8 semesters) studies are offered. Although the education profile in Hungarian includes chemical, biochemical and environmental engineering at each level, pharmaceutical and polymer and textile engineering at MSc level, the English curricula are only offered in chemical engineering (all levels), in environmental engineering (master level) and as doctoral studies. However, elective courses are available in English in all areas of our education. All programs are organised in the credit system providing a relatively high degree of freedom in subject selection, but prerequisites have to be taken into account when the individual study program is set.

Further information on the Faculty can be found at our website: http://ch.bme.hu/en/

Bachelor in chemical engineering

The BSc degree course in chemical engineering provides the appropriate skills and knowledge in chemistry, chemical engineering and economic sciences. The degree holder should be able to manage chemical technologies, conduct analytical tests, intermediate and final quality control, and can take part in R&D, planning, and public administration. Part of the education is specialisation in a branch.

Applicants of interested in chemical engineering are welcome. Entrance exams include chemistry or physics and mathematics. A B2 level (according to CEFR) of English is required. A one year long pre-engineering study is also possible if needed (see the relevant chapter of this bulletin).

Students in the BSc chemical engineering program receive a thorough core curriculum. These include natural sciences as chemistry, mathematics and physics, and engineering fundamentals as unit operations, process control. We assure, that our students besides a profound theoretical knowledge, can acquire up-to-date laboratory skills, get acquainted with the machines and apparati used in the chemical industry, know

the principles needed for their optimal operation, and develop expertise in a more specific technology within the chemical, food and light industries. Furthermore, our chemical engineering branch, compared to the typical curricula internationally, is highly synthetic and analytical chemistry focused resulting in an excellent understanding of chemical processes and their monitoring. Specialisations start in the fifth semester and are available to students depending on the number of applicants (minimum 6):

- Analytical and Structural Chemistry
- Chemical and Process Engineering
- Industrial Pharmaceutics
- Materials Science
- Plastic and Textile Technology

The studies are completed by performing an individual bachelor thesis project and submission of the thesis. Graduation is completed, after all required credits are gained, by a successful defence of the thesis and a final examination before the Final Examination Board of professors and eminent industrialists.

Master in chemical engineering

Chemical engineering MSc students get a high level knowledge in natural sciences, engineering, informatics and economics as well as in humanities. On an international comparison our curriculum is chemistry focused, and it is especially suitable for motivated applicants having carrier plans in research and development or project management.

Applicants of holding chemical engineering bachelor degree (or related) are welcome to widen their knowledge and skills in technological scientific fields of the chemical industry. Entrance exam includes chemical engineering. A B2 level (according to CEFR) of English is required.

Graduates will be versed in:

- operations and personnel involved in chemical processes on an industrial scale,
- development of the technology and products of industrial chemical processes,
- design of industrial chemical processes,

- how a chemical product or application is introduced into the national economy, and
- innovation of chemical processes, operations and technologies.

The newly reformed specialisation program offers a wide selection of courses grouped in five modules: analytics, materials science, biotechnology, pharmaceuticals and technology. Those, who completely gain the credits of any of these modules, will receive an extra certificate at their graduation. It is also possible to select the most interesting ones from the listed courses to gain a wide knowledge of the most important fields of the modern chemical industry.

The studies are completed by performing an individual master thesis project and submission of the thesis. Graduation is completed, after all required credits are gained, by a successful defence of the thesis and a final examination before the Final Examination Board of professors and eminent industrialists.

Master in environmental engineering

Protection of the environment is a major global issue and all nations have their task to ensure the availability of pure air, drinking water and rich soil for our and for the next generation. Obviously, industrial production is required to fulfil the needs of our societies. Thus engineers are required in each sectors of industry having deep knowledge both in their sector and in the environmental protection field. One of the biggest and most reputed institutions of this kind in Europe, the Budapest University of Technology and Economics has educated generations of engineers since its foundation in 1782. Its eight faculties of different engineering disciplines, sciences, economics and humanities actively participate in environmental education granting among others postgraduate degrees from 1974 onwards. The University has excellent training facilities: laboratories, pilot plants, computer network and a wide system of international relations.

Environmental engineering graduates are able to

- understand technologies especially be involved in developments aiming emission minimization
- select the best technique for environment protection and has a good understanding on the role of optimization
- evaluate and use analytical data and make decisions based on evidence
- are practiced in using the management tools of environmental protection
- communicate efficiently with professionals of various fields and with the public as well.

Environmental engineers find jobs in all industrial sectors since the environmental protection has profound importance in the modern industry. Environmental engineers graduated at BME are excellent in understanding chemical pollution, chemical analytics and chemical processes.

Applicants of holding any engineering degrees are welcome to widen their knowledge and skills in technological and managements fields of environmental protection. Good knowledge in chemistry, mathematics and engineering are required, since the aim of the curricula to top up an instantly applicable knowledge in all areas of environmental protection. Entrance exam includes basic chemistry. A B2 level (according to CEFR) of English is required.

The environmental engineering curricula is offered with a completely reformed program from September 2017 to ensure, that we meet the needs and challenges of students planning their career either in developed or in developing countries. For the actual study program please visit our website. Two specialisations are available (min 10 applicants): environmental technology and environmental management. All environmental engineers are trained in both fields, but selecting a specialization gives the possibility to focus on the more preferred area.

Environmental technology especially focuses on applied environmental science and technological aspects of environmental protection, pollution evaluation, data evaluation, reduction of waste formation and primary energy requirement of various processes and pollution removal. The specialization offers a large selectivity among specialized courses. Environmental management aims to develop the theoretical and soft skills required to actively and efficiently coordinate activities for the protection of the environment, to manage financial, technical and human resources for the sake of protecting air and water and reducing or reusing waste.

The studies are completed by performing an individual master's thesis project and submission of the thesis. Graduation is completed, after all required credits are gained, by a successful defence of the thesis and a final examination before the Final Examination Board of professors and eminent industrialists.

Doctoral studies

The George Oláh PhD School is eligible to issue PhD degrees from:

- Chemistry
- Chemical- bio- and environmental engineering

We are proudly having the allowance of Nobel Laurate George Oláh, a former student and faculty member, to use his name. "Nomen est Omen", in accordance with the high expectations our PhD School has strong requirements at an internationally highly competitive level (see also PhD minimum requirements). The PhD program lasts for 2+2 years. After the first two years, the prerequisite for the continuation is a successful completion of a "complex examination". During this evaluation the examining board investigates if the PhD candidate has made an appropriate progress in the PhD work within the time frame of the first two years, and whether the continuation will predictably result in the successful completion of the PhD work within the next two years.

The basic requirement for the enrollment is an MSc (or equivalent) degree from chemistry, chemical engineering or a related topic. For the enrollment the previous results during the BSc and MSc studies, documents about any scientific activities (papers, scientific presentations etc.) should be presented, and an interview (personally, or via skype, or by any other possible means) should be carried out in the presence of the prospective supervisor and two other members of the examining committee. The decision about the enrolment of a PhD candidate will then be made by the Council of the Doctoral School upon the suggestion given by the examining committee.

The list of the approved PhD research projects to be offered are renewed two times a year (next update is on November, 2018). The research projects offered can be modified with the agreement of the supervisor. All projects are subject to approval by the Council of the Doctoral School to ensure that they are likely to result in a successful completion with the expectedly devoted work of the applicant.

The most important part of the PhD curriculum is the research work carried out by the guidance of the supervisor. The supervisor is a key person during the PhD process, and a thorough cooperation between the PhD candidate and the supervisor is of utmost importance. The research project must be worked out by the supervisor, since the necessary background (laboratory facilities, specific instruments etc.) determines the success of the entire PhD project. To obtain information on the supervisor it is advised to study the approved PhD research projects offered, the personal home page, as well as the scientific publications in the Web of Science database if available, or alternatively in Google Scholar, which is free of charge.

Additionally to the research work itself, which is the core of the PhD studies, some PhD courses from the basic disciplines of chemistry, as well as from highly specialized topics should be completed. The "directed teaching" is an integral part of the curriculum as well, aimed at broadening the knowledge of the PhD student by teaching undergraduates. This teaching activity is maximized in four hours per week during a semester.

The PhD degree can be awarded upon the decision of the Doctoral Council of the University, provided that certain "minimum requirements" among others of a (i) completion of the "complex examination" (ii) publication of at least three peer reviewed scientific papers in journals with SCI impact factors with dominating (more than 50%) contribution of the applicant (iii) successful defence of the thesis are fulfilled. In spite of these strict minimum requirements more than 70% of our enrolled PhD students obtain the degree. A detailed description of the PhD requirements is available upon request.

For further information please contact Ms. Evelin Bell, via e-mail (bell.evelin@mail.bme.hu) and visit our dedicated website (http://www.ch.bme.hu/en/education/PhD)

Departments

- Department of Inorganic and Analytical Chemistry
- Department of Physical Chemistry and Materials Science
- Department of Organic Chemistry and Technology
- Department of Chemical and Environmental Process Engineering
- Department of Applied Biotechnology and Food Science

Budapest University of Technology and Economics
Faculty of Chemical Technology and Biotechnology
Faculty Office:
Building R, ground floor, room 1.
Mailing Address: Műegyetem rkp. 7-9.
H-1111 Budapest, Hungary
Phone: (+36-1) 463-4604
Fax: (+36-1) 463-2550

Dean of the Faculty: Dr József Nagy
Course Director: Dr. Zoltán Hell
Program Coordinator: Mrs Nóra Gáspár

Curriculum of BSc Subjects
General Subjects

Subject			lectures/practical lectures/laboratory							
Name	Code	Credits	1	2	3	4	5	6	7	Requisities
English for Chemical Studies 1.	BMEGT63ECS1	3	0/4/0f							
English for Chemical Studies 2	BMEGT63ECS2	3		0/4/0f						
English for Engineers	BMEGT63A051	2			0/2/0p					
Communication Skills - English OR	BMEGT63A061	2				0/2/0p				Elective
Manager Communication - English OR	BMEGT63A071	2				0/2/0p				Elective
Intercultural Comm. - English	BMEGT63A091	2				0/2/0p				Elective
Mathematics A1a - Calculus	BMETE90AX00	6	4/2/0e							
General Chemistry	BMEVESAA101	5	4/0/0e							
General Chemistry Calculations	BMEVESAA104	4	0/3/0p							
General Chemistry Laboratory Practice	BMEVESAA209	5		0/0/6p						BMEVESAA101, BMEVESAA104, BMEVESZA101
Computing	BMEVESAA103	2	0/2/0p							
Chemical Eng. Fundamentals	BMEGEVGAV03	2			2/0/0e					
Chemical Engineering Practice	BMEGEVGAV04	3			0/1/2p					
Macro- and Microeconomics	BMEGT30A001	4	4/0/0e							
Mathematics A2c	BMETE90AX17	6		4/2/0e						BMETE90AX00
Mathematics A3 for Chemical Engineers and Bioengineers	BMETE90AX18	4			2/2/0e					
Physics 1 - Mechanics	BMETE14AX15	4	2/2/0e							
Inorganic Chemistry	BMEVESAA208	3		3/0/0p						BMEVESAA101, BMEVESAA104
Inorganic Chemistry Laboratory Practice	BMEVESAA301	3			0/0/4p					BMEVESAA208, BMEVESAA209
Organic Chemistry I.	BMEVESZA301	5			3/2/0e					BMEVESAA101
Chemical Technology	BMEVEKFA203	3		2/0/0p						BMEVESAA101
Physics 1 Electrodynamics	BMETE14AX04	2		2/0/0e						BMETE14AX15
Physics Laboratory	BMETE14AX05	2		0/0/3p						BMETE14AX15
Organic Chemistry II.	BMEVESZA401	4				3/0/0e				BMEVESZA301
Analytical Chemistry	BMEVESAA302	5			4/0/0p					BMEVESAA101, BMEVESAA104
Physical Chemistry I	BMEVEFKA304	5		3/1/0e						BMEVESAA101, BMETE90AX17
Plastics	BMEVEFAA306	5			2/0/2p					BMEVESAA101
Organic Synthesis Laboratory Practice	BMEVESZA402	4				0/0/5p				BMEVESAA104, BMEVESAA209, BMEVESZA301
Analytical Chemistry Laboratory Practice	BMEVESAA403	4				1/0/4p				BMEVESAA209, BMEVESAA302
Physical Chemistry II	BMEVEFAA405	4			2/1/0e					BMEVEFKA304
Medicines	BMEVESZA403	3				2/0/0e				
Colloid chemical approach to nanotechnology	BMEVEFAA409	3				3/0/0p				BMEVEFKA304
Environmental Chemistry and Technology	BMEVEKFA403	4				3/0/0e				BMEVESAA208, BMEVESZA401, BMEVEKFA203
Organic Chemical Technology	BMEVESTA411	3				2/0/0e				BMEVESZA301
Organic Chemical Technology Practice	BMEVESZA412	3				0/0/4p				BMEVESZA301,
Chemical Unit Operations I	BMEVEKFA410	6				3/2/0p				BMETE90AX17; BMEGEVGAV03
Business Law	BMEGT55A001	2					2/0/0p			
Design of Experiments	BMEVEVMA606	3					2/1/0p			BMETE90AX18
Hydrocarbon Processing	BMEVEKFA506	3					2/0/1e			BMEVEKFA203, BMEVEFKA304, BMEVESZA301
Biochemistry	BMEVEBEA301	4					3/0/0e			BMEVESZA401
Physical Chemistry Lab. Prac.	BMEVEFAA506	3					0/0/4p			BMEVEFAA405, BMETE14AX05
Chemical Process Control	BMEVEVMA504	5						2/1/1p		BMEVEKFA410
Chemical Unit Operations II	BMEVEKFA512	6					2/1/4e			BMEVEKFA410
Management and Business Economics	BMEGT20A001	4						4/0/0p		
Industrial Safety	BMEVESZA101	2	2/0/0p							
Quality Management	BMEVEKFA615	4							3/0/0p	
Chemical Unit Op. Practice	BMEVEKFA613	3						0/0/4p		BMEVEKFA512
Electives (humanities)	2 subjects	4								
Specialization		26								
Thesis	BMEVE..A999	15							0/0/14p	
Summer Practice	BMEVE..A888	0								6 weeks/s
Electives		10								

Curriculum of BSc Subjects of Specialization

Subject			working hours / week			
Name	**Code**	**Cre-dits**	**5**	**6**	**7**	**Requisities**
Analytical and Structural Chemistry Specialization						
Analytical and Structure Determination Laboratory	BMEVESAA604	5		1/0/4p		BMEVESAA512, BMEVESAA403
Elemental Analysis	BMEVESAA701	3	2/0/0p			BMEVESAA403
Chemical and Biosensors	BMEVEAAA708	3			2/0/0e	BMEVESAA403
Chromatography	BMEVEAAA611	3		2/0/0e		BMEVESAA403
Elucidation of Organic Structures	BMEVESAA512	3	3/0/0p			BMEVESZA401
Theory of Testing Methods in Material Sciences	BMEVEFAA708	4			3/0/0e	BMEVESZA301, BMETE14AX15, BMETE90AX17
Organic Chemistry III	BMEVESKA504	2	2/0/0e			BMEVESZA401
Project Work	BMEVESAA777	3			0/1/0p	BMEVESAA403
Chemical and Process Engineering Specialization						
Hydrocarbon Technology and Catalysis	BMEVEKFA503	5		2/0/3p		BMEVEKFA506
Process Engineering	BMEVEVMA605	5		3/0/2e		BMEVEKFA512
Environmental Benign Chemical Processes	BMEVEVMA607	4		3/0/0e		
Computer Process Control	BMEVEVMA709	3			2/0/1e	BMEVEVMA504
Chemical Production Control	BMEVEKTA707	3			2/0/1p	BMEVEKFA203, BMEVEKFA512
Radiochemistry and Nuclear Energetics	BMEVEKFA502	3	2/0/1p			BMEVESAA101
Project work	BMEVEKFA777	3			0/1/0p	
Industrial Pharmaceutics Specialization						
Elucidation of Organic Structures	BMEVESAA512	3	3/0/0p			BMEVESZA401
Organic Chemistry III	BMEVESKA504	2		2/0/0e		BMEVESZA401
Organic Chemistry Laboratory Practice II	BMEVESKA605	5	0/0/6p			BMEVESZA401, BMEVESZA402
Pharmaceutical Technology I.	BMEVESTA704	2			2/0/0p	BMEVESTA606
Unit processes in Industrial Drug Synthesis Laboratory Practice	BMEVESTA705	4			0/0/5p	BMEVESTA606
Unit processes in Industrial Drug Synthesis	BMEVESTA606	2		2/0/0e		
Technology of Pharmaceutical Materials	BMEVESTA607	3		2/0/1e		BMEVESZA301
Unit Processes of Organic Chemistry	BMEVESTA508	2	2/0/0e			BMEVESTA411
Project work	BMEVESZA777	3			0/1/0p	
Materials Science Specialization						
Testing Methods in Material Sciences	BMEVEMGA502	3			0/0/4p	
Physical Chemistry of Surfaces	BMEVEFKA603	3		2/0/0e		BMEVEFAA409
Material Science Laboratory Practice	BMEVEMGA603	3		0/0/4p		BMEVEFAA708
Polymer Physics	BMEVEMGA511	3	2/0/0e			BMEVEFAA306
Project Work	BMEVEFAA777	3			0/1/0p	
Nonconventional Materials	BMEVEFAA707	3			2/0/1p	BMEVEFAA405
Metals and Metal Matrix Composites	BMEVEFAA602	2		2/0/0e		
Modern Engineering Ceramics	BMEVEFAA601	2		2/0/0e		
Theory of Testing Methods in Material Sciences	BMEVEFAA708	4	3/0/0p			
Polymer Technology Specialization						
Theory of Testing Methods in Material Sciences	BMEVEFAA708	4	3/0/0p			BMEVESAA208
Machines and Moulds for Polymer Processing	BMEVEFAA705	4			2/0/1p	BMEVEMGA608
Polymer Processing	BMEVEMGA608	7		4/0/5e		BMEVEMGA511
Polymer Physics Laboratory Practice	BMVEMGA509	3	0/0/4p			BMEVEFAA306
Polymer Additives	BMEVEMGA610	2		2/0/0e		BMEVEFAA306
Polymer Physics	BMEVEMGA511	3	2/0/0e			BMEVEFAA306
Project work	BMEVEFAA777	3			0/1/0p	
Textile Technology Specialization						
Theory of Testing Methods in Material Sciences	BMEVEFAA708	4	3/0/0p			BMEVESAA208
Fibre Forming Polymers	BMEVEMGA512	2	2/0/0p			BMEVESZA401
Chemistry of Dyes and Surfactants	BMEVESTA510	2	2/0/0p			BMEVESZA401
Colorimetry, Colormeasurement	BMEVEMGA515	2	2/0/0p			
Textile Mechanical Technology	BMEGEPTAKV1	2		2/0/0p		
Chemical Technology of Textiles I.	BMEVEMGA617	7		3/0/4e		BMEVEMGA512
Chemical Technology of Textiles II.	BMEVEFAA718	4			2/0/2p	BMEVEMGA617
Project work	BMEVEFAA777	3			0/1/0p	

Curriculum of MSc Subjects

Subject			hours/week				
Name	**Code**	**Credits**	**1**	**2**	**3**	**4**	**Remarks**
General subjects							
English for Chemical Studies 1.	BMEGT63ECS1	3	0/4/0f				
English for Chemical Studies 2	BMEGT63ECS2	3		0/4/0f			
Material Science Analysis Methods	BMEVESAM202	4	2/0/2p				fall semester
Physical Chemistry and Structural Chemistry	BMEVEFAM201	5	5/0/0e				fall semester
Environmentally Benign and Catalytic Processes	BMEVEKFM210	5	3/0/1e				fall semester
Organic Chemical Technology II	BMEVESZM201	5	2/0/2p				fall semester
Computational Chemistry	BMEVESAM301	3				2/0/1e	spring semester
Chemical Production Control	BMEVEKFM303	2			2/0/0e		spring semester
Thesis Project I	BMEVEyyMxxx	15			0/0/11p		x and y depend on the department
Summer Practice	BMEVExxM888	0		4 weeks/s			x depends on the department
Thesis Project II	BMEVEyyMxxx	15				0/0/11p	x and y depend on the department
Materials science: Traditional Structural Materials and Polymers	BMEVEFAM110	4		2/0/1e			spring semester
Chemical Process Design and Control	BMEVEKFM101	4		2/0/2p			spring semester
Complex and Inorganic Chemistry	BMEVESAM101	2		2/0/0p			spring semester
Mathematics M1c - Differential Equations	BMETE90MX44	3		2/1/0e			spring semester
Organic Chemistry	BMEVESZM101	4		3/0/0e			spring semester
Social and Visual Communication	BMEGT43MS07	2		2/0/0p			spring semester
Design of Experiments 2	BMEVEKFM209	3	2/0/0p				fall semester
Modern Physics for Chemical Engineers	BMETE14MX00	3			3/0/0e		fall semester
Biology, Biotechnology	BMEVEMBM301	3				2/0/0p	spring semester
Economic Analyses of Technology	BMEGT30MS07	2				2/0/0e	spring semester
Quality Control	BMEVESAM206	2			2/0/0p		fall semester
Technology Management	BMEGT20M005	2			2/0/0p		fall semester
Elective subjects		6					
Modern Chemical Technology							
Modern Separation Technologies	BMEVEKFM104	3				2/0/1p	technology modul, spring semester
Organic Chemical Technology	BMEVESZM503	3				2/0/0e	pharmaceuticals modul, spring semester
Process Engineering	BMEVEKFM211	4			2/0/1p		technology modul, fall semester
Intellectual Property Management	BMEVEFAM103	2		2/0/0e			spring semester
Conventional and Modern Forms of Energy Production	BMEVEKFM302	4				2/0/1e	technology modul, spring semester
Petrochemistry	BMEVEKFM402	6			2/0/3e		technology modul, fall semester
Unit Processes of Organic Chemistry	BMEVESZM207	3			0/2/0p		pharmaceuticals modul, fall semester
Bioinformatics 2 - proteomics	BMEVESZM501	4			2/0/1p		biotechnology modul, fall semester
Hydrocarbon Technology	BMEVEKFM503	3			2/0/0e		technology modul, fall semester
Radiochemistry and Nuclear Energetics	BMEVEKFM502	3			2/0/1p		technology modul, fall semester
Environmentally Benign Chemical Processes	BMEVEKFM501	4				3/0/0e	technology modul, spring semester
Inorganic Chemistry Laboratory Practice	BMEVESAM502	3			0/0/4p		analytics modul, fall semester
Applied electrochemistry	BMEVESAM505	3			2/0/0e		analytics modul, spring semester
Plastics	BMEVEFAM502	5			2/0/2p		materials sciences modul, fall semester
Analytical and Structure Determintaion Laboratory	BMEVESAM504	5				1/0/4p	analytics modul, spring semester
Chemistry and Technology of Biomaterials	BMEVESZM708	2			2/0/0p		pharmaceuticals modul, fall semester
Medicines	BMEVESZM502	3				2/0/0e	pharmaceuticals modul, spring semester
Biocatalysis	BMEVESZM704	2			2/0/0p		biotechnology modul, fall semester
Nonconventional Materials	BMEVEFAM503	3			2/0/0p		materials sciences modul, fall semester
Biopolymers	BMEVEFAM212	4			2/0/1e		materials science modul, fall semester
Bioinorganic Chemistry	BMEVESAM501	2			2/0/0p		analytics modul, fall semester
Physical Chemistry of Surfaces	BMEVEFAM501	3				2/0/0e	materials science modul, spring semester
Chromatography	BMEVESAM503	3			2/0/0e		analytics modul, fall semester
Environmental Toxicology	BMEVEMBM501	3			1/0/1p		biotechnology modul, fall semester
Bioregulation	BMEVEMBM111	3				2/0/0e	biotechnology modul, spring semester
Methods in Molecular Biology	BMEVEMBM210	3			2/0/0e		biotechnology modul, fall semester

Description of BSc Courses

Analytical Chemistry

BMEVESAA302

Dr Róbert E Gyurcsányi
To provide thorough understanding of the fundamental principles, main methods and applications of chemical analysis (volumetric, gravimetric and instrumental analysis), as well as their tools of trade. The subject aims to provide a basis for later subjects including the Analytical Chemistry Laboratory and other advanced analytical chemistry subjects within Analytical and Structural Chemistry Specialization (5 credits)

Analytical Chemistry Laboratory Practice

BMEVESAA403

Dr Róbert E Gyurcsányi, Dr Gergely Lautner
Based on the theoretical background obtained in the analytical chemistry course the primary objective of the Analytical Chemistry Laboratory Practice is to gain hands-on experience in the various analytical techniques, i.e., volumetric analysis and instrumental methods of analysis. During laboratory practices the students will learn the workflow of quantitative and qualitative analysis gaining insight in the main parts and practical operation of analytical instruments. (4 credits)

Biochemistry

BMEVEBEA301

Dr András Szarka
The subject (biochemistry) is not intended to provide the students with a comprehensive biochemistry knowledge. Instead, it offers a short overview of the biochemical pathways and their connections. Its first part covers basic knowledge from the field of cell biology. The second part focuses on the fundamental principles of enzymology and bioenergetics, which additionally serves as the basis for the third part that concentrates on metabolic processes including the energy production pathways of oxidative phosphorylation and photosynthesis. Finally, the fourth part discusses the basics of molecular biology. (4 credits)

Business Law

BMEGT55A001

The problems of the area will be treated in two major parts. Part One introduces students to the general topics, for example the concept of law, the functions of the law in the socioeconomic life. Some basic legal problems, like the conception, characteristics and functions of the modern state and, in a comparative view, the characteristics of the Anglo-Saxon and continental systems of business law and the development of the Hungarian business law will be also discussed. The emphasis of Part Two is on the questions of company law and competition law presented in a European context. The lectures of this part outline not only the regulations of the Hungarian Company Act and Company Registry Act but they cover EU directives and regulations on companies and competition as well. (2 credits)

Chemical Eng. Fundamentals

BMEGEVGAV03

Statics of rigid and elastic bodies. Materials of mechanical structures. Machine elements: fasteners, seals, vessels, pipes and pipe accessories, bearings, couplings, chain, belt, V-belt drive. Fluid mechanics. System approach. Basic law of fluid flow in pipes. Boundary layers. Compressible flow. Non-Newtonian fluids. Operation, performance and selection of pumps, compressors and vacuum pumps. Handling and transportation of solids in bulk. Characteristics of solids. Fluidization. Storage in silos. Pneumatic conveying. Belt and screw conveyors and bucket elevators. (2 credits) (2 credits)

Chemical Engineering Practice

BMEGEVGAV04

All drawings are made only on the practice hours and are made with free hand used the half ready worksheets. Fundamental rules of technical drawing. Arrangement of views by the European projection system. Sections. Threaded parts. Drawing of welded joints. Fits and tolerances. Reading and detailing training of assembly drawings by free hand sketches. Laboratory exercises: measurement of revolution per minute, measurement of pressure, of flow rate and velocity. Fan measurement. Friction losses in pipes and pipe fittings. Sieve analysis. (3 credits)

Chemical Process Control

BMEVEVMA504

Dr Péter Mizsey, Dr Katalin Koczka, Tibor Nagy
The subject is aiming to teach the students the elementary theoretical and practical knowledge of the control, so that, the engineers of the future will be able to work in a team that designs plants, technologies, devices. And, these items are to be controlled, such a work needs also control knowledge for the chemical and biochemical engineers. (5 credits)

Chemical Technology

BMEVEKFA203

Dr György Pátzay, Dávid Havasi
The aim of the subject is providing information in the fields of chemical technology, chemical and environmental technologies, including knowledge in corrosion protection, energy produc-tion and fuels.
Lectures in the field of chemical technology, basic principles and characteristics, economical environmental and energy efficiency aspects of chemical technologies. Balances, yield, schemes. Inorganic chemical technologies, ammonia, nitric acid, urea, sulfuric acid, fertilizer, iron and steel, aluminium, chlorine and sodium hydroxide productions. Energy production and corrosion processes, crude oil, natural gas and coal processing, ceramic and water treatment industries. (3 credits)

Chemical Unit Operations I

BMEVEKFA410

Dr Endre Rév
Chemical unit operations are basic building units of chemical processes. This first course pro-vides an introduction to hydrodynamic and thermal processes only. This includes material and heat balance, momentum balance, fluid mechanics, concepts of fluid behaviour, Bernoulli equations, transportation of fluids, hydrodynamic models, flow in pipes and channels, steady flow, rheology, viscosity, boundary-layer formation, friction factor, pressure flow through equipment, pressure drop across packed towers. Hydrodynamic unit operations: flow in pipes, mixing, sedimentation (settling), filtration, fluidization. Thermal operations: heat

conduction, heat convection, radiation. Rate of heat transfer, heat transfer coefficient (film theory), Nusselt, Reynolds, Prandtl analogy. Dimensional analysis. Heat transfer of condensation. Double pipe and shell and tube heat exchangers. Evaporation, boiling point rise. Standard and multiple-effect evaporators, vapour compression. (6 credits)

Chemical Unit Operations II

BMEVEKFA512

Dr Edit Székely

This is an introductory course on separation processes and on basic calculations of chemical reactors. Topics cover the basic methods of mass transfer calculations and principles of differ-ent mass transfer processes. Mass, component and heat balance equations are used throughout the course. Distillation, extraction and absorption are discussed in details including equipment and short-cut calculations. Simple estimations for chemical reactors are included. (6 credits)

Chemical Unit Operations Laboratory Practice

BMEVEKFA613

Dr Edit Székely

The aim of the course is to introduce engineer students into the chemical unit operation by a detailed laboratory practice. During the course the students meet selected measurements that represent the most important separation processes, reaction kinetic measurements, and model-ling of some chemical units. (3 credits)

Colloid chemical approach to nanotechnology

BMEVEFAA409

Dr Zoltán Hórvölgyi, Dr Emőke Albert

The main objective of the course is to provide a strong colloid chemical background for the preparation, characterization and application of nanomaterials. (3 credits)

Computing

BMEVESAA103

Dr Gábor Csonka

Basic IT support for engineering computations and presentation of the results (Excel, Word, ChemSketch). Programming in Visual Basic for Excel. (2 credits)

Design of Experiments

BMEVEVMA606

Péter Kunovszki

To teach the basic principles and methods of mathematical statistical treatment of measure-ment data.

To teach the design and analysis of the most basic full factorial experimental designs. (3 credits)

Environmental Chemistry and Technology

BMEVEKFA403

Dr Andrea Nagy-Szabó, Dr Gábor Bajnóczy

Understanding the formation, possible reactions of environmentally polluting materials. Students becomes familiar with the chemistry of pollutants in the air, water and soil.

They get to know main chemical and physico-chemical processes in the atmosphere, hydro-sphere, lithosphere and biosphere will be discussed. Chemical basis and the effects of the en-vironmentally harmful materials on the living and non-living objects will be presented as well. The students will be able to identify contaminants emitted by technological processes. They learn about modern technological processes reducing the harmful emissions decreasing the environmental degradation. (4 credits)

General Chemistry

BMEVESAA101

Dr Gábor Csonka, Dr László Nyulászi

To get a basic overview of the principles of Chemistry, providing introductory information, including definitions etc. which can be used in later specific subjects. The course consists of three parts. In the first one the macroscopic properties of the matter are discussed, including phase transitions. In the second part basic chemical principles as acid-base and redox processes, chemical equilibria, electrochemistry and chemical kinetics will be covered briefly. In the third part the atomic and molecular structure, the chemical bonding and the rules in the periodic table are explained. (5 credits)

General Chemistry Calculations for Chemical Engineers

BMEVESAA104

Dr Gábor Csonka, Dr Zoltán Benkő

The aim of the subject is to increase the knowledge of the freshman students on chemical calculations to the level which provides competent basis for further chemical and technological disciplines (inorganic chemistry, organic chemistry, physical chemistry, unit operation, chemical technology etc.). The practice is held in small groups, depending on the former skills of the students. (4 credits)

General Chemistry Laboratory Practice

BMEVESAA209

Dr Ilona Kovács

In this subject the basic chemistry procedures are practiced (e.g. distillation, recrystallization, sublimation). Passing these exercises the students acquire knowledge about the basic laboratory equipment as well. Simple measurements are also performed (e.g. measurements of mass and volume, measuring the melting and boiling point, density measurement methods, pH measurement). Simple preparative tasks (e.g. precipitation, dissolution of metals, producing gas in laboratory, calefaction, preparation of complexes, electrochemistry) are also completed. (5 credits)

Hydrocarbon processing

BMEVEKFA506

Dr Ákos Fürcht

The aim of the subject is to discuss the importance of crude oil, as a primary energy source. It presents crude oil processing technologies and discuss the common use of the products and describes the challenges of the oil refining business. (3 credits)

Industrial Safety

BMEVESZA101

Dr István Csontos

The aim of this course is to introduce the students to the concepts related to fire and explosion hazards and the treatment of toxic material, which is essential for engineers. Another goal is to provide the essentials of safe work and management skills through many practical examples. The subject also presents the standard safety concepts and practice used in the EU and in the U.S. (2 credits)

Inorganic Chemistry

BMEVESAA208

Dr László Nyulászi

Get a basic overview of the field of Inorganic chemistry. The most important trends and rules determining the physical and chemical properties of the elements and simple chemical compounds, such as the periodic system, redox properties, complexing abilities, acid-base properties are discussed. Physical and chemical properties of the elements and basic inorganic compounds (hydrides, halides, oxides, common inorganic acids and bases) and the chemistry of industrially important inorganic systems are explained. (3 credits)

Inorganic Chemistry Laboratory Practice

BMEVESAA301

Dr Ödön Wagner

The aim of this laboratory practice is to increase the knowledge of the students on the topic of inorganic chemistry. The properties of inorganic compounds and the methods of qualitative analysis are explained. (3 credits)

Macro- and Microeconomics

BMEGT30A001

Introduction to macroeconomics. Output and aggregata demand. Fiscal policy and foregn trade. Money and banking. Interest rates and monetray transmission. Monetray and fiscal policy. Aggregate supply, prices and adjustment to shocks. Inflation, expectations, and credibility. Unemployment. Exchange rates and the balance of payments. Economic growth. Economics and the economy. Tools of economic analysis. Demand, supply and the market. Elasticities of demand and supply. Consumer choice and demand decisions. Introducing supply decisions. Costs and supply. Perfect competition and pure monopoly. Market structure and imperfect competition. The labor market. Factor markets and income distribution. (4 credits)

Management and Business Economics

BMEGT20A001

This course introduces the essentials of management as they apply within the contemporary work environment and gives a conceptual understanding of the role of management in the decision making process. It particular attention is paid to management theories, corporate finance, leadership, teamwork, quality management, management of technology, economics calculation and operations management. For problem formulation both the managerial interpretation and the mathematical techniques are applied. (4 credits) (4 credits)

Mathematics A1a - Calculus

BMETE90AX00

Dr. László Ketskeméty, György Richlik

Algebra of vectors in plane and in space. Arithmetic of complex numbers. Infinite sequences. Limit of a function, some important limits. Continuity. Differentiation: rules, derivatives of elementary functions. Mean value theorems, l'Hospital's rule, Taylor theorem. Curve sketchig for a function, local and absolute extrema. Integration: properties of the Riemann integral, Newton-Leibniz theorem, antiderivatives, integration by parts, integration by substitution. Integration in special classes of functions. Improper integrals. Applications of the integral. (6 credits) (6 credits)

Mathematics A2c

BMETE90AX17

Dr László Ketskeméty, György Richlik

Solving systems of linear equations: elementary row operations, Gauss- Jordan- and Gaussian elimination. Homogeneous systems of linear equations. Arithmetic and rank of matrices. Determinant: geometric interpretation, expansion of determinants. Cramer's rule, interpolation, Vandermonde determinant. Linear space, subspace, generating system, basis, orthogonal and orthonormal basis. Linear maps, linear transformations and their matrices. Kernel, image, dimension theorem. Linear transformations and systems of linear equations. Eigenvalues, eigenvectors, similarity, diagonalizability. Infinite series: convergence, divergence, absolute convergence. Sequences and series of functions, convergence criteria, power series, Taylor series. Fourier series: expansion, odd and even functions. Functions in several variables: continuity, differential and integral calculus, partial derivatives, Young's theorem. Local and global maxima/minima. Vector-vector functions, their derivatives, Jacobi matrix. Integrals: area and volume integral. (6 credits) (6 credits)

Mathematics A3 for Chemical Engineers and Bioengineers

BMETE90AX18

Dr Márta Lázi

Outcomes, events, and probability, conditional probability and independence, discret and continuous random variables, distribution function, density function, expected values and variance, binomial, geometric, poisson, uniform, exponential, normal distribution, joint distributions, and independence, covariance and correlation, the law of large numbers, central limit theorem, exploraory data analysis, graphical and numerical summaries, estimators, unbiased estimators, the linear regression model, confidence intervals, testing hypotheses (4 credits)

Medicines

BMEVESZA403

Dr Ervin Kovács, Dr Ferenc Faigl

The subject gives a brief introduction to the medicinal chemistry and pharmacology. The fun-damental pharmacological definitions and concepts as well as the historical background of drug discovery and design are presented. Selected examples of drug activity at some common target receptors demonstrate the importance of the specific receptor-drug interactions and the importance of chemical modifications of the lead molecules to produce highly selective medi-cines. Concepts related to pharmacokinetics are introduced, such as absorption, distribution, metabolism and excretion. (3 credits)

Organic Chemical Technology

BMEVESTA411

Dr László Hegedűs, Dr György Keglevich

The subject discusses the main fields of organic chemical industry through many suitable examples. (3 credits)

Organic Chemical Technology Practice

BMEVESZA412

Dr István Csontos

The development of practical engineering approach through the presentation of the elements and characteristics of the chemical technologies. (3 credits)

Organic Chemistry I.

BMEVESZA301

Dr Ildikó Móczár, Dr József Kupai, Dr Tünde Tóth

Providing up-to-date basics for chemical engineering students in the field of natural sciences. During this course the students should learn the basics of organic chemistry, they should develop an organic chemistry approach and gain proper theoretical and practical foundation for their further studies on material sciences, organic chemistry, chemical technology and biochemistry (5 credits)

Organic Chemistry II.

BMEVESZA401

Dr József Kupai, Dr Idikó Móczár, Dr Tünde Tóth

Providing up-to-date basics for chemical engineering students in the field of natural sciences. During this course the students should learn the basics of organic chemistry, they should develop an organic chemistry approach and gain proper theoretical and practical foundation for their further studies on material sciences, organic chemistry, chemical technology and biochemistry. This subject is the completion of the subject Organic Chemistry I. (4 credits)

Organic Synthesis Laboratory Practice

BMEVESZA402

Dr László Poppe, Dr Gábor Hornyánszki, Dr Tünde Tóth

Basic laboratory practice for chemical engineering students to acquire the skill of performing laboratory tasks and new laboratory methodologies of organic chemistry. During this course the students learn the basics of synthetic laboratory work, safe work methods, simple and rapid identification of the synthesized materials, and the use of the literature of organic chemistry, deepen their knowledge in this field, and gain substantial knowledge on the properties of organic compounds. (4 credits)

Physical Chemistry I

BMEVEFKA304

Dr Mihály Kállay, Dr Krisztina László

The course is part of the compulsory curriculum. A theoretical and practical introduction to physico-chemical phenomena related to equilibrium". Topics covered include: Definition of thermodynamic state functions and demonstration of their use in chemical engineering and biochemical engineering practices; Interpretation of multicomponent phase equilibria and chemical equilibria with the help of chemical potential. The rate of processes is covered in Physical Chemistry II. (5 credits)

Physical Chemistry II

BMEVEFAA405

Dr András Szilágyi, Dr Mihály Kállay

The course provides theoretical and practical knowledge on the chapters of physical chemistry related to change". The rates of processes, as well as equilibrium electrochemistry are discussed. The three main chapters of Physical Chemistry II are Reaction Kinetics, Transport Processes and Electrochemistry (4 credits)

Physical Chemistry Laboratory Practice

BMEVEFAA506

Dr Benjámin Gyarmati, Dr János Bódiss

Further deepening of the knowledge gained in Physical Chemistry (I-II) and Colloid Chemical Approach to Nanotechnology by the introduction of basic experimental methods in thermodynamics and reaction kinetics. Laboratory work and measurements of physico-chemical properties of materials will be accompanied by determination of experimental errors using statistical methods, and introducing some basic skills in experimental design. (3 credits)

Physics 1 - Mechanics

BMETE14AX15

Introduction. Models, theories and laws. Units, standards, SI system. Reference frames. Coordinate systems. Vectors and scalars. Kinematics: speed, displacement, average velocity, instantaneous velocity, acceleration. Uniform motion, uniformly accelerated motion, falling bodies projectile motion. Circular motions. Dynamics: interactions, force, Newton's laws of motion, mass. Applications of Newton's laws. Gravitation and Newton's synthesis. Weight and weightlessness. Kepler's laws. Work and energy. Work-energy theorem. Translational energy. Conservative forces. Potential energy. Mechanical energy and its conservation. Non-conservative forces. Law of energy conservation. Linear momentum and its relation to force. Conservation of the linear momentum. Many bodies problem. Center of mass. Conservation of momentum and the energy in collisions. Oscillations. Simple harmonic motion. Damped harmonic motion. Forced vibrations. Resonance. Simple pendulum. Rotational motion. Angular quantities. Moment of the force: torque. Angular momentum. Conservation of angular momentum. Rotational dynamics. Rigid bodies. Angular momentum and torque for a rigid body. Moment of inertia. Elasticity and elastic moduli. Stress and strain. Fluids at rest. Pressure. Pascal's principle. Fluids in gravitational field. Archimedes' principle. Characteristics of flow. Flow rate and equations of continuity. Laminar flow. Bernoulli's equation. Viscosity. Turbulent flow. Drag force. Dynamical lift. (4 credits)

Physics 1 Electrodynamics

BMETE14AX04

Maxwell equations: a qualitative introduction. Main chapters of Electrodynamics according to the Maxwell equations. Electrostatics. Coulomb's law. E the electric field strength and its measurement. D the electric induction and its measurement. Electric charge density. Local form of Gauss' law. Electric voltage and potential. Capacitors. Electric field and potential in conductors. Electric wind. The electric dipole and its potential field. Electric field and induction in dielectric materials. Polarization mechanisms. Piezo- and ferro-electricity. Magnetostatics. Para-, ferro- and diamagnetism. Stationary fields and direct current. Electric current and current density. Global and local forms of Ohm's law. Mechanisms of the electric conduction. Work and power of the electric current. Kirchhoff's current and voltage law. Batteries. Electromotive force. The magnetic field H of the electric current. The Oersted experiment and Ampére's law. Magnetic field of a solenoid and measurement of H by compensation. The force acting on a current and the torque acting on a current loop in a magnetic field. Measurement of the magnetic induction B. Moving point charge in a magnetic field. Forces between currents. Quasi-stationary fields and alternating currents. Faraday's law of electromagnetic induction. Eddy currents and Lenz' law. Self induction and mutual induction. Complex amplitude of the alternating current and voltage. AC circuits. Average power of AC. Rapidly changing electromagnetic fields and waves. Displacement current. Hertz' experiment. Summary of electrodynamics. (2 credits)

Physics Laboratory

BMETE14AX05

Introduction: Evaluation of measurement data; DC and AC circuits. Measurements, prctices: nonlinear curve fitting; mechanics: elastic force, periodic motions; DC circuit: control of electric current and voltage; geometrical optics: lenses, prism, refractory index; physical optics: diffraction, wave length, Brewster angle, polarization; AC circuit: resonance in series RLC circuit; semiconductor diodes; temperature measurement; logical circuits; dynamical systems (2 credits)

Plastics

BMEVEFAA306

Dr Béla Pukánszky, Dr János Móczó

To supply basic information about plastics for chemical engineering students. Encountering plastics is unavoidable these days both in everyday life and in engineering practice. The course provides the necessary basic knowledge for engineering practice, teaches ways to recognize the main sources of actual problems and offers methods to remedy them. The individual classes discuss the production, processing, behaviour and properties of plastics, as well as related environmental issues. (5 credits)

Quality Management

BMEVEKFA615

Péter Kunovszki, Bálint Bedzsula

To learn the philosophy and fundamental techniques of quality management. To learn the most important statistical tools of quality engineering. (4 credits)

Description of BSc Courses - Specializations

Analytical and Structural Chemistry

Analytical and Structure Determination Laboratory

BMEVESAA604

Dr Imre Miklós Szilágyi

During the laboratory practices the students will become familiar with the state-of-the-art analytical and structural chemistry instruments at the disposal of the Department of Inorganic and Analytical Chemistry (and at the Faculty of Chemical Technology and Biotechnology). They will learn the basics of advanced and coupled instrumental measurement methods of quantitative analysis, as well as of the study and elucidation of the molecular structure. (5 credits)

Chemical and Biosensors

BMEVEAAA708

Dr Róbert E Gyurcsányi

The course covers the principles, materials, methods and selected applications of chemical and biosensing devices and systems. It presents the main modalities to integrate molecular recognition with various forms of signal transduction, such as electrochemical, optical, mass, and acoustic. The performance characteristics of the sensors are linked to their design, type of receptors, materials and signal transduction, identifying strategies for enhanced selectivity and sensitivity. The topics emphasize state of the art medical diagnostic, environmental and food safety applications of chemical and biosensors. Upon successful completion of the course, students are expected:

a) to understand chemical and biosensing and the motivation behind sensor development

b) to understand the performance characteristics and applicability of chemical and biosensors

c) to become familiar with synthetic and biological origin receptors and the basics of molecular recognition mechanisms.

d) to understand transduction mechanisms and the modalities of coupling with selective molecular recognition

e) to be able to extend the principles of chemical and biosensing towards developing biosensing devices. (3 credits)

Chromatography

BMEVEAAA611

Dr Blanka Tóth

The subject lays emphasis on the basics and applications of chromatographic analysis: theoretical background and practice will be discussed in order to develop skills for method development and application of hyphenated techniques. (3 credits)

Elemental Analysis

BMEVESAA701

Dr János Madarász, Dr Lászl Bezur

This introductory course deals with the modern instrumental analytical methods used for element analysis, trace element analysis. Topics like the basic principles of atomic absorption methods, ICP-OES method and ICP-MS method, the construction principles of instrumentation, the characteristic analytical parameters of the methods, and the principles of analytical method development are discussed (3 credits)

Elucidation of Organic Structures

BMEVESAA512

Dr András Simon

Introduction into the theory of ultraviolet/visible, infrared, mass and nuclear magnetic resonance spectroscopy.. Interpretation of ultraviolet/visible, infrared, EI-mass as well as one-dimensional ^{1}H and ^{13}C NMR spectra. Presentation of their application for the solution of practical problems. Presentation of their joint application in the elucidation of the structure of simple unknown compounds. (3 credits)

Organic Chemistry III

BMEVESKA504

Dr László Poppe, Dr Gábor Hornyánszki
Based on the knowledge of subjects Organic Chemistry I and II, this subject puts major emphasis on all aspects of chemical problems associated with chiral compounds. By systematic classification of all major stereochemical terms and stereoselective syntheses, this subject adds solid knowledge to the previously acquired bases in organic chemistry for the future chemical engineers of pharmaceutical and fine chemical industry (2 credits)

Theory of Testing Methods in Material Sciences

BMEVEFAA708

Dr Mihály Kállay
Introduction (the models of molecules, crystals, liquids, amorphous materials; interaction of materials with electromagnetic radiation); infrared and Raman spectroscopy; absorption UV-Vis spectroscopy; optical and electronic properties of solids; photoelectron spectroscopy (UPS, XPS, AES); NMR spectroscopy (molecular and solid state), X-ray diffraction (crystal, liquid, small angle); microscopy (SEM, TEM, AFM). (4 credits)

Chemical and Process Engineering

Chemical Production Control

BMEVEKTA707

László Rácz
Learning chemical processes from design operation and product delivery. Treatment of side products and wastes . Liabilty and operability study. Quality insurance.
Studying chemical processes from the design of operations all the way until product delivery. The subject also gives an overview about the treatment of side products and wastes. It also discusses liability and operability of chemical processes as well as the problems of quality insurance. (3 credits)

Computer Process Control

BMEVEKFA709

Dr Péter Mizsey
Process control gives funded knowledge about control theory and practice. Currently, computers are used everywhere, including in process control. Computers help, however, not only with controlling but also with designing of control structures. It enables the engineer to calculate controllability features and also modelling both steady state and dynamic processes. (3 credits)

Environmental Benign Chemical Processes

BMEVEVMA607

Dr Edit Székely
The course gives an overview of possibilities to be evaluated, understood and of the environ-mental impact of various technologies to be taken into account. Besides, through case studies the best available technique concept is demonstrated and discussed in details. Concepts and typical applications of separation methods from high vacuum to high pressure techniques is explained. (4 credits)

Hydrocarbon Technology and Catalysis

BMEVEKFA503

Dr Ákos Fürcht
To provide specialised knowledge about crude oil processing. To discuss the ecopolitical importance of crude oil, as one of the most important raw materials. To present crude oil produc-ing technologies and discuss the refinery flow scheme. To describe the catalyst management options, which may affect the profit possibilities. (5 credits)

Process Engineering

BMEVEVMA605

Dr Endre Rév
This Process Engineering course for BSc students targets three main clusters of basic Chemical Process Modelling knowledge, namely (i) flowsheeting, i.e. calculating steady state of complex chemical processes usually with recycling streams, (ii) practical selection and use of physico-chemical models for calculating phase equilibria and phase distribution, and (iii) basic numerical methods indispensable for engineers. An outlook to process synthesis problems and techniques is also provided. (5 credits)

Radiochemistry and Nuclear Energetics

BMEVEKFA502

Dr György Pátzay
Energy and matter. Atomic structure and bounding forces. Basic knowledge in nuclear energy production, fission and fusion. Types of radiations, alpha, beta gamma, neutron radiations. Detectors and nuclear measur-ements. Environmental radioactivity. Dosimetry and radiation protection. Nuclear power plants and nuclear fuel cycles. Radioactive wastes, waste treatments. Future of nuclear energy. (3 credits)

Industrial Pharmaceutics

Elucidation of Organic Structures

BMEVESAA512

Dr András Simon
Introduction into the theory of ultraviolet/visible, infrared, mass and nuclear magnetic resonance spectroscopy.. Interpretation of ultraviolet/visible, infrared, EI-mass as well as one-dimensional 1H and 13C NMR spectra. Presentation of their application for the solution of practical problems. Presentation of their joint application in the elucidation of the structure of simple unknown compounds (3 credits)

Organic Chemistry III

BMEVESKA504

Dr László Poppe, Dr Gábor Hornyánszki
Based on the knowledge of subjects Organic Chemistry I and II, this subject puts major emphasis on all aspects of chemical problems associated with chiral compounds. By systematic classification of all major stereochemical terms and stereoselective syntheses, this subject adds solid knowledge to the previously acquired bases in organic chemistry for the future chemical engineers of pharmaceutical and fine chemical industry. (2 credits)

Organic Chemistry Laboratory Practice II

BMEVESKA605

Dr Gábor Hornyánszki
Students are to acquire a mastery of the methodology of lab-

oratory practice necessary to complete tasks in the fields of the pharmaceutical industry and the research-development sector of the organic chemical industry, and to successfully participate in the MSc studies. The aim of the laboratory practice is to carry out organic chemical reaction sequences, to learn about modern organic reactions, procedures and separation techniques, and to learn the requirements of conducting independent research (this involves the demonstration and practice of the structure elucidation of organic compounds, as well as the introduction of the methods of current organic chemical literature search, online search, the use of monographs and series, and the practice of the application of softwares). (5 credits)

Pharmaceutical Technology I.

BMEVESTA704

Dr Zoltán Hell

This subject gives an overview on the characteristic methods for the industrial synthesis of active pharmaceutical ingredients (API) based on the known technologies of Hungarian and other producers. The discussed fields are the followings: choice of the synthesis strategy, continuous development of the industrial technology from different aspects such as the environment protection, the quality assurance, the safety, the thrift and the protection of the copyright. The criteria of choosing the appropriate equipment, the technologies of the separation of APIs and their intermediates from natural raw materials (plants, animals) are presented. Aspects of the diminution of the waste products, waste treatment are also discussed. (2 credits)

Project Work

BMEVESZA777

Dr Antal Gajáry, Dr Alajos Grün

The aim of the subject is to present the research and development processes that result in industrial scale production. In the first half of the semester the elements and aspects of a development process are discussed. After that the students are given the opportunity to prove their skills in this field by working on a project divided into small groups (3 credits)

Technology of Pharmaceutical Materials

BMEVESTA607

Dr György Marosi

The aim of the subject is to introduce the students to the technology of pharmaceutical products including the relevant theory and practice. The characteristics of the applicable pharmaceutical excipients and drug delivery systems are also discussed. Understanding of the relevant structure-activity relationships are initiated based on the characteristics of the most important manufacturing methods of different types of pharmaceutical products. The analytical methods serve the understanding of this field are also introduced. After the successful completion of the subject one should be familiar with the theoretical bases of the medicine formulation and have a basic knowledge about each step of the manufacturing of pharmaceuticals and capable of discussing with the specialists of those fields. The subject is supposed to serve as a good basis for deeper research in the relevant field or can be a core of a BSc thesis. (3 credits)

Unit processes in Industrial Drug Synthesis

BMEVESTA606

Dr Ferenc Faigl

The subject deals with the typical chemical transformations, isomer separation techniques and scale-up processes of the pharmaceutical and fine chemical industries. Among the unit processes the special N-, O- and C-alkylations, C-C bond forming reactions (Claisen-, Dieckmann-, Knoevenagel- and Darzens-condensation, Vilsmeyer-formylation, reactions of polar organometallics, cross-coupling reactions), and selective reductions with inorganic and organic hydrides are discussed. The theory and methods of the separation and enrichment of optical isomers, as well as the application of dry technologies are discussed and illustrated through industrial examples (2 credits)

Unit processes in Industrial Drug Synthesis Laboratory Practice

BMEVESTA705

Dr Ferenc Faigl, Dr Zolán Hell

In the framework of the practice typical industrial scale synthetic technologies and processes are presented for the students. The theoretical background of the unit processes applied in the presented technologies has been discussed in the lectures of Unit Processes in Drug Synthesis" which is highlighted again during the practices. (4 credits)

Unit Processes of Organic Chemistry

BMEVESTA508

Dr György Keglevich

Presentation of the chemical transformations most commonly used in the chemical industry. The environmentally friendly aspects and implementations are given special emphasis. (2 credits)

Materials Science

Material Science Laboratory Practice

BMEVEMGA603

Dr Emilia Csiszár

Introduction; Characterization of plastics; Fracture mechanics; Determination of mechanical properties of plastics (tensile and bending tests); Thermal characterization of polymers; Fibre reinforced polymers; Characterization of fibrous materials; Investigations of layers; Electrochemical investigation of galvanic corrosion; Investigation of diffusion kinetics; (3 credits)

Metals and Metal Matrix Composites

BMEVEFAA602

Dr Kornél Májlinger, József Hári

During both their everyday life and professional work chemical engineers often meet a variety of traditional and modern metallic materials. The course provides important knowledge in the fields of natural science and engineering related to the production, processing and application of metallic functional materials. A further aim of the course is to present – from the perspective of materials science – the ability of metals, alloys and complex metallic matrices, as well as their associated systems, to satisfy the demands of the modern economy. (2 credits)

Modern Engineering Ceramics

BMEVEFAA601

Dr Alfréd Kállay-Menyhárd

During both their everyday life and professional work chemical engineers often meet a variety of traditional and modern ceramic materials. The course provides important knowledge in the fields of natural science and engineering related to the production, processing and application of ceramic functional materials. A further aim of the course is to present – from the perspective of materials science – the ability of modern industrial ceramics and their associated systems to satisfy the demands of the modern economy. (2 credits)

Nonconventional Materals

BMEVEFAA707

Dr András Szilágyi, Dr Krisztina László, Dr Zoltán Hórvölgyi
Metal foams. Shape memory alloys and polymers, special ceramics. Complex fluids. Gels and their application in drug delivery. Self-assembly. Responsive and other special nanocoatings. Aerogels. Materials with ordered porosity. Nanotubes. The course includes laboratory work; there are 4 compulsory laboratory practical classes in the aforementioned topics. (3 credits)

Physical Chemistry of Surfaces

BMEVEFKA603

Dr Krisztina László
Fundamentals of solid/fluid interfaces. The qualitative description of the surface layer, the concept of surface excess. Thermodynamics of the interfaces, surface tension and interaction potential. Interactions at solid/gas and solid/liquid interfaces. Adsorption isotherms, their interpretation (Langmuir, BET, Dubinin-Radushkevich and DFT models). Experimental methods, including calorimetry. Fractality. Particle size analysis.
Applied surface science: the role of interfaces in materials science, environmental and industrial processes. Heterogeneous catalysis, Pressure/Temperature Swing Adsorption. (3 credits)

Polyer Physics

BMEVEMGA511

Dr Béla Pukánszky
Introduction. Terms and definitions: monomer, polymer, homo- and copolymer. Structure of the polymer, segments, entanglement. Supramolecular structure, amorphous and crystalline materials. The individual chain. Shape, conformation, conformation distribution. The freely jointed chain model. Interactions, solutions, determination of molecular weight. Phases and physical states, thermomechanics. Rubber elastic state, thermodynamics, kinetics. Flow, rheology. Measurement of viscosity. Glassy state, fracture, polarization optics. Crystalline polymers, structure. Crystallization kinetics, melting. Structure-property correlations, plasticization (3 credits)

Project Work

BMEVEFAA777

Dr Alfréd Kállay-Menyhárd
The integration and application of the knowledge obtained by the students during their university studies through the design of a plant or factory manufacturing a given product. Demonstration of the complexity of problems related to the design and operation of a manufacturing plant. The course calls attention to problems rarely or not at all mentioned during other courses. The course helps students develop their ability to solve problems, make decisions and to present their results. (3 credits)

Testing Methods in Material Sciences

BMEVEMGA502

Dr Béla Pukánszky
Methods using the excitation of the electronic structure: XPS, UPS, AES, SIMS, absorption spectroscopy of solids; Methods using the excitation of the lattice: Thermal analysis, IR and Raman spectroscopy; Methods for studying the structure: XRD, SEM + EDX, SPM ((EC)-STM, (EC)-AFM, nanoindenter) (3 credits)

Theory of Testing Methods in Material Sciences

BMEVEFAA708

Dr Mihály Kállay
Introduction (the models of molecules, crystals, liquids, amorphous materials; interaction of materials with electromagnetic radiation); infrared and Raman spectroscopy; absorption UV-Vis spectroscopy; optical and electronic properties of solids; photoelectron spectroscopy (UPS, XPS, AES); NMR spectroscopy (molecular and solid state), X-ray diffraction (crystal, liquid, small angle); microscopy (SEM, TEM, AFM). (4 credits)

Polymer Technology

Machines and Moulds for Polymer Processing

BMEVEFAA705

Péter Müller
Introduction; Extrusion: components of an extruder, operation of an extruder, extruder screws; choosing the proper screw for a polymer; Characteristics of an extruder screw and its optimal operating point, film blowing, sheet extrusion; Wire coating, profile extrusion, filament extrusion, coextrusion; Injection moulding: Tool designing, simulation software; Special injection moulding techniques: Gas and water injection, Injection moulding on films, Injection moulding on textiles; Compression moulding machines and tools; Thermoforming machines and tools;
Practical work: Visits in manufacturing plants. (4 credits)

Polymer Additives

BMEVEMGA610

Dr János Móczó
Introduction; Changes taking place during the processing and application of plastics, chemical reactions, degradation, ageing; Degradation and stabilization; Light stabilization; PVC degradation and stabilization; Degradation and stabilization of other polymers; Lubricants; Fillers, surfactants, coupling agents; Polymer additives (impact modifiers, processing aids), their purpose and mechanism; Flame retardants; Blowing agents, colorants; Other additives; Further aspects of the use of additives, Additive packages, interaction of additives – PVC, polyolefins (2 credits)

Polymer Physics

BMEVEMGA511

Dr Béla Pukánszky
Introduction. Terms and definitions: monomer, polymer, homo- and copolymer. Structure of the polymer, segments, entanglement. Supramolecular structure, amorphous and crystalline materials. The individual chain. Shape, conformation, conformation distribution. The freely jointed chain model. Interactions, solutions, determination of molecular weight. Phases and physical states, thermomechanics. Rubber elastic state, thermodynamics, kinetics. Flow, rheology. Measurement of viscosity. Glassy state, fracture, polariza-

tion optics. Crystalline polymers, structure. Crystallization kinetics, melting. Structure-property correlations, plasticization. (3 credits)

Polymer Physics Laboratory Practice

BMEVEMGA509

Dr Béla Pukánszky

Introduction; Preparation and reactions of polymers; Qualitative analysis of polymers, Rheology; IR spectroscopy; Thermal analysis I; Thermal analysis II; Impact testing; Mechanical properties of polymers; Fibre-reinforced composites; Polymer foams, Welding of polymers (3 credits)

Polymer Processing

BMEVEMGA608

Dr Béla Pukánszky

Introduction; Rheology – flow, viscosity; The measurement of the characteristics of the melt (viscosity, elastic properties); Heat transfer processes; Extrusion – equipment, basic processes; Extrusion – dies, products; Injection moulding – equipment, the mould filling process; Injection moulding – the structure of injection moulded products; moulds; Extrusion and injection blow moulding, rotational moulding; Calendering; Welding and other operations; Processing of thermoset resins; Other processing technologies;

Laboratory classes: Introduction; Processing of polymer blends and particulate filled polymers; Extrusion of thermoplastics; Injection moulding of thermoplastics; Production of PVC compounds; Thermoforming; Thermo-retardation; Processing of thermoset resins: Epoxy resins, Compression moulding, Time-temperature-conversion correlations; Standard testing of rubbers (7 credits)

Project Work

BMEVEFAA777

Dr Alfréd Kállay-Menyhárd

The integration and application of the knowledge obtained by the students during their university studies through the design of a plant or factory manufacturing a given product. Demonstration of the complexity of problems related to the design and operation of a manufacturing plant. The course calls attention to problems rarely or not at all mentioned during other courses. The course helps students develop their ability to solve problems, make decisions and to present their results. (3 credits)

Theory of Testing Methods in Material Sciences

BMEVEFAA708

Dr Mihály Kállay

Introduction (the models of molecules, crystals, liquids, amorphous materials; interaction of materials with electromagnetic radiation); infrared and Raman spectroscopy; absorption UV-Vis spectroscopy; optical and electronic properties of solids; photoelectron spectroscopy (UPS, XPS, AES); NMR spectroscopy (molecular and solid state), X-ray diffraction (crystal, liquid, small angle); microscopy (SEM, TEM, AFM). (4 credits)

Textile Technology

Chemical Technology of Textiles I.

BMEVEMGA617

Dr Emilia Csiszár

Preparatory processes: desizing, scouring, bleaching, carbonizing; Mercerization and liquid ammonia treatment; Dyeing processes: fundamentals and methods; Textile printing; Laboratory classes: Identification of textile materials; Preparatory processes: desizing, scouring and bleaching; Dyeing of cellulosic fibres; Dyeing of wool; Dyeing of synthetic-polymer fibres; Textile printing; (7 credits)

Chemical Technology of Textiles II.

BMEVEFAA718

Dr Emilia Csiszár, Dr Judit Borsa

The main goal of the course is to give basic information about the most important chemical treatments for improving functional and aesthetic properties of textiles. The course gives a detailed account of the knowledge related to textile quality, the practical aspects of quality, as well as the environmental impact of the chemical finishing processes of textiles. (4 credits)

Chemistry of Dyes and Surfactants

BMEVESTA510

Dr András Víg

Demonstration of the classification, production, chemical and technological properties and use of dyes and surfactants applied in the textile and paper industry. Discussion of the application of different dyes and surfactants in the practice by means of industrial examples. (2 credits)

Colorimetry, Colormeasurement

BMEVEMGA515

Dr Sándor Csányi

The main goals of the course are to give basic information about the colours, colour spaces, methods of colour measurement and other related topics; to offer information about the colour measuring instruments and the measurement and evaluation of whiteness. (2 credits)

Fibre Forming Polymers

BMEVEMGA512

Dr Judit Borsa

An introduction to textile chemistry and technology, understanding the various applications of fibres. (2 credits)

Project Work

BMEVEFAA777

Dr. Alfréd Kállay-Menyhárd

The integration and application of the knowledge obtained by the students during their university studies through the design of a plant or factory manufacturing a given product. Demonstration of the complexity of problems related to the design and operation of a manufacturing plant. The course calls attention to problems rarely or not at all mentioned during other courses. The course helps students develop their ability to solve problems, make decisions and to present their results. (3 credits)

Theory of Testing Methods in Material Sciences

BMEVEFAA708

Dr Mihály Kállay

Introduction (the models of molecules, crystals, liquids, amorphous materials; interaction of materials with electromagnetic radiation); infrared and Raman spectroscopy; absorption UV-Vis spectroscopy; optical and electronic properties of solids; photoelectron spectroscopy (UPS, XPS, AES); NMR spectroscopy (molecular and solid state), X-ray diffraction (crystal, liquid, small angle); microscopy (SEM, TEM, AFM). (4 credits)

Description of MSc Courses

Biology, biotechnology

BMEVEMBM301

Dr Miklós Pécs

The subject gives an overview of modern biotechnology by focusing on its prominent areas of chemical industrial and engineering interest. After providing an introduction of cell biology and microbiology, the subject concentrates on the possibilities of biotechnology branches termed as white and green biotechnology. Furthermore, it discusses the most important bioindustrial unit operations and environmental bio-solutions. (3 credits)

Chemical Process Design and Control

BMEVEKFM101

Dr Péter Mizsey

To teach the students the elementary knowledge of chemical process design and control. The process design step is the creative challenge of the chemical engineer. Selection/ determination of the proper design alternative is a difficult task. Investigation of the controllability of the process designed is also the part of the creative activity where the mutual effect of process and control should be considered. (4 credits)

Complex and Inorganic Chemistry

BMEVESAM101

Dr Ilona Kovács

The aim of the subject is to give a general knowledge in the field of the organometallic chemistry (classifications, structure, stability, reactivity) and to give more detailed information about the industrial applications of these compounds. The lectures have been structured in the traditional way – following the periodic table for the main-group element organometallics (alkali, alkali-earth, aluminum, tin, lead and silicon will be discussed in detail) and according to the nature of the ligand in transition-metal complexes. At the end of the course the industrial applied catalytic reactions (Heck, Suzuki, etc.) will be discussed. (2 credits)

Computational Chemistry

BMEVESAM301

Dr Dénes Szieberth, Tibor Höltzl

The subject gives an overview about the principles used to describe the structure of molecules and bulk phases. The modeling of physico-chemical parameters, chemical processes will be presented together with the usual techniques. Practical examples for the solution of chemical- and physico-chemical problems by computer modeling will be done during the course. (3 credits)

Design of Experiments 2

BMEVEKFM209

Péter Kunovszki, Dr Sándor Kemény

To learn one of the most important and widely used statistical methods, the analysis of variance.

To deepen the knowledge attained in the introductory course about factorial designs. (3 credits)

Environmentally Benign and Catalytic Processes

BMEVEKFM210

Dr Edit Székely

The aim of the course is to give an overview of current environmental regulations, environ-mentally benign and industrially applied catalytic technologies and the trends of their devel-opment from the aspect of chemical engineers. The students gain insight to selected innovative processes and technologies and develop a broader understanding of the selection of a suitable technology for a given purpose. (5 credits)

Material Science Analysis Methods

BMEVESAM202

Dr Imre Miklós Szilágyi

The course will give a broad overview on the measurement methods used in materials science involving nanotechnology, inorganic chemistry, polymers, biomaterials, organic materials. During the laboratory practices students will get both theoretical knowledge and practical experience about a large number of analytical methods and instruments. (4 credits)

Materials science: traditional structural materials and polymers

BMEVEFAM110

Dr Alfréd Kállay-Menyhárd

Materials science explores the relationship between the processing technology, the structure and the properties of materials with the aim of meeting the requirements of specific applications. The goal of the course is to offer information about the structure, properties and behaviour of the most frequently used structural and functional solid materials. The course demonstrates the importance of the design, production and shaping of materials and products through real-life examples. The course discusses in detail the structure-property correlations of plastics, metals and ceramics, as well as structural and functional solid materials based on renewable resources. This course also highlights the important similarities and differences between the studied structural materials. (4 credits)

Organic Chemical Technology II

BMEVESZM201

Dr László Hegedűs, Dr György Keglevich

Principles of environmentally friendly chemistry and chemical technology, up-to-date methods and techniques including catalytic transformations, sonochemistry and microwave-assisted chemistry, the use of green solvents and ionic liquids, phase-transfer catalysis. All these are shown via applications in industrial syntheses together with cost optimization, up-to-date analytical and separation technologies. (5 credits)

Organic Chemistry

BMEVESZM101

Dr Péter Huszthy

The aim of the subject is to get deep insight in organic chemistry at an advanced level. (4 credits)

Physical chemistry and structural chemistry

BMEVEFAM201

Dr Mihály Kállay

The course deals with the experimental and calculation methods and the related theoretical background that provide information about the structure and properties of molecules and molecule ensembles. (5 credits)

Modern Chemical Technology

Analytical and structure determination laboratory

BMEVESAM504

Dr Imre Szilágyi, Dr Róbert E Gyurcsányi

During the laboratory practices the students will become familiar with the state-of-the-art ana-lytical and structural chemistry instruments at the disposal of the Department of Inorganic and Analytical Chemistry (and at the Faculty of Chemical Technology and Biotechnology). They will learn the basics of advanced and coupled instrumental measurement methods of quantita-tive analysis, as well as of the study and elucidation of the molecular structure. (5 credits)

Applied Electrochemistry

BMEVESAM505

Dr Lajos Höfler

This course focuses on two major fields of electrochemistry: sensors and energy storage de-vices. Students can learn about theory, development and the analytical methods of some widely used electrochemical sensors, and batteries. The discussed topics cover the thermodynamics and kinetics of these devices. Various simulation methods to describe the response mechanism are included. (3 credits)

Biocatalysis

BMEVESZM704

Dr László Poppe

The aim of the subject is to provide high-level scientific and practical knowledge to the future chemical and bioengineers of chemical and biological industries (pharmaceutical, agro- and fine chemical, cosmetic and food industries) with special focus on the development of prob-lem solving skills related to chemical problems by using the tools of biotechnology. (2 credits)

Bioinformatics 2-proteomics

BMEVESZM501

Dr László Poppe

The aim of the subject is to provide high-level scientific and practical knowledge to the future bioengineers of chemical and biological industries (pharmaceutical, fine chemical, cosmetic, food, etc.) with special emphasis on the development of problem solving skills especially in the field of protein structure-activity relationships in the research and development. The course gives an overview of theoretical issues in proteomics, which is important to promote the practical applications, and provides insight into their applications in specific areas by computer practice. (4 credits)

Bioinorganic chemistry

BMEVESAM501

Dr Julianna Oláh

During the course students get acquainted with the combination of inorganic chemistry and biochemistry, the so-called bioinorganic chemistry, which draws great attention as a complete-ly new scientific field. Topics to be discussed: the role of the elements and inorganic com-pounds in biological processes, the formation of metal containing biocomplexes, the toxicity of some inorganic compounds, bioactive compounds with inorganic ions used in pharmaceuti-cal chemistry. (2 credits)

Biopolymers

BMEVEFAM212

Dr Emilia Csiszár

Biopolymers are polymers produced by living organisms (e.g. microorganisms or higher-order plants and animals) or synthesized from bio-based building blocks (e.g. acids, amino acids, carbohydrates, natural triglycerides) in a chemical process. The course provides an introduction to the most significant biopolymers, their chemical structure, properties and most important applications. (4 credits)

Chemistry and Technology of Biomaterials

BMEVESZM708

Dr György Marosi

The subject aims at getting the students acquainted with the use of materials in biomedical applications, the excipients of biologically active materials, the concepts of the selection and preparation of biocompatible materials, their physical-chemical properties, and their use in the technology of medical products with special emphasis on the controlled release of drugs. The lectures include the classification of biomaterials; chemical and enzymatic reactions in relation to biomaterials (synthesis, modification and decomposition), macromolecular systems of envi-ronmental technologies, the relevant biodegradable polymers, macromolecular bases of pharmaceutical technologies (such as the preparation of nanocapsules, implants and their ap-plication). Special emphasis is put on the manufacturing technologies of biocomposites. All of these topics are established by the relevant basic summary regarding the considerations of material science, surface modification and analytics as well as physical chemistry of smart biomaterials. The seminars promote the understanding of the interactions between different classes of materials and many tissues of the human body. Topics such as soft tissue replace-ment, biosensors, bio-devices and pharmaceuticals are included in the lectures as well. (2 credits)

Chromatography

BMEVESAM503

Dr György Horvai, Dr Viola Horváth, Dr Blanka Tóth

The basics and application fields of chromatography are presented in order to enable the students to learn method development and the use of hyphenated technics. (3 credits)

Conventional and Modern Forms of Energy Production

BMEVEKFM302

Dr György Pátzay

The aim of the subject is to introduce the theory and practice of energy production technolo-gies, conventional and modern forms of energy production to students. They will be informed about fossil, fissile and renewable energy sources and energy production technologies as well as about future fields of modern energy production, storage and distribution. (4 credits)

Environmental Toxicology

BMEVEMBM501

Dr Mónika Molnár, Dr Viktória Feigl

Environmental toxicology as part of the risk-based environmental management plays an increasingly important role. The main aim of the subject is to give an overview on the effect-based tools of the modern environmental risk management. The course covers both the theoretical background and the detailed practical aspects of environmental toxicology together with its applications in the risk assessment, risk management and in the environmental decision making. The topics discussed throughout the course are the following.

- The basics of environmental toxicology, qualitative and quantitative assessment of the toxicity effects of chemicals.
- The measurement of toxicity and other adverse effects, the classification of the test methods according to different aspects e.g. test-organism, size and type of tests, duration, and endpoints.
- The introduction of the most widespread related methodologies, their evaluation, statistics and interpretation. The use of ecotoxicity enables generic and site-specific risk assessment of chemicals; site- and land usage-specific assessment of contaminated land; integrated environmental monitoring; establishment of environmental quality criteria and priority setting as well as risk-based environmental management and decision making.
- Soil and soil-specific tests with emphasis on the importance of the Soil Testing Triad.

The typical applications of the environmental toxicity testing are discussed in details and are illustrated with interactive case studies. (3 credits)

Environmentally Benign Chemical Processes

BMEVEKFM501

Dr Edit Székely, Dr László Mika, Katalin Koczka, Ildikó Kmecz

The course gives an overview of possibilities to evaluate, understand and take into account the environmental impact of various technologies. Furthermore, through case studies the best available technique concept is demonstrated and discussed in details. Concepts and typical applications of separation methods from high vacuum to high pressure techniques are explained. (4 credits)

Hydrocarbon Technology

BMEVEKFM503

Dr Iván Gresits, Dr Ákos Fürcht

To discuss the importance of crude oil, as primary energy source. To present the crude oil pro-cessing technologies and discuss the common use of the products. To describe the challenges of the oil refining business (3 credits)

Inorganic Chemistry Laboratory Practice

BMEVESAM502

Dr Zoltán Benkő, Dr Dénes Szieberth

During laboratory exercises, physical and chemical properties of metallic and non-metallic elements and simple inorganic compounds are reviewed Students also gain knowledge on the solubilities of the elements and inorganic salts/compounds in water, acids and bases. Typical reactions of inorganic ions are studied via simple and complex qualitative analytical exercises. (3 credits)

Medicines

BMEVESZM502

Dr Ferenc Faigl, Ervin Kovács

The subject gives a breaf introduction to the medicinal chemistry and pharmacology. The fun-damental pharmacological definitions and concepts as well as the historical background of drug discovery and design are presented. Selected examples of drug activity at some common target receptors demonstrate the importance of the specific receptor-drug interactions and the importance of chemical modifications of the lead molecules to produce highly selective medi-cines. Concepts related to pharmacokinetics are introduced, such as absorption, distribution, metabolism and excretion. (3 credits)

Modern separation technologies

BMEVEKFM104

Dr Edit Székely, Dr László Mika, Katalin Koczka, Ildikó Kmecz

The subject gives an overview of environmentally friendly processes and unit operations of the chemical, biochemical and food industries. It deals with widely applied and currently re-searched technologies as well. During the course we will focus on how the development, se-lection and optimisation of a novel technology are influenced by environmental aspects be-sides selectivity and improved yield. By new separation technologies, adding different modifiers, solvents, etc. are not favoured and toxic adducts are one by one substituted to less harmful analogues. Modelling and design aspects will be also considered and explained through detailed description and evaluation of main application examples. (3 credits)

Nonconventional Materials

BMEVEFAM503

Dr András Szilágyi. Dr Krisztina László, Dr Zoltán Hórvölgyi

This course covers the following topics: Metal foams. Shape memory alloys and polymers. Special ceramics. Complex fluids. Gels and their application in drug delivery. Self-assembly. Responsive and other special nanocoatings. Aerogels. Materials with ordered porosity. Nanotubes. (3 credits)

Organic Chemical Technology

BMEVESZM503

Dr György Keglevich, Dr László Hegedűs
The subject discusses the main fields of organic chemical industry through many suitable ex-amples. (3 credits)

Petrochemistry

BMEVEKFM402

Dr Ákos Fürcht, Dr Iván Gresits
To provide specialised knowledge about the further processing of crude oil refinery products. To provide insight to the daily operation of petrochemical companies via several site visits. (6 credits)

Physical Chemistry of Surfaces

BMEVEFAM501

Dr Krisztina László
Fundamentals of solid/fluid interfaces. The qualitative description of the surface layer, the concept of surface excess. Thermodynamics of the interfaces, surface tension and interaction potential. Interactions at solid/gas and solid/liquid interfaces. Adsorption isotherms, their interpretation (Langmuir, BET, Dubinin-Radushkevich and DFT models). Experimental methods, including calorimetry. Fractality. Particle size analysis.
Applied surface science: the role of interfaces in materials science, environmental and industrial processes. Heterogeneous catalysis, Pressure/Temperature Swing Adsorption. (3 credits)

Plastics

BMEVEFAM502

Dr Béla Pukánszky, Dr János Móczó
To supply basic information about plastics for chemical engineering students. Encountering plastics is unavoidable these days both in everyday life and in engineering practice. The course provides the necessary basic knowledge for engineering practice, teaches ways to recognize the main sources of actual problems and offers methods to remedy them. The individual classes discuss the production, processing, behaviour and properties of plastics, as well as related environmental issues. (5 credits)

Process Engineering

BMEVEKFM211

Dr Endre Rév
This Process Engineering course targets ideas and basic techniques of Process Structure Design, also called Chemical Process Synthesis. The most important problems and solution methods of process synthesis are presented. Included are detailed discussion of energy recovery networks and mass exchange networks, distillation sequencing, energetically efficient continuous rectification variants, continuous distillative separation processes applicable to azeotropic and near boiling mixtures. Optionally, depending on progress, feasibility methods applicable in assigning batch distillation of azeotropes, as well as the most important heuristics of scheduling are also discussed. (4 credits)

Radiochemistry and Nuclear Energetics

BMEVEKFM502

Dr György Pátzay, Tibor Nagy, Dávid Havasi
Energy and matter. Atomic structure and bounding forces. Basic knowledge in nuclear energy production, fission and fusion. Types of radioations, alpha, beta gamma, neutron radiations. Detectors and nuclear measuerements. Environmental radioactivity. Dosimetry and radiation protection. Nuclear power plants and nuclear fuel cycles. Radioactive wastes, waste treat-ments. Future of nuclear energy. (3 credits)

Unit Processes of Organic Chemistry

BMEVESZM207

Dr György Keglevich, Dr Nóra Kiss
Presentation of the chemical transformations most commonly used in the chemical industry. The environmentally friendly aspects and implementations are given special emphasis. (2 credits)

Environmental Engineering
Curriculum of MSc Subjects - Environmental Management Spec.

Subject			hours/week				
Name	**Code**	**Credits**	**1**	**2**	**3**	**4**	**Remarks**
Environmental Management Specialization							
Applied chemistry	BMEVEKFM103	4	2+2+0e				2+2+0e
Environmental Economics	BMEGT42M410	3	2+0+0p				2+0+0p
Environmental Management	BMEGT42M411	3	2+0+0p				2+0+0p
Environmental and Remediation Processes	BMEVEKFM107	4	3+0+0e				3+0+0e
Mathematics M1c - Probability Theory and Statistics	BMETE90MX61	4	3+0+0e				3+0+0e
Engineering Ecology	BMEEOVKMKM1	3	2+0+0p				2+0+0p
Economic Analysis of Technology	BMEGT30M401	3	2+0+0p				2+0+0p
Water Environmental Monitoring and Assessment	BMEEOVKMKM6	3	2+1+0p				2+1+0p
Bioengineering: unit operations and processes	BMEVEMBM214	3		2+0+0e			2+0+0e
Environmental Analysis	BMEVESAM207	5		3+0+1p			3+0+1p
Case Studies in Environment Assessment and Audit	BMEKOVJM953	3		1+1+0p			1+1+0p
Environmental Planning	BMEGT42M412	3		2+0+0p			2+0+0p
Environmental Management Systems	BMEGT42M413	3		1+1+0p			1+1+0p
Social and Visual Communication	BMEGT43M401	3		0+0+0p			0+0+0p
Technology Management	BMEGT20M410	3		2+0+0p			2+0+0p
Conventional and New Technologies of Energy Production	BMEVEKFM304	3			2+0+0e		2+0+0e
Environmental microbiology and bio-technology	BMEVEMBM308	4			3+0+0p		3+0+0p
Modelling of Environmental Systems	BMEEOVKMKM5	5			2+2+0e		2+2+0e
Environmental Efficiency Evaluation	BMEGT42M414	3			1+1+0p		1+1+0p
Circular Economy	BMEGT42M416	3				2+0+0p	2+0+0p
Risk Evaluation and Risk Management	BMEGT42M417	3				2+0+0e	2+0+0e
Environmental Marketing	BMEGT42M418	3				0+2+0p	0+2+0p
Occupational Health and Safety, Fire Protection, Noise and Vibration Protection	BMEKOMVM951	4				2+1+0e	2+1+0e
Electives		6					
Thesis project I		15			0+0+10p		
Thesis project II		15				0+0+10p	
Summer Practice	BMEGT42MN18	0		4 weeks			

Environmental Engineering
Curriculum of MSc Subjects - Environmental Technology Spec.

Subject			hours/week				
Name	**Code**	**Credits**	**1**	**2**	**3**	**4**	**Remarks**
Environmental technology specialization							
Applied Chemistry	BMEVEKFM103	4	2+2+0e				2+2+0e
Environmental Economics	BMEGT42M410	3	2+0+0p				2+0+0p
Environmental Management	BMEGT42M411	3	2+0+0p				2+0+0p
Environmental Technology Project	BMEVEKFM108	3	1+1+0p				1+1+0p
Environmental and Remediation Processes	BMEVEKFM107	4	3+0+0e				3+0+0e
Mathematics M1c - Probability Theory and Statistics	BMETE90MX61	4	3+0+0e				3+0+0e
Engineering Ecology	BMEEOVKMKM1	3	2+0+0p				2+0+0p
Economic Analysis of Technology	BMEGT30M401	3	2+0+0p				2+0+0p
Water Environmental Monitoring and Assessment	BMEEOVKMKM6	3	2+1+0p				2+1+0p
Bioengineering: unit operations and processes	BMEVEMBM214	3		2+0+0e			2+0+0e
Environmental Analysis	BMEVESAM207	5		3+0+1p			3+0+1p
Case Studies in Environment Assesment and Audit	BMEKOVJM953	3		1+1+0p			1+1+0p
Social and Visual Communication	BMEGT43M401	3		0+0+0p			0+0+0p
Technology Management	BMEGT20M410	3		2+0+0p			2+0+0p
Database systems*	BMEEOFTMI51	3			0+2+0p		0+2+0p
Energy Efficiency and Certification *	BMEGEÉEMKK3	3			2+1+0p		2+1+0p
Conventional and New Technologies of Energy Production	BMEVEKFM304	3			2+0+0e		2+0+0e
Waste managment*	BMEGEÉEMKK2	3			2+1+0e		2+1+0e
Environmental microbiology and bio-technology	BMEVEMBM308	4			3+0+0p		3+0+0p
Modelling of Environmental Systems	BMEEOVKMKM5	5			2+2+0e		2+2+0e
Operation of chemical processes*	BMEVEKFM305	3			2+0+1p		2+0+1p
Drinking water and wastewater treatment plants*	BMEEOVKMV61	3			2+1+0p		2+1+0p
Modern Environment.friendly Transporta-tion Systems*	BMEKOVJM955	3				2+0+0p	2+0+0p
Environmental toxicology*	BMEVEMBM401	3				2+0+1p	2+0+1p
Air Pollution Control*	BMEGEÉEMKK1	3				2+0+0e	2+0+0e
Occupational Health and Safety, Fire Pro-tection, Noise and Vibration Protection	BMEKOMVM951	4				2+1+0e	2+1+0e
Technical Acoustics and Noise Control*	BMEGEÁTMKK3	3				1+1+0p	1+1+0p
Technologies in the chemical industry*	BMEVESZM206	3				2+0+0p	2+0+0p
Planning of Studies*	BMEVEKFM403	3				2+1+0p	2+1+0p
Electives		6					
Thesis project I		15			0+0+10p		The code depends on the department
Thesis project II		15				0+0+10p	The code depends on the department
Summer Practice	BMEVEKFM888	0		4 weeks			

* Specialization elective subject: 12 credits has to be collected

Description of MSc Courses Environmental Engineering

Environmental Management Specialization

Applied Chemistry

BMEVEKFM103

Dr Andrea Nagy-Szabó, Dr Krisztina László, Dr Gábor Bajnóczy

Upgrading course in general chemistry, physical chemistry environmental chemistry and calculations.
(4 credits)

Environmental Economics

BMEGT42M410

Dr. Gábor Bartus

The course unit aims to achieve two main goals. Firstly, to teach students the economic theory governing the efficient allocation of environmental and natural resources, based on their scarcity and renewability. Secondly, to offer an insight into the practical use-related questions of the various types of environmental and natural resources, with an overview of best practices currently available.
(3 credits)

Environmental Management

BMEGT42M411

Dr Kálmán Kósi

The aim of the course is to highlight that the activities of organisations ought to be managed through the system of processes, or, in other words, highlighting the process oriented approach. This approach may be applied for all processes, for management functions, in other words, to the entire PDCA cycle. The course unit aims to empower students to understand and to be capable the integration of environmental protection in the management functions.
(3 credits)

Environmental and Remediation Processes

BMEVEKFM107

Dr László Mika

The course aims to provide theoretical and practical knowledge of operations and devices of environmental and remediation processes, furthermore planning and direction of remediation projects. Detection and treatment of soil, oil, air, industrial pollution and disasters in focus with chemical industries. Basic knowledge of waste treatment and management. (4 credits)

Mathematics M1c - Probability Theory and Statistics

BMETE90MX61

Dr Márta Lázi

(4 credits)

Engineering Ecology

BMEEOVKMKM1

Ferenc Szilágyi

The aim of this course is to provide basic knowledge and practical experiences to the MSc students who are going to deal with solution of environmental problems in their future work. The main goal is to give alternative and ecologically more acceptable practical practices which are based on self-regulatory behaviour of natural ecosystems. The methods of ecological engineering can often replace the commonly used artificial engineering solutions and they can more suitable from society point of view. The phasing of the needs of ecosystems and the society is also a goal of the subject showing the relevant practical measures.
(3 credits)

Economic Analysis of Technology

BMEGT30M401

Dr László Vígh

(3 credits)

Water Environmental Monitoring and Assessment

BMEEOVKMKM6

Adrienne Clement

The course aims to provide theoretical and practical knowledge in the field of environmental monitoring systems, assessment of environmental hazard and the status evaluation. During the theoretical lectures and practical exercises students learn design and operation of environmental monitoring systems, become familiar with sampling theory, data collection and information systems with special focus on water and aquatic ecosystem. Practical skills will be obtained through monitoring network design, introduction of sampling methods and instruments, analytical methods, biomonitoring, data processing and evaluation. (3 credits)

Bioengineering: unit operations and processes

BMEVEMBM214

Dr Áron Németh

The main object of these lectures are to introduce operations and procedures in biotechnological industry for students with special attention to their quantitative relationships. This object applies the toolbar of mathematic modeling for description of processes and for simulation of optimal operations. (3 credits)

Environmental Analysis

BMEVESAM207

Dr Viola Horváth

The course aims to provide a theoretical and practical knowledge in the analysis of air, water and soil contaminants and that of waste. During the lectures and group projects the student will learn the most up-to-date sampling and analytical measurement techniques. In addition they acquire information about the quality assurance of such measurements. They will learn how to setup air, water and soil monitoring systems. Practical skills will be taught in environmental sampling, sample pretreatment and the determination of contaminant concentrations with various analytical techniques. (5 credits)

Case Studies in Environment Assessment and Audit

BMEKOVJM953

Dr Gergely Tulipánt

The students should acquire, from environmental point of view, those modern knowledge which have significant effect on investments and activities for making environmental influence examination and for the environment protecting re-examinations of these activities concerning those up-to-date knowledge that relate to audition via working out case-studies. They should familiarize themselves with those ruling environmental protecting elements which are used for overall examination of the environmental status.
(3 credits)

Environmental Planning

BMEGT42M412

Dr Tamás Pálvölgyi

The main objective of the course is to present the theory and practice of environmental planning at EU, national and municipal level, as well as to introduce the use of major planning and regulatory tools. Secondly, to offer an insight into methodology of environmental strategy-making, with a strong emphasis on best practices of strategic environmental assessment. (3 credits)

Environmental Management Systems

BMEGT42M413

Dr Kálmán Kósi

The aim of the course is to introduce the benefits and underlying opportunities of the implementation of system-oriented management in the environmental protection efforts of businesses. (3 credits)

Social and Visual Communication

BMEGT43M401

Zsolt Bátori

The course aims to provide students with theoretical knowledge in the field of communication and visual communication regarding the role and the goals of communication in the human society. In addition to the theoretical discussions students are given practical skills for communicating and presenting complex professional ideas and reasons to expert or layman audience. Students learn about different language, rhetorical and visual tools that can be used in presentations and participatory situations. (3 credits)

Technology Management

BMEGT20M410

Dr Béla Pataki

The program:to show the role of technology and engineering work in the successful operation of organizations, to help the deeper understanding of the competitive nature of technology, to introduce some proven methods of technology management, to qualify the students to effectively cooperate with the business side of the organization (e.g. with the marketing department). (3 credits)

Conventional and New Technologies of Energy Production

BMEVEKFM304

Dr György Pátzay

(3 credits)

Environmental microbiology and biotechnology

BMEVEMBM308

Dr Mónika Molnár

The main aim of the subject is to help the students develop a bio and eco-engineering view when dealing with environmental biotechnologies; furthermore to get familiar with the natural biological – microbiological and plant-assisted processes substantiating these technologies. The subject includes the theoretical background of environmental bio- and eco-technologies, their practical implementation and evaluation even via case studies targeting amendment of degraded soils and remediation of contaminated (environmental) elements, primarily contaminated soil, ground water, wastewater. Within this topic the focus will be on the ecosystem, especially on microorganisms and primarily on the multilevel interaction between the chemical substances and the environment, especially the chemical substances contaminating the soil and ground water, on the utilisation of the microbiological processes in the environmental technologies, mainly in the bioremediation of contaminated environmental elements and amendment of degraded soils, as well as in biological wastewater treatment. (4 credits)

Modelling of Environmental Systems

BMEEOVKMKM5

Dr László Koncsos

The course aims to introduce the core steps of environmental modelling including problem and model identification, calibration, validation and sensitivity analysis. The course provides theoretical and practical knowledge about key concepts of different modelling techniques such as the integrated simulation of multimedia environmental processes as well as the description of point and non-point source pollutant and nutrient transport. Surface-subsurface water and material transport and air pollution is introduced. Evaluation of various environmental risks is also a relevant part of the material. During the course various mathematical methods will be presented including statistical and analytical approaches, numerical solution of differential equations and soft computing techniques. (5 credits)

Environmental Efficiency Evaluation

BMEGT42M414

Dr Kálmán Kósi

The aim of the course unit is to introduce environmental performance assessment techniques and methods. The course unit introduces macro level performance assessment methods, and the necessity and aims of the application of such methods, and the practical applicability of methods and their findings in organisational practice. (3 credits)

Circular Economy

BMEGT42M416

Dr Gábor Bartus

The material throughput increased significantly in the last century, the societies are using more and more natural resources as input materials for manufacturing goods and services in order to enhance well-being of the humankind. The increased material throughput has caused the loss of biodiversity and environmental problems. The goal of the concept of the circular economy is to manage the material use, to decrease the natural resource input, to prevent the environmental harms from material use. The circular economy concept evaluates the technical and logistic alternatives of material use decrease and waste management. The circular economy is also about the economic evaluation of the governmental action in order to create relevant incentives and regulations. (3 credits)

Risk Evaluation and Risk Management

BMEGT42M417

Dr Noémi Nagypál-Csige

The course aims to provide knowledge about the theoretical background of environmental valuation, the reasons for the special approach of environmental valuation and the methods available. The students gain knowledge about the classification of valuation methods, the steps of application of each method, as well as their advantages and limitation. The students will learn why it is important to manage environmental risk in a complex way, the social aspects of risk management and various approaches and the steps of cyclic risk management. (3 credits)

Environmental Marketing

BMEGT42M418

Dr László Valkó

To present the role of marketing among environmental management techniques-methods. To highlight the position and role of environmental marketing in case of market oriented organisations. To prepare the student to system integrative way of thinking. To gain experience in the formulation of organisational environmental marketing concept. (3 credits)

Occupational Health and Safety, Fire Protection, Noise and Vibration Protection

BMEKOMVM951

Dr Mária Koch

The course aims to provide theoretical and practical knowledge in both fire protection and occupational safety while highlighting the most important obligations of the employer towards the field of action. They must be clear on what specific fire protection or occupational safety tasks they need to solve while working under organized circumstances, but also need to know which of these is a complex problem, that requires the handling of a professional. Another focus of the course is to provide a basic knowledge in the field of noise and vibration protection. This will help students understand the basic requirements in the industry. (4 credits)

Environmental Technology Specialization

Applied Chemistry

BMEVEKFM103

Dr Andrea Nagy-Szabó

Upgrading course in general chemistry, physical chemistry environmental chemistry and calculations (4 credits)

Environmental Economics

BMEGT42M410

Dr Gábor Bartus

The course unit aims to achieve two main goals. Firstly, to teach students the economic theory governing the efficient allocation of environmental and natural resources, based on their scarcity and renewability. Secondly, to offer an insight into the practical use-related questions of the various types of environmental and natural resources, with an overview of best practices currently available. (3 credits)

Environmental Management

BMEGT42M411

Dr Kálmán Kósi

(3 credits)

Environmental Technology Project

BMEVEKFM108

Dr Zsolt Csikor

The course aims to provide a general view on the range of technological solutions applied in enviromental problems and their future potentials. With this knowledge, the students can estimate the role of technological solutions, their potential results and their limitations when trying to solve the world's sustainability problems. (3 credits)

Environmental and Remediation Processes

BMEVEKFM107

Dr László Mika

The course aims to provide theoretical and practical knowledge of operations and devices of environmental and remediation processes, furthermore planning and direction of remediation projects. Detection and treatment of soil, oil, air, industrial pollution and disasters in focus with chemical industries. Basic knowledge of waste treatment and management. (4 credits)

Mathematics M1c - Probability Theory and Statistics

BMETE90MX61

Dr Márta Lázi

(4 credits)

Engineering Ecology

BMEEOVKMKM1

Ferenc Szilágyi

The aim of this course is to provide basic knowledge and practical experiences to the MSc students who are going to deal with solution of environmental problems in their future work. The main goal is to give alternative and ecologically more acceptable practical practices which are based on self-regulatory behaviour of natural ecosystems. The methods of ecological engineering can often replace the commonly used artificial engineering solutions and they can more suitable from society point of view. The phasing of the needs of ecosystems and the society is also a goal of the subject showing the relevant practical measures. (3 credits)

Economic Analysis of Technology

BMEGT30M401

Dr László Vígh

(3 credits)

Water Environmental Monitoring and Assessment

BMEEOVKMKM6

Adrienne Clement

The course aims to provide theoretical and practical knowledge in the field of environmental monitoring systems, assessment of environmental hazard and the status evaluation. During the theoretical lectures and practical exercises students learn design and operation of environmental monitoring systems, become familiar with sampling theory, data collection and information systems with special focus on water and aquatic ecosystem. Practical skills will be obtained through monitoring network design, introduction of sampling methods and instruments, analytical methods, biomonitoring, data processing and evaluation. (3 credits)

Bioengineering: unit operations and processes

BMEVEMBM214

Dr Áron Németh

The main object of these lectures are to introduce operations and procedures in biotechnological industry for students with special attention to their quantitative relationships. This object applies the toolbar of mathematic modeling for description of processes and for simulation of optimal operations. (3 credits)

Environmental Analysis

BMEVESAM207

Dr Viola Horváth

The course aims to provide a theoretical and practical knowledge in the analysis of air, water and soil contaminants and that of waste. During the lectures and group projects the student will learn the most up-to-date sampling and analytical measurement techniques. In addition they acquire information about the quality assurance of such measurements. They will learn how to setup air, water and soil monitoring systems. Practical skills will be taught in environmental sampling, sample pretreatment and the determination of contaminant concentrations with various analytical techniques. (5 credits)

Case Studies in Environment Assessment and Audit

BMEKOVJM953

Dr Gergely Tulipánt

The students should acquire, from environmental point of view, those modern knowledge which have significant effect on investments and activities for making environmental influence examination and for the environment protecting re-examinations of these activities concerning those up-to-date knowledge that relate to audition via working out case-studies. They should familiarize themselves with those ruling environmental protecting elements which are used for overall examination of the environmental status. (3 credits)

Social and Visual Communication

BMEGT43M401

Dr Zsolt Bátori

The course aims to provide students with theoretical knowledge in the field of communication and visual communication regarding the role and the goals of communication in the human society. In addition to the theoretical discussions students are given practical skills for communicating and presenting complex professional ideas and reasons to expert or layman audience. Students learn about different language, rhetorical and visual tools that can be used in presentations and participatory situations. (3 credits)

Technology Management

BMEGT20M410

Dr Béla Pataki

The program:to show the role of technology and engineering work in the successful operation of organizations, to help the deeper understanding of the competitive nature of technology, to introduce some proven methods of technology management to qualify the students to effectively cooperate with the business side of the organization (e.g. with the marketing department). (3 credits)

Database systems*

BMEEOFTMI51

The course aims to provide theoretical and practical knowledge in the field of data analysis. During the semester basic concept of efficient and consistent data management will be presented. In addition students get knowledge how to build a complex database system as a project with teamwork.
(3 credits)

Energy Efficiency and Cdertification*

BMEGEÉEMKK3

Dr Tamás Csoknyai

The course aims to provide theoretical and practical knowledge in the field of energy efficiency of large energy systems and buildings. It covers fundamental meteorological aspects, energy balance of buildings, calculation frameworks, energy efficiency measures and building integrated renewable energy systems, energy performance and environmental indicators. Energy performance certification schemes will also be discussed such as life cycle assessment of buildings. (3 credits)

Conventional and New Technologies of Energy Production

BMEVEKFM304

Dr György Pátzay

(3 credits)

Waste Management*

BMEGEÉEMKK2

Dr Orsolya Molnár

The course introduces main sources and types of industrial and communal waste, waste hierarchy and up-to-date directives regarding to waste management. Insight is gained into waste disposal and treatment processes, main equipment and processes of waste management are taught. During the theoretical lectures and organized field trips students become familiar with environmental and sustainability problems regarding to thermal treatment and disposal of hazardous and municipal wastes. The course aims to intensify engineering skills and to train professionals focusing on environmental and sustainability aspects of waste management. (3 credits)

Environmental microbiology and biotechnology

BMEVEMBM308

Dr Mónika Molnár

The main aim of the subject is to help the students develop a bio and eco-engineering view when dealing with environmental biotechnologies; furthermore to get familiar with the natural biological – microbiological and plant-assisted processes substantiating these technologies. The subject includes the theoretical background of environmental bio- and eco-technologies, their practical implementation and evaluation even via case studies targeting amendment of degraded soils and remediation of contaminated (environmental) elements, primarily contaminated soil, ground water, wastewater. Within this topic the focus will be on the ecosystem, especially on microorganisms and primarily on the multilevel interaction between the chemical substances and the environment, especially the chemical substances contaminating the soil and ground water, on the utilisation of the microbiological processes in the environmental technologies, mainly in the bioremediation of contaminated environmental elements and amendment of degraded soils, as well as in biological wastewater treatment. (4 credits)

Modelling of Environmental Systems

BMEEOVKMKM5

Dr László Koncsos

The course aims to introduce the core steps of environmental modelling including problem and model identification, calibration, validation and sensitivity analysis. The course provides theoretical and practical knowledge about key concepts of different modelling techniques such as the integrated simulation of multimedia environmental processes as well as the description of point and non-point source pollutant and nutrient transport. Surface-subsurface water and material transport and air pollution is introduced. Evaluation of various environmental risks is also a relevant part of the material. During the course various mathematical methods will be presented including statistical and analytical approaches, numerical solution of differential equations and soft computing techniques. (5 credits)

Operation of chemical processes*

BMEVEKFM305

Teaching the basics of operation and control, so that the environmental engineers will became able to work in a team with process engineers to design and complete the control structure of any process. The theoretical subjects are demonstrated in the frame laboratory practices. (3 credits)

Drinking water and wastewater treatment plants*

BMEEOVKMV61

The course aims to provide theoretical and practical knowledge in the field of applied treatment technologies at drinking water and wastewater treatment plants. The first part of the semester deals with drinking water treatment technologies. (1) water bases and contaminants in the raw water, (2) disinfection of drinking water, iron, manganese, arsenic and ammonium ion removal technologies, (3) removal of dissolved gases and solid particles from drinking water, (4) complex technologies for drinking water treatment. The second part of the semester deals with wastewater treatment technologies: (1) the definition of wastewater, (2) mechanical wastewater treatment, (2) basics of biological wastewater treatment, (3) basics of chemical wastewater treatment, the removal of phosphorous and nitrogen from wastewater, (4) sludge formation during wastewater treatment, aerobic and anaerobic treatment and disposal of sludge. (3 credits)

Modern Environment.friendly Transportation Systems*

BMEKOVJM955

Dr Gergely Tulipánt

The students should acquire and get an overall picture about the environmental questions which determine the transport in the present environmental burden and they should handle the total transport system in unified, environmental point of view. They should familiarize with the relevant modern knowledge for reduction of environmental pollution. (3 credits)

Environmental toxicology*

BMEVEMBM401

Dr Mónika Molnár

Environmental toxicology is one of the most important tools in the modern, risk-based environmental management, as is the study of the impacts of chemical substances upon the structure and function of ecological system. This subject explains the principles and practice of environmental toxicology and its application in environmental risk management, risk assessment, risk reduction and decisions concerning the protection of the environment. At the laboratory practice we get familiar with laboratory test methods applied in environmental toxicology and the most important testorganisms used in aquatic and terrestrial ecotoxicology. (3 credits)

Ocupational Health and Safety, Fire Protection, Noise and Vibration Protection

BMEKOMVM951

The course aims to provide theoretical and practical knowledge in both fire protection and occupational safety while highlighting the most important obligations of the employer towards the field of action. They must be clear on what specific fire protection or occupational safety tasks they need to solve while working under organized circumstances, but also need to know which of these is a complex problem, that requires the handling of a professional. Another focus of the course is to provide a basic knowledge in the field of noise and vibration protection. This will help students understand the basic requirements in the industry. (4 credits)

Technical Acoustics and Noise Control*

BMEGEÁTMKK3

Dr János Gábor Vad

(3 credits)

Technologies in the chemical industry*

BMEVESZM206

Dr Alajos Grün

The aim of this subject is to show the principles of environmentally friendly chemistry, methods, equipment and techniques, along with the application of the green chemical tools in the organic chemical industry and in syntheses of practical importance. Criterions of up-to-date technologies, and point of views of economical and environ protecting operations are also discussed via case studies. (3 credits)

Planning of Studies*

BMEVEKFM403

Dr Kinga Komka

The course aims to teach the basics and methods of mathematical statistical treatment of measured data and to teach the design and analisys of the most basic full factorial designs. During the theoretical lectures and practical exercises students learn the theoretical background of the statistical analysis of data and the most important statistical methods including hypothesis testing, parameter estimation, correlation and linear regression. Practical skills will be obtained through design of experiments and the statistical analysis of measured data. (3 credits)

Faculty of Civil Engineering

The Faculty of Civil Engineering is the oldest faculty of the Budapest University of Technology and Economics and can trace its history back to the University's predecessor, the Institutum Geometricum, founded by Emperor Joseph II in 1782. Since then, thousands of engineers have graduated from this Faculty to work worldwide as educators, international researchers and engineering project managers.

The most essential service of the Faculty – education linked closely to research and engineering work – is reflected in the scientific activities of nearly 110 lecturers in 9 departments. They have contributed significantly to a professional, scientifically sound solution of diverse engineering problems. Out of the approximately 1200 students who study at this Faculty, 100 students from abroad participate in the English language program annually.

The BSc engineering program in English leads to a BSc degree in four years. Two specialisations are offered: Structural Engineering and Infrastructure Engineering. Graduates from the BSc Specialization in Structural Engineering are able to design, construct and organize the investments of mechanically, structurally and technologically complex structures in close cooperation with architects as well as transportation and hydraulic specialists. These structures include bridges and underground passages for transportation networks; power stations, cooling towers, craneways, transmission and telecommunication line structures; warehouses, industrial plants, and multi-storey buildings as well as hydraulic and water utility structures. Graduates from the BSc Specialization in Infrastructure Engineering are able to design and construct urban and regional infrastructure, such as roads, railways, water and wastewater utilities, hydraulic constructions, and organize engineering activities in these fields.

The Faculty offers an MSc programme in Structural Engineering with a duration of 1.5 years. The MSc programme has three specializations: Specialization in Numerical Modelling, Specialization in Structures, and Specialization in Geotechnics and Geology. Specialization in Numerical Modelling provides advanced knowledge of structural analysis using contemporary computer techniques, including the theoretical background of the methods. Specialization in Structures provides thorough knowledge in structural design, skills enabling to carry out independent project coordination and to execute special design, construction and development procedures. The main goal of the Specialization in Geotechnics and Geology is to provide enhanced knowledge and skills in the field of engineering geology, geotechnics modelling, underground structures and foundations. These specializations are useful for research oriented students pursuing a doctoral degree in a PhD programme, as well as for the next generation of practicing leading engineers, who will solve special structural problems and innovate the construction procedures.

The doctoral school of the Faculty offers a 4-year PhD programme in Civil Engineering and Earth Sciences.

Departments

Geodesy and Surveying
Construction Materials and Technologies
Photogrammetry and Geoinformatics
Engineering Geology and Geotechnics
Structural Engineering
Structural Mechanics
Highway and Railway Engineering
Hydraulic and Water Resources Engineering
Sanitary and Environmental Engineering

Budapest University of Technology and Economics
Faculty of Civil Engineering
Faculty Office:
Building K, 1st floor, room 128
Mailing Address: Műegyetem rkp. 7-9.
H-1111 Budapest, Hungary
Phone: (+36-1) 463-3531
Fax: (+36-1) 463-3530
Web: www.epito.bme.hu

Dean: Dr. László Dunai
Course-director: Dr. Olivér Fenyvesi
Program coordinator: Ms. Nóra Gáspár

Curriculum of BSc in Civil Engineering
Core subjects (8 semesters)

Subject			lecture/seminar/laboratory/exam								Preliminary require-ment(s)
Name	Code	Cre-dits	1	2	3	4	5	6	7	8	
Core subjects											
Compulsory English 1	BMEGT63A3E1	4	4/0/4/M								
Surveying 1	BMEEOAFAT41	3	3/1/2/M								
Chemistry of Construction Materials	BMEEOEMAT41	2	2/2/0/M								
Civil Engineering Representation and Drawing	BMEEOEMAT42	4	4/2/2/M								
CAD for Civil Engineers	BMEEOFTAT41	2	2/0/2/M								
Geology	BMEEOGMAT41	3	3/1/2/E								
Basis of Statics and Dynamics	BMEEOTMAT41	6	6/0/5/E								
Mathematics A1a - Calculus	BMETE90AX00	6	6/4/2/E								
Physics for Civil Engineers	BMETE11AX13	2	2/2/0/M								
Compulsory English 2	BMEGT63A3E2	4	4/0/4/M	4/0/4/M							
Surveying 2	BMEEOAFAT42	4		4/2/2/E							EOAFAT41 EOFTAT41
Construction Materials 1	BMEEOEMAT43	5		5/2/0/2/E							EOEMAT41
Civil Engineering Informatics	BMEEOFTAT42	5		5/2/2/M							EOFTAT41
Building Construction Study	BMEEOEMAT44	3		3/1/2/M							EOEMAT42
Introduction to Strength of Materials	BMEEOTMAT42	6		6/0/5/M							EOTMAT41 TE90AX00~
Hydraulics 1	BMEEOVVAT42	3		3/2/1/E							
Mathematics A2a - Vector Functions	BMETE90AX02	6		6/4/2/E							TE90AX00
Surveying Field Course	BMEEOAFAT43	3		3/0/0/M	9 days						EOAFAT42~
Soil Mechanics	BMEEOGMAT42	4			4/2/2/M						EOGMAT41 EOTMAT42
Geoinformatics	BMEEOFTAT43	3			3/2/1/M						EOAFAT42
Basis of Design	BMEEOHSAT41	3			3/2/0/M						EOTMAT41~
Structural Analysis 1	BMEEOTMAT43	4			4/4/0/E						EOTMAT42 TE90AX00
Railway Tracks	BMEEOUVAT41	3			3/3/0/E						EOAFAT41
Basics of Environmental Engineering	BMEEOVKAT41	3			3/2/0/M						
Public Works 1	BMEEOVKAT42	3			3/2/1/E						EOVVAT42
Hydrology 1	BMEEOVVAT41	3			3/2/1/M						
Mathematics A3 for Civil Engineers	BMETE90AX07	4			4/2/2/E						TE90AX02
Earthworks	BMEEOGMAT43	3				3/2/1/E					EOGMAT42
Steel Structures	BMEEOHSAT42	3				3/3/0/M					EOTMAT42 EOEMAT43~ EOHSAT41
Reinforced Concrete Structures	BMEEOHSAT43	3				3/3/0/M					EOTMAT42 EOEMAT43~ EOHSAT41
Roads	BMEEOUVAT42	2				2/2/0/M					EOUVAT41
Hydraulic Engineering, Water Manag.	BMEEOVVAT43	3				3/2/1/E					EOVVAT41 EOVVAT42
Construction Management	BMEEPEKAT41	3				3/2/1/M					EOEMAT44 EOGMAT42
Business Law	BMEGT55A001	2				2/2/0/M					
Foundation Engineering	BMEEOGMAT45	4					4/3/0/E				EOGMAT43
Management and Enterprise	BMEGT20A001	4					4/4/0/M				
Micro- and Macroeconomics	BMEGT30A001	4						4/4/0/E			
Communication Skills for Civil Engineers	BMEGT60A6EO	2						2/0/2/M			
Urban and Regional Development	BMEEOUVAT43	3							3/2/0/M		
Elective subject		4							4/4/0/M		

Curriculum of BSc in Civil Engineering
Specialization in Structural Engineering

Subject			lecture/seminar/laboratory/exam								Preliminary require-ment(s)
Name	Code	Cre-dits	1	2	3	4	5	6	7	8	
Specialization in Structural Engineering											
Building Construction 1	BMEEOEMAS42	3				3/1/2/E					EOEMAT44
Timber Structures	BMEEOHSAS44	3				3/2/0/M					EOTMAT42 EOEMAT43 EOHSAT41
Strength of Materials	BMEEOTMAS41	3				3/2/0/E					EOTMAT43
Construction Materials 2	BMEEOEMAS41	3					3/1/0/2/E				EOEMAT43
Building Construction 2	BMEEOEMAS43	3					3/1/2/E				EOEMAS42 EOHSAT41
Steel and Composite Structures	BMEEOHSAS47	4					4/2/1/M				EOHSAT42 EOHSAT43
RC and Masonry Structures	BMEEOHSAS42	4					4/2/1/M				EOHSAT43 EOEMAS42 EOTMAT43
Bridges and Infrastructures	BMEEOHSAS43	3					3/2/0/E				EOHSAT42 EOHSAT43
Laboratory Practice of Testing of Structures and Materials	BMEEOHSAS46	2					2/0/04/M				EOHSAT42 EOHSAT43
Structural Analysis 2	BMEEOTMAS42	4					4/3/1/M				EOTMAT43 EOTMAS41 TE90AX07
Rock Mechanics	BMEEOGMAS41	3					3/1/1/M	3/1/1/M			EOGMAT41 EOGMAT42
Underground Structures, Deep Found.	BMEEOGMAS42	3					3/2/1/M	3/2/1/M			EOGMAT45
3D Constructional Modelling of Structures	BMEEOHSAS45	3					3/0/2/M	3/0/2/M			EOHSAT42 EOHSAT43 EOFTAT42
Design of Structures Projectwork	BMEEODHAS41	6					6/0/0/M	6/0/0/M			EOHSAS47 EOHSAS42 EOGMAT45
Public Administration and Land Registry	BMEEOUVAT44	3					3/2/0/M	3/2/0/M	3/2/0/M		GT55A001
Field Course of Structural Surveys	BMEEOAFAS42	1					1/0/0/2/M	1/0/0/2/M	1/0/02/M		EOAFAT43 EOHSAT42 EOHSAT43
Dynamics of Structures	BMEEOTMAS43	3					3/2/0/M	3/2/0/M	3/2/0/M		EOTMAT43 TE90AX07
Technical Internship	BMEEODHAS42	0					0/0/0/S	0/0/0/S	0/0/0/S		EOHSAS47 EOHSAS42 EOGMAT45
Steel Buildings	BMEEOHSA-A1	5					5/3/1/E	5/3/1/E	5/3/1/E		EOHSAS47
Reinforced Concrete Buildings	BMEEOHSA-A2	5					5/3/1/E	5/3/1/E	5/3/1/E		EOHSAS42 EOHSAS44
Methodology of Building Construc-tion Design	BMEEOEMA-A1	2					2/1/1/E	2/1/1/E	2/1/1/E		EOEMAS43
Engineering Works	BMEEOHSA-B3	3					3/2/0/E	3/2/0/E	3/2/0/E		EOHSAT43 EOHSAS43 EOGMAS42
Structural Design Projectwork	BMEEOHSA-PP	6					6/0/0/M	6/0/0/M	6/0/0/M		EODHAS41 EOHSA-A1 EOHSA-A2
Diploma Project	BMEEODHA-PD	24								M	EOHSA-PP

Curriculum of BSc in Civil Engineering
Specialization in Infrastructure Engineering

Subject			lecture/seminar/laboratory/exam								Preliminary require-ment(s)
Name	Code	Cre-dits	1	2	3	4	5	6	7	8	
Specialization in Infrastructure Engineering											
Infrastructure CAD Course	BMEEOUVAI45	1				1/0/0/2/M					EOUVAT41 EOVKAT42 EOFTAT42
Water Chemistry and Hydrobiology	BMEEOVKAI43	3				3/2/0/1/E					EOVKAT41
Legal Aspects of Water and Environment	BMEEOVKAI45	2				2/2/0/M					
Hydraulics 2	BMEEOVVAI42	3				3/2/1/E					EOVVAT42
Highway and Railway Structures	BMEEOUVAI41	5				5/4/0/E	5/4/0/E				EOUVAT41 EOUVAT42
Highway and Railway Design	BMEEOUVAI43	5					5/3/2/E				EOUVAT41 EOUVAT42 EOAFAT43
Public Works 2	BMEEOVKAI41	5					5/2/2/E				EOVKAT42
Urban Environment	BMEEOVKAI42	3					3/2/0/M				EOVKAT41
Water Quality Management	BMEEOVKAI44	3					3/2/1/M				EOVKAI43 EOVVAI42
Hydrology 2	BMEEOVVAI41	3					3/2/1/M				EOVVAT41
Transportation Networks	BMEEOUVAI42	3					3/2/0/M	3/2/0/M			EOUVAT42
Highway and Railway Laboratory Course	BMEEOUVAI44	1					1/0/0/3/M	1/0/0/3/M			EOUVAI41
Water Resources Management	BMEEOVVAI43	3					3/2/0/E	3/2/0/E			EOVVAT43
Hydraulic Engineering Field Course	BMEEOVVAI44	2					2/0/0/M	2/0/0/M			EOVVAI41 EOVVAI42
Infrastructure Design Project	BMEEODHAI41	6					6/0/0/M	6/0/0/M			EOVVAT43 EOUVAI43 EOVKAI41
Public Administration and Land Registry	BMEEOUVAT44	3							3/2/0/M		GT55A001
Earthworks and Drainage of Transportation Infrastructures	BMEEOGMAI41	3							3/3/0/E		EOGMAT43 EOVVAT41
Technical Internship	BMEEODHAI42	0							0/0/0/S		EOVVAT43 EOVVAI43 EOVVAI42
Highway Planning and Design	BMEEOUVA-E1	3							3/0/2/E		EOUVAI43
Water Damage Prevention and Water Use	BMEEOVVA-F1	5						5/4/0/E	5/4/0/E		EOVVAT43 EOVVAI41 EOVVAI42
Drinking Water and Wastewater Treatment	BMEEOVKA-H1	4						4/3/0/E	4/3/0/E		EOVKAI41
Railway Planning and Design	BMEEOUVA-E2	3							3/0/2/E		EOUVAI43
River Basin Management	BMEEOVVA-F2	3							3/2/0/E		EOVVAI43 EOVKAI44
Environmental Impact Assessment	BMEEOVKA-H3	3							3/3/0/E		EOVKAI42 EOVKAI44 EOVKAI45
Transportation Facility Design Project	BMEEOUVA-QP	6							6/0/0/M		EOHAI41 EOUVAI44 EOUVA-E2
Hydraulic Engineering Design Project	BMEEOVVA-QP	6							6/0/0/M		EODHAI41 EOVVA-F1 EOVVA-F2
Urban Water Infrastructure Design Project	BMEEOVKA-QP	6							6/0/0/M		EODHAI41 EOVKA-H1 EOVKA-H3
Diploma Project	BMEEODHA-QD	24								M	*EOUVA-QP *EOVVA-QP *EOVKA-QP

Curriculum of MSc in Civil Engineering Structural Engineering

Subject			lectures/practical lectures/laboratory		
Name	**Code**	**Credits**	**1**	**2**	**3**
Core subjects					
Advanced Mathematics	BMETE90MX33	3	2/1/0/E		
Physics Laboratory	BMETE11MX22	1		0/0/1/M	
Methods of Engineering Analysis	BMEEOHSMK51	3	1/1/0/M		
Numerical Methods	BMEEOFTMK51	4	0/0/3/M		
Geodynamics	BMEEOGMMS51	3		2/0/0/M	
FEM for Civil Engineers	BMEEOTMMS51	5	2/2/0/E		
Soil-structure interaction	BMEEOGMMS52	5	3/1/0/M		
Structures 1	BMEEOHSMS51	5	3/1/0/E		
Numerical modeling project	BMEEOTMMS5P	5		0/0/0/2/M	
Decision Supporting Methods	BMEEPEKMST4	2			2/0/0/M
Accounting, Controlling, Taxation	BMEGT35M014	2			2/0/0/M
Corporate Finance	BMEGT35M411	2			2/0/0/M
Engineering Ethics	BMEGT41M004	2			2/0/0/M
Specialization in Numerical Modelling					
Obligatory Subjects					
Structural Dynamics	BMEEOTMMN-1	4		2/1/0/M	
Stability of Structures	BMEEOHSMT-2	4		2/1/0/E	
Nonlinear Mechanics	BMEEOTMMN-2	4	2/1/0/E		
Diploma Project	BMEEODHMN-D	20			
Recommended elective subjects					
Plasticity	BMEEOTMMN61	3		1/1/0/M	
Nonlinear FEM	BMEEOTMMN62	3		2/0/0/M	
Analysis of Rods and Frames	BMEEOTMMN63	3		1/1/0/M	
Discrete Element Method	BMEEOTMMN64	3		1/1/0/M	
Specialization in Structures					
Obligatory Subjects					
Structures 2	BMEEOHSMT-1	4		2/1/0/E	
Stability of Structures	BMEEOHSMT-2	4		2/1/0/E	
Seismic Design	BMEEOHSMT-3	4		2/1/0/M	
Structural Dynamics	BMEEOTMMN-1	4		2/1/0/M	
Diploma Project	BMEEODHMT-D	20			
Recommended elective subjects					
Applied Fracture Mechanics	BMEEOHSMT61	4		2/1/0/M	
Prestressing Technologies	BMEEOHSMT62	3		1/1/0/M	
Strengthening of Structures	BMEEOHSMT63	3		1/1/0/M	
Specialization in Geotechnics and Geology					
Engineering Geology MSc	BMEEOGMMG-1	4		2/1/0/E	
Environmental Geology	BMEEOGMMG-2	4	2/1/0/M		
Geotechnical Design	BMEEOGMMG-3	4		2/1/0/M	
Earthworks of Infrastructures	BMEEOGMMG-4	4		2/1/0/M	
Diploma Project	BMEEODHMG-D	20			
Recommended elective subjects					
Tunneling	BMEEOGMMG61	3		2/0/0/M	
Hydrogeology	BMEEOGMMG62	3		2/0/0/M	
Numerical Methods in Geotechnics	BMEEOGMMG63	3	1/0/1/M		
Engineering Geology of Hungary	BMEEOGMMG64	3		2/0/0/M	

Description of BSc Courses
Civil engineering BSc - Major in Structural Engineering

Compulsory English 1.

BMEGT63A3E1

The course is designed to enable students to communicate fluently and effectively in study environment. Receptive, productive and interactive activities and strategies are included in the curricula. (4 credits)

Surveying I.

BMEEOAFAT41

Surveying and Geodesy. Height systems. Optical levelling, the surveyors' level. Line levelling (procedure, field observations and processing). Systematic error sources of levelling, the two-peg-test. Line levelling, detail point levelling. Height observations for horizontal layouts.
Horizontal positioning observations. Angular observations and the theodolite. Calibration procedure of the theodolite. Measuring with the theodolites: set up, sighting, horizontal and vertical angular observations, systematic error sources. The computation of the mean direction and the zenith angle. Centring excentric observations. Trigonometric heighting.
Distance observations: corrections, reductions. Physical methods of distance measurements. Electrooptical Distance Meters. Processing distance observations.
Plane surveying. Computation of horizontal coordinates on the projection grid. Orientation of the horizontal circle. Intersections. (3 credits)

Chemistry of Construction Materials

BMEEOEMAT41

The importance and necessity of chemistry in civil engineering. The structure of atoms, the electron shell structure, the structure of molecules and chemical bonding models. States of materials - explanation by intermolecular forces. Ideal and real laws of gases. Fluid systems properties. The structure of crystalline solids (ionic, atomic, molecular and metallic lattice crystal structure and properties). Difference between ideal and realistic structure, macroscopic properties of crystalline materials, lattice defects. Structure and properties of non-crystalline (amorphous or glassy) solids. Macromolecular substances and its chemical properties. Homogeneous and heterogeneous systems. Gibbs law. interfacial phenomena. The types of chemical reactions, speed of chemical reactions. Activation energy and reaction heat. Hess's law. Chemical equilibrium. Acids, bases and salts. The pH concept. Hydrolysis of salts. Electrochemistry. Redox processes, redox potentials. Production of metals, corrosion of metals. Binding materials and binding mechanism. Cement chemistry. Chemical and mineralogical composition of cements. Hydration products, CSH, CAH, CH, primary and secondary ettringite. Application of theoretical knowledge in engineering practice. (2 credits)

Civil Engineering Representation and Drawing

BMEEOEMAT42

3 main parts of the subject: 1. Descriptive geometry 2. Engineering drawing 3. Freehand drawing. 1. Basics of descriptive geometry course modules: Students gain knowledge and skills in regularities and techniques of descriptive geometry, developing spacial reasoning. Topics: basic constructions in planes of projections, transformations, tasks of intersections, intersections and interpenetrations of plane and curved solids, cast shadows, construction in scale, special revolution solids and skew surfaces. Additional representation systems: dimensioned representations, orthogonal axonometry, perspective projection. 2. Engineering drawing course modules: Students gain knowledge and skills in engineering drawing, specific notations, proportions and scale, magnification, minification, construction of ground plans and sections. 3. Engineering free-hand representation course modules: develop free-hand drawing in scale. (4 credits)

CAD for Civil Engineers

BMEEOFTAT41

Besides an overview on CAD systems and application fields, students will learn the 2D drawing commands that enable carrying out basic design tasks. Layer management, block definition and applying annotations and dimensions are discussed in detail. Learning printing options and parameters supports further design works in the BSc civil engineering program. The aim of the course is to let students understand the potential and capabilities of CAD systems and their applications. The course introduces the basic spatial drawing solutions providing bases for high level courses involving 3D constructions, BIM applications. (2 credits)

Geology

BMEEOGMAT41

The geology provides the characterisation of geological formations and materials from a civil engineering point of view. It describes the processes and the interactions between the engineering works and the geological environment. The dynamics of the Earth, the description of raw materials and geo-materials used in engineering practice (minerals and rocks), the geological risks such as earthquakes, volcanism, landslides and their effect, characterisation of surface and subsurface waters and related geological problems. (3 credits)

Basis of Statics and Dynamics

BMEEOTMAT41

Classification of mechanics, basic vector operations. Kinematics of particles, description of motion in Cartesian coordinate system. Newton's laws of motion. Concurrent and general force systems in the plane, distributed forces: reduction, resultant, centroid, equilibration. Mechanical work. Planar motion of rigid bodies. Centroid and moment of inertia of rigid bodies. Kinetics of rigid bodies moving in the plane. Linear momentum, angular momentum, theorems of change of kinetic energy for particles and rigid bodies. Constraints. External and internal forces of planar structures and trusses. Statical determinacy. Spatial force systems: reduction, resultant, equilibration. Spatial structures. Internal force diagrams of statically determinate planar bar structures, relationships between internal force diagrams. Sliding friction and rolling resistance. (6 credits)

Mathematics A1a - Calculus

BMETE90AX00

Algebra of vectors in plane and in space. Arithmetic of complex numbers. Infinite sequences. Limit of a function, some important limits. Continuity. Differentiation: rules, derivatives of elementary fuctions. Mean value theorems, l'Hospital's rule, Taylor theorem. Curve sketchig for a function, local and absolute extrema. Integration: properties of the Riemann integral, Newton-Leibniz theorem, antiderivatives, integration by parts, integration by substitution. Integration in special classes of functions. Improper integrals. Applications of the integral. (6 credits)

Physics for Civil Engineers

BMETE11AX13

Electric charge, Coulomb's law, electric field, electric flux. Work and energy in electric fields. Electric potential. Capacitors, dielectrics. The piezoelectric effect and its applications. The contact potential, its application for temperature measurements. Electric current, Kirchhoff's laws, electric circuits. Magnetic field. The Biot-Savart law, Ampere's law. Forces in magnetic fields, practical applications. Magnetic flux, Faraday's law. Practical applications of Faraday's law in sensors. Self induction, mutual induction. Varying electromagnetic fields. Magnetic properties of matter, magnetic circuits. ACcircuits, impedance. Sensors in measurements. Measurement of basic electric quantities. Resistance, capacitance and magnetic induction based sensors. Magnetic, thermoelectric and piezoelectric sensors. Measurement of displacement, force, acceleration. Measurement of flow of gases and liquids. Measurement of liquid level. Measurement of humidity and temperature. Thermovision, thermograms. (2 credits)

Compulsory English 2.

BMEGT63A3E2

The courses are designed to enable students to communicate fluently and effectively in study environment. Receptive, productive and interactive activities and strategies are included in the curricula. By the end of the semester the overall language ability of the students is at level B2 (by the Common European Framework of Reference
(4 credits)

Surveying II.

BMEEOAFAT42

Properties of analogue and digital maps, the application of maps in engineering practice. Traversing, the types of traverse lines. Localizing blunder in traverse lines: the linear and angular error. Offset surveys. The determination of the horizontal and vertical positions of detail points: the tacheometry. Total stations and their application in surveying. Topographic surveys: reconnesaince, sketch, detail survey and mapping. Free stationing. The principles of computational adjustments, the law of error propagation. Construction tolerances and the fundamental of geometrical quality control. Horizontal and vertical deformation monitoring.
Setting out straight lines, curves, transition curves and points in a given elevation. The global navigation satellite systems (GPS, GLONASS, Galileo, ...) and their application in surveying. Building surveys. The localization of underground public utilities. Mapping public utilities and the public utility register. (4 credits)

Construction Materials I.

BMEEOEMAT43

Basic physical and hydrotechnical characteristics of the most important structural materials: stress, strength, deformation, fatigue, creep, shrinkage, toughness, relaxation, brittleness, hardness. Binding materials: Lime, gypsum, production of cements, the klinker minerals, hydration and properties. Mortar. Concrete: Aggregates, admixtures. Fresh concrete: consistency, mix design. Hardened concrete: Interpretation of strength, and its evaluation. Metals: iron, steel yield strength, ultimate tensile strength, ultimate strain, influence of temperature, weldability. Timber. Mechanical properties, shrinkage, swelling. Bricks and masonry . Main constituents and porperties of glass. Types of polymers. (5 credits)

Civil Engineering Informatics

BMEEOFTAT42

The course gives an overview on the major areas of informatics, on the components of information technology systems. Besides supporting the labs, some practical problems and particular tasks are also discussed on the lectures. On the labs, students use spreadsheet application to solve different tasks, then learn the basics of numerical and non-numerical methods in mathematical software environment. Students also learn the basics of programming; most of the tasks have to be solved by own scripts, routines, programs. Civil engineering informatics discusses 2D and 3D computer graphics and the basics of database management that supports high level courses involving spatial construction and database systems. (5 credits)

Soil Mechanics

BMEEOGMAT42

Origin of soils, soil exploration, soil samples. Components of soils (phase relationships, grain size distribution, consistency limits), soil classification, compaction. Stresses in the soil (under static conditions, conditions of steady vertical flow). Flow of water through soil due gravity (Darcy's law, coefficient of permeability, flow nets). Compressibility of soil (reasons and types of compression). Shear strength of soil (Mohr-Coulomb failure criterion, determination of shearing strength). (4 credits)

Introduction to Strength of Materials

BMEEOTMAT42

Internal forces and internal force diagrams of planar and spatial structures (revision, generalization). Moments of inertia and principal directions of planar figures. Strength properties of materials. Concept of stresses and deformations. Material models: linearly elastic material and linerly elastic and perfectly plastic material. Beam element, beam model composed of elastically connected cross-sections. Computation of normal stresses in beams for centric tension/compression, simple bending, skew bending, and tension/compression combined with bending. Computation of shear stresses in beams for pure shearing, torsion, and shearing combined with bending. Eccentric compression of cross-sections of no tension matrials. Shear centre of thin-walled cross-sections. Displacements of bent beams with straight axis. Principal stresses and principal directions. (6 credits)

Hydraulics I.

BMEEOVVAT42

Physical properties of water. Hydrostatics: pressure distribution, absolute and relative equilibrium. Equilibrium of suBMErged and floating bodies. The flow of fluids: velocity, discharge, continuity, specific energy head, other properties. Laminar and turbulent motion. Behaviour of ideal and real fluids. Outflow, through-flow. Channel flow. Hydraulic jump, energy breaker. Weirs, sluice-gates. Steady-state flow in pipes. Seepage in porous media. Wells. Turbo-machines. (3 credits)

Mathematics A2a - Vector Functions

BMETE90AX02

Solving systems of linear equations: elementary row operations, Gauss-Jordan- and Gaussian elimination. Homogeneous systems of linear equations. Arithmetic and rank of matrices. Determinant: geometric interpretation, expansion of determinants. Cramer's rule, interpolation, Vandermonde determinant. Linear space, subspace, generating system, basis, orthogonal and orthonormal basis. Linear maps, linear transformations and their matrices. Kernel, image, dimension theorem. Linear transformations and systems of linear equations. Eigenvalues, eigenvectors, similarity, diagonalizability. Infinite series: convergence, divergence, absolute convergence. Sewuences and series of functions, convergence criteria, power series, Taylor series. Fourier series: expansion, odd and even functions. Functions in several variables: continuity, differential and integral calculus, partial derivatives, Young's theorem. Local and global maxima/minima. Vector-vector functions, their derivatives, Jacobi matrix. Integrals: area and volume integrals. (6 credits)

Surveying Field Course

BMEEOAFAT43

Using the theoretical background of the courses Surveying 1 & 2 students are required to: assess the existing datasets used for mapping; define the necessary surveying activities; practice the surveying observations, planning, data processing and documentation; practice profile boarding, setting out of roads; learn to use modern surveying instruments (total stations, GPS/GNSS receivers, electronic levels, digital photography). (3 credits)

Building Construction Study

BMEEOEMAT44

Subject of architectural engineering, fundamental terms and base definitions. elations of buildings and building constructions. Effects on buildings, requirements of building constructions. Building blocks and specific brick connections. Load-bearing wall systems and lintel beams in wall structures. Groups of foundation modes and characteristics. Water insulation of under grade parts of buildings. Slabs and ring beams. Balconies. Basics of mechanical installations of residential buildings. Frame system buildings, construction systems and materials. Structures of stairs, systematization. Railings, main coverings. Types of traditional roof trusses, specialties, rainwater gutters and roof claddings. Order of layers of flat roofs, rainwater drainage, gullies, waterproofing materials. Types and materials of typical external and internal doors and windows. Classic contact facade finishes. Basics of building physics. (3 credits)

Geoinformatics

BMEEOFTAT43

The aim of Geoinformatics is to introduce the principles and potential application fields of geographic information systems (GIS) in the civil engineering practice. The course discusses the basic concepts and applications of GIS, the modelling process needed to create GIS, the reference systems of geometric data, the spatial data sources and data acquisition methods, the aspects of data quality, the resources, tools, databases of GIS, the basics of data analysis, visualization and implementation of GIS. Through the lectures and labs students learn the GIS workflow based on desktop and web-based solutions, and tools of spatial process modelling, data management and web integration. (3 credits)

Basis of Design

BMEEOHSAT41

Modelling of structures, design process. Selection of structural form and material. Structural model. Thrust line. Probabilistic basics of structural design, partial (safety) factor method. Selection of critical load case, design load. Actions on structures. Material laws. Geometrically linear and nonlinear analysis, Elastic and plastic resistance. Superposition. Limit states. Load-carrying capacity and serviceability. Beams and columns. Design of structures for horizontal actions. Spatial structures. Classification of structures according to their form and static behaviour. (3 credits)

Structural Analysis I.

BMEEOTMAT43

Principle of small displacements: displacements of rigid body chains using small displacements. Computation of displacements of statically determinate simple and compound structures using displacement equivalency statements. Virtual force systems, concept of virtual complementary work, theorem of virtual forces. Computation of displacements of statically determinate simple and compound structures using the theorem of virtual forces. Influence lines of internal forces and displacements of statically determinate structures. Maximal internal forces. Concept of envelope curves. Computation of statically indeterminate planar structures under fix loads using the force method. Computation of statically indeterminate planar structures under moving load using the force method: influence lines. Computation of statically indeterminate planar structures under fix loads using the displacement method. (4 credits)

Railway Tracks

BMEEOUVAT41

Basic concepts of the railway tracks and vehicles, most important technical parameters. Features of normal railways, suburban railways, urban railways, classification of different types of railways. Speed, acceleration, changing of acceleration. Horizontal and vertical alignment of the railway tracks, straights, circular curves and transition curves, superelevation, vertical curves. Elements of the substructure and superstructure. Rails, sleepers, rail fastenings, ballast, subgrade, strengthening of the subgrade. Setting out major and detail points of curves and transition curves. Structures and solutions of dewatering and drainage of railway tracks. Basic concepts of conventional and continuously welded rail tracks. Types of turnouts and simple track connections. Basic concepts of railway stations, platforms, passenger access. (3 credits)

Basics of Environmental Engineering

BMEEOVKAT41

The aim of the course is to provide basic scientific and engineering background for further studies in environmental engineering by giving introduction to the following subjects: basics of ecology, the natural cycle of ecologically important elements and substances, the environmental effects of human activities, the ecological footprint, energy consumption patterns and energy production technologies, renewable energy sources. Selected environmental problems associated with civil engineering activities (water, air and soil pollution), with focus on the urban environment. Tools and methods for conducting environmental impact assessment. (3 credits)

Public Works I.

BMEEOVKAT42

The main goal of the subject is to provide information about the most important features of the public works. The subject is also including the connections between the different public works and other establishments. Further aim is to provide knowledge for the future general designers and technical managers to make the right decisions on the underground infrastructure of settlements. Main scopes are: system knowledge and design of different publc work types like water acquisiton, drinking water supply, waste water networks, storm water networks and public works asset management. (3 credits)

Hydrology I.

BMEEOVVAT41

The global water cycle. The water balance. Basic elements of hydrometeorology. Evaporation and its main features. The origin of the precipitation, quantitative characteristics, principles of precipitation. Weather, weather conditions, climate. The concept and principles of runoff. Infiltration. runoff estimation on small and large catchments. Elements of hydrography. Exploration of natural streams. Characterisation of subsurface waters and their principles. Characterisation of groundwater regime. (3 credits)

Mathematics A3 for Civil Engineers

BMETE90AX07

Differential geometry of curves and surfaces. Scalar and vector fields. Potential theory. Classification of differential equations. Linear differential equation of the second order. Nonlinear differential equations. Systems of linear differential equations. The concept of probability. Discrete random variables an their distributions. Random variables of continuous distribution. Two-dimensional distributions, correlation and regression. Basic notions of mathematical statistics. (4 credits)

Earthworks

BMEEOGMAT43

Scope of earth works. Plastic limit states, Rankine earth pressures. Earth pressure and passive resistance of real" walls. Soilstatical design of retaining structures. Stability of earth works. Construction of earth works. The designal, executional and monitoring questions of construction. Dewatering of earth works. Geosynthetics. (3 credits)

Steel Structures

BMEEOHSAT42

Lectures of Steel Structures have the general aim to study the basics of the design of steel stuctures, which consists of the design of simple structural members, simple joints and the investigation of the basic failure phenomenon, which can occure in steel structures. The program consists of the following topics:

Steel grades, mechanical properties of the steel material. Calculation of cross sectional properties. Design of centrically loaded tension members. Design of Centrically loaded compression members. Buckling problem – behaviour – design method. Design of beams: construction, behaviour under bending and shear interaction. Beam structural behaviour - design approaches for lateral torsional buckling. Design of bolted connections. Design of welded connections. Fatigue design and brittle fracture. Plate buckling phenomena, basics of the cross section classification. (3 credits)

Reinforced Concrete Structures

BMEEOHSAT43

Structural safety of reinforced concrete (RC) structures; loads and effects on RC strucrures, material properties of concrete and reinforcing steel; moment- curvature relation of RC cross sections; Uncracked and cracked cross section; flexural strength theory, strength and ductility; design of RC cross section; eccentric compression; shear failure in beams without and with shear reinforcement; strength in bending and torsion; anchorage and stress development, bar curtailment; deflection and crack width. (3 credits)

Roads

BMEEOUVAT42

History of transportation. Sustainable transportation and transportation policy. The system of tracks, vehicles and drivers/passengers. Design and behavioural patterns and self-explaining roads. Transport facilities. Elements of the alignment in cross sections, horizontal and vertical alignment. Basic rules and disciplines of planning and design. Transition of superelevation. Planning process: planning, design project, construction, operation. Traffic operation basics: measures of traffic, traffic operation and management. Intersections and junctions. Urban transportation planning, the concept of accessibility. Characteristics, production and installation of asphalt pavements. Types of tracks, layers, materials. Design of new pavement structures. Construction, management and operation of road networks. Project 1: Authorization plan of a curved section of a secondary main road with transition curves: site plan on a contour line map with long section and cross sections. Drainage, earthwork, road marking. Project 2: Feasibility study of a main road between two point on a contour line map. (2 credits)

Hydraulic Engineering, Water Manag.

BMEEOVVAT43

The tasks, methods and tools of water management. Hungarian and European specialities of water management. Types and tasks of hydraulic engineering structures with the following topics: Watershed management of lowland and hilly areas, regulation of lakes and rivers, reservoirs and storage, flood control and land drainage, inland navigation, water power development, water intake and pumping stations, small hydraulic engineering structures, caracteristic environmental impacts of hydraulic engineering structures. During the practical lessons four design works will be elaborated. (3 credits)

Construction Management

BMEEPEKAT41

Curricula, themes, individual projects, tests, subjects of lectures and seminars of the Course are embracing managerial and organizational learnings useful and necessary for all civil engineers, such as:

- jobs and organizational structure of Contracting Construction Trade; - jobs and relations of parties collaborating in executing construction projects; - time and resource needs of executing construction projects (basic methods and terms of time-, resource- and cost estimates); - basics of mechanizing Construction, construction equipments and auxiliary plants, typical applications; - organizing construction site (site layout designs).

Individual project: Organizational plans (time estimates, resources calculations and site layout designs) of building a simple linear structure (reinforced concrete retaining wall) well known in practice of all civil engineers. (3 credits)

Business Law

BMEGT55A001

The problems of the area will be treated in two major parts. Part One introduces students to the general topics, for example the concept of law, the functions of the law in the socieconomic life. Some basic legal problems, like the conception, characteristics and functions of the modern state and, in a comparative view, the characteristics of the Anglo-Saxon and continetal systems of business law and the development of the Hungarian business law will be also discussed. The emphasis of Part Two is on the questions of company law and competition law presented in a European context. The lectures of this part outline not only the regulations of the Hungarian Company Act and Company Registry Act but they cover EU directives and regulations on companies and competition as well. (2 credits)

Foundation Engineering

BMEEOGMAT44

Foundation Types.Design of rigid and flexibile shalow foundations (spread, pier, slab, box foundation). Determination the bearing capacity and settlements of soils under load. Factors effecting the value of differential settlements. Stability analysis. Types and design of different support systems of Excavations. Bearing capacity of pile foundations. Anchorages. Design of ground Anchors. Design and construction of cast in situ and prefabricated diaphragm walls. Dewatering. (4 credits)

Management and Enterprise

BMEGT20A001

Intended for engineering students who would like a better conceptual understanding of the role of management int he decision making process. This course introduces the essentials of management as they apply within the contemporary work environment. Particular attention is paid to management theories, corporate finance, leadership, teamwork, quality management, management of technology, economics calculation and operations management. For problem formulation both the managerial interpretation and the mathematical techniques are applied. (4 credits)

Micro- and Macroeconomics

BMEGT30A001

Introduction to macroeconomics. Output and aggregata demand. Fiscal policy and foregn trade. Money and banking. Interest rates and monetray transmission. Monetray and fiscal policy. Aggregate supply, prices and adjustment to shocks. Inflation, expectations, and credibility. Unemployment. Exchange rates and the balance of payments. Economic growth. Economics and the economy. Tools of economicanalysis. Demand, supply and the market. Elasticities of demand and supply. Consumer choice and demand decisions. Introducing supply decisions. Costs and supply. Perfect competition and pure monopoly. Market structure and imperfect competition. The labor market. Factor markets and income distribution. (4 credits)

Communication Skills for Civil Engineers

BMEGT60A6EO

The Communication Skills course is designed to meet the language needs of civil engineering students in academic and professional fields. Special emphasis is on the language of meetings and discussions, oral presentation and summary writing. (2 credits)

Urban and Regional Development

BMEEOUVAT43

Infrastructure and Regional Development. Historical construction processes of canals, railways, motorways. Aviation and the internet age. Livable, sustainable cities, regions. Computer aided teamwork. Construction projects, mobility measures; parking regulations. Improving traffic safety, Traffic management and intelligent investments. Basics of Land-Use Planning. Cities with road pricing, congestion pricing. Lessons learned in Oslo, London, Stockholm, Singapore. Calculations with demand curves.
The city as a system. [Area, core network]. The morphology of the city. Basics on the the Hungarian settlement system. Development of large cities. Concentration, suburbanization. Fundamentals of urban planning. Case studies: Paris, Budapest – Vienna – Prague.
The regional development strategy of the European Union. Steps and documents of the implementation in Hungary. Strategic Environmental Assessments. Monitoring of Environmental Effects. (3 credits)

Branch of Structural Engineering

Building Construction I.

BMEEOEMAS42

Students gain knowledge and skills during the semester work in the following topics: Flat and deep foundations, relation to sub-soil insulation of buildings. Masonry works, prefabricated panel systems. Plasters and ETICS. Reinforced concrete, steel and wooden beam slab constructions. Stairs. High roofs. Passable and non-passable flat roofs, green roofs. Insulations against functional water. (3 credits)

Timber Structures

BMEEOHSAS44

Introduction and comparative analysis of existing timber structures. Material characteristics and strength grades of timber material. Design of timber structural members for ULS according to EC5 (compression, tension, bending, shear, torsion, combined actions, stability analysis). Design of timber structural members for SLS according to EC5 (deformations, durability). Basis of the fire design of timber structures. Design of single and multiple shear plane connections with metal dowel-type fasteners (nailed and bolted connections). Design of connections with punched metal plate fasteners, split ring connectors and toothed plate connectors. Bonded connections, design of glued-laminated timber structures. Analysis of stress concentration sites in timber structures. Constructive protection methods and typical construction details of timber structures. (3 credits)

Strength of Materials

BMEEOTMAS41

Differential equation of the elastic curve, computation of the deflected shape for various boundary conditions. Virtual displacement systems, virtual work. Theorem of virtual displacements. Computation of external and internal forces of statically determinate structures using the theorem of virtual displacements. Concept of potential energy, theorem of stationarity of potential energy, application of the theorem for the computation of displacements of structures. Concept of complementary potential, theorem of minimum complementary potential energy, using the theorem for the computation of reactions of structures. Revision of common work and energy theorems of mechanics. Characterization of equilibrium states, concept of critical load. Methods of stability analysis: statical, kinematical, and energy methods. Elastic Euler buckling. (3 credits)

Construction Materials II.

BMEEOEMAS41

Importance of selection construction materals. Ranges of applicability of construction materials. Influencing factors to the strength of concrete. Steam curing. Influencing factors to the water tightness and the freeze-thaw resistance of concrete. Fibre reinforced concrete. Light weight concrete. Metals. Aluminium. Production of iron and steel. Steel-carbon interaction diagram. Martenzite. Heat curing of steel. Steel corrosion. Normal potential. Roads. Road making materials. Aggreagates and possible binders to pavements. Properties of bitumen and asphalt. Concrete pavements. Properties of road marking. Concrete corrosion. Protection against concrete corrosion. Properties of polymers. Polymeric protection layers. Thermal and sound insulations. (3 credits)

Building Construction II.

BMEEOEMAS43

Floor structures, finishes, orders of layers: floors on ground, floors of intermediate slabs, floors of attics, terraces, prefabricated concrete and stone pavings. Tile and plate roof claddings, metal sheet seamed strip claddings: orders of layers, materials, rules of technique, details, rainwater gutter systems. Structures of built-in-roofs: structures and roofing of pitched roofs, orders of layers, foils of vapour-/air-/waterproofing. Facade claddings: plastered, thermal insulated, assembled light and heavy claddings. Posterior thermal insulation of facades. Curtain walls, glass roofs. Structures and materials of dry technologies: assembled walls, ceilings, floors. Building physics: thermal and vapour protection. Acoustics, protection against noise. Building construction solutions of building reconstruction, tasks of refurbishment. (3 credits)

Steel and Composite Structures

BMEEOHSAS47

Design specialities of plated steel girders: plate and web buckling phenomena and design according Eurocodes. Design of steel structural members subjected to bending and axial compression – interaction formulae according EC3. Simple joints in steel structures – structural behaviour and design. Structural behaviour of steel and concrete composite members; design of composite beams and columns according EC4. (4 credits)

RC and Masonry Structures

BMEEOHSAS42

Design principles of reinforced concrete slab and frame structures, exact and approximate design methods, structural details. Bracing systems of reinforced concrete buildings, determination of the forces acting to the individual shear walls, checking of stability. Detailing of reinforced concrete structures (beam end, corbel, frame corner, curved bars, stairs, force transfer between members, expansion joints, etc.). Types and strength characteristics of masonry. Design principles of unreinforced masonry walls according to EC6. Reinforced masonry walls. (4 credits)

Bridges and Infrastructures

BMEEOHSAS43

Historical development of bridges. Basic terms of bridges. Classification of bridges. Superstructure systems. Typical superstructures of steel, steel and concrete composite as well as concrete bridges. Composite action between main girders. Basis of bridge design. Traffic load models and their application rules for highway and railway bridges. Testing of bridges. Substructures of bridges: abutments and piers. Bridge equipment. Conceptual design of bridges. Fitting of bridges into environment, bridge aesthetics. Supervision of bridges. Reconstruction and strengthening of bridges. Civil engineering work in traffic infrastructure, systems and hydraulic engineering. (3 credits)

Laboratory Practice of Testing of Structures and Materials

BMEEOHSAS46

Experimental demonstration the behaviour of the loaded structural members and joints made from different materials (steel, reinforced or prestressed concrete, composite, glass...). Introduction into different experimental and measurement techniques and equipments. Up-to-date building materials and material testing methods. General and specific analytical and diagnostic methods for building materials and structures. (2 credits)

Structural Analysis II.

BMEEOTMAS42

Problem statements for mechanical problems. Solution with approximative displacement functions, Ritz method. Fundamentals of the finite element method. Fundamentals of matrix analysis and application for computation of structures. Equations of the Euler-Bernoulli beam model. Equations of the Timoshenko beam model. Models of bar structures: equations of truss, grid, planar and spatial frame models. Differential equations of the classical plate theory. Differential equations of the Mindlin plate theory. Analytical solution methods for the equations of plate problems, application of the finite element method. Differential equations of discs in the states of plane stress and plane strain. Analytical solutions of discs problems, application of the finite element method. Derivation of shell models, shell elements of the finite element method. (4 credits)

Rock Mechanics

BMEEOGMAS41

Petrophysical properties of solid rocks, the characterisation of rock blocks and rock masses, the jointing system in the rock environment. The deformation processes and rheological characters in rock mechanics, the influence of joint spacing. The durability and effect of rock environment on the engineering structures. The evaluation of geological conditions in rock environment at tunnels foundations and rocky slopes. The influence of material properties on the petrophysical properties of rocks. (3 credits)

Underground Structures, Deep Found.

BMEEOGMAS42

Types and field of application of deep foundations (stone columns, diaphragm walls). Load transfer mechanizm of deep foundations. Determination the bearing capacity and settlement by different methods (by theoretical formulas,load tests,sounding).Design and construction of Pedestrian subways, Underground garages. Analysis against uplift. Insulations. (3 credits)

3D constructional modelling of structures

BMEEOHSAS45

The aim of the course is to introduce the 3 dimensional detailing of steel-, reinforce concrete- and timber structures to the students. The course intends to develop basic practical skills by real 3D modelling of structures where the model is able to provide drawings and lists automatically for fabrication and construction processes. The course provides insight into the integration of the 3D constructional model of structures with other branches like architectural, mechanical, electrical and plumbing models into a BIM (Building Information Modelling) model. The students will learn the necessary knowledge and also obtain experience for the later project home works and diploma works by the help of presentations, small examples and a modelling home work. (3 credits)

Design of Structures Projectwork

BMEEODHAS41

Students need to accomplish a complex design projectwork that is based on the knowledge gained through the branch courses. The project work is supervised by three lecturers from three areas of structural engineering. (6 credits)

Public Administration and Land Registry

BMEEOUVAT44

Preparation of major civil engineering projects. Governance of Civil Engineering activities. World-wide examples. Case studies for Public Transport and/or Water Management. Private and public projects. Investments by modern Public Private Partnerships. Lessons on Civil Engineering "Mega-Projects". [Major Canals, Bridges. Motorways. Channel Tunnel, Oresund Bridge.] Student studies and presentations on actual projects. Public participation. The Role of Civil Organisations. Chamber of Engineers, Institute of Civil Engineers. International Organisations. [PIARC, IRF, UIC, UITP, IABSE, IAHR]. The process of public procurements. Competition and transparency requirements.
Authorisitation processes. Participants and stake-holders. Legal and administrative requirements. Environmental Acts, Decrees and Guidelines. Land registry processes and tasks. Real estate valuation. Elementary Cost – Benefit – Analysis. Financing and banking requirements. (3 credits)

Field Course of Structural Geodesy

BMEEOAFAS42

The main purpose of the subject is introduce the most modern techniques and methods for students in the field of state surveying and movement detection of civil engineering structures. The students apply the skills and knowledges learned in Surveying I, II and Field Course of Surveying to solve more complex structural engineering projects. Project are solved by students team. During the practices students survey some inner parts of a more levelled building, determine the geometry of axis of an about 30 m high brick chimney. Furthermore they determine the deflections of a slab and the distortions of floor. They determine the deflection of a cable bridge caused by traffic. They are introduced into the applications of photogrammetry, remote sensing and laserscanning in the area of construction engineering. (1 credit)

Dynamics of Structures

BMEEOTMAS43

Computation of the equivalent mechanical model of structures with a single degree of freedom: stiffness, mass, damping, consideration of friction. Differential equation of motion. Vibration of mechanical systems with a single degree of freedom: free vibration, forced vibrations with harmonic excitation, general excitation, and excitation with support motion for undamped and damped systems. Modeling of systems with multiple degrees of freedom, meaning of the matrices of the system. Differential equation system of motion. Vibrations of mechanical systems with multiple degrees of freedom: free vibration, forced vibrations with harmonic excitation, general excitation, and excitation with support motion. Free vibrations of continua: differential equation of vibrating strings, axial and flexural vibration of beams. Fundamentals of earthquake analysis, response function of structures, meaning and usage of response spectrum. (3 credits)

Industrial Practice

BMEEODHAS42

20 days of industrial practive at a civil engineering construction company. (0 credits)

Major of Buildings

Steel Buildings

BMEEOHSA-A1

Low rise industrial halls. Lattice girders. Crane girders. Design of secondary members (purlins, sheeting). Analysis and design: Principles, analysis and modelling methods, global analysis of frames.
Stability analysis and design of steel structures. Floor systems, design of composite floor systems. Joints and connections in steel and composite building structures. Bracing of steel and composite structures. Seismic design of structures. Fire design. Highrise and tall buildings. (5 credits)

Reinforced Concrete Buildings

BMEEOHSA-A2

Formation of reinforced concrete buildings, loads and effects, basics of earthquake design. Plastic behaviour of flat slabs, prestressing. Structural systems of highrise buildings. structural elements of the stiffening systems: shear walls, flat-slabs, cores, frames with masonry infill. Formation of timber halls, sizing of prefabricated prestressed and glued laminated timber structural elements. Masonry structures. (5 credits)

Building Construction Methodology

BMEEOEMA-A1

During the semester methodology of planning, methods of design of building constructions are presented. Listing of requirements depend on function of building (building physical, acoustical point of views and fire protection). Designation of structural hierarchy based on the determined requirements. Building constructional relationship and design rules: i) skirtings - connections of load-bearing structures ii) structures of floors (floors on ground, floors of general slabs) - connections of load-bearing structures iii) facade - connections of load-bearing structures iv) thermal insulation and rainwater seepage, soil moisture and waterproofing - connections of load-bearing structures v) special building constructions (windows, doors, gates), structures of fire protection (skylights, suspended walls against fume spreading). (2 credits)

Engineering Works

BMEEOHSA-B3

The basis of the design and construction of engineering works is presented. The discussion holds on the waterproofing of reinforced concrete structures with waterthight concrete, on the thermal effects and on the description of time dependent strains of concrete structures. The use of cast-in-place and precast concrete in engineering works is presented. Some other modules: modelling the soil and structure interaction. Design aspects of pools, tanks and tower-like structures. Internal forces and reinforcements of typical structural elements of engineering works: rectangular, circular and ring plates, walls, wallbeams, box-like and shell structures. Dynamics of tower-line structures: wind effects and seismic action, dampers, wind turbines. (3 credits)

Building Design Projectwork

BMEEOHSA-AP

Students need to accomplish a complex projectwork that is based on the major subjects. Students need to regularly attend consultations and get support from the supervisor(s). (6 credits)

Diploma Project

BMEEODHA-AD

(24 credits)

Elective option:

Reinforced Concrete bridges

(BMEEOHSA-B2)

Long-term behaviour of concrete. Typical cross-sectional forms of concrete superstructures. Reinforced concrete slabs. Grid type and box girder bridges. Precast concrete superstructures. Prestressing in bridges: idea and technologies. Modern construction methods: incremental launching, segmental and monolithic balanced cantilever methods. Cable-stayed bridges. Arch bridges. Maintenance and strengthening of concrete superstructures. Typical structural types of timber bridges: truss, frame, arch, plate, hipped-plate and suspension bridges. Structural analysis of timber pedestrian bridges. Durability and fire timber bridges. Constructive timber preservation. (4 credits)

Description of MSc Courses
MSc in Structural Engineering

Advanced Mathematics

BMETE90MX33

Heat equation on an interval. The wave equation on an interval The wave equation on the line. Convolution Fourier transform. The fundamental subspaces of a matrix. Orthogonal projection to a subspace. Power method. Singular value decomposition. Pseudoinverse. (3 credits)

Physics Laboratory

BMETE11MX22

Measurement of the eigenmodes of a vibrating string by an oscilloscope. Study of the excited vibration of a mass on a spring with the help of a computer controlled ultrasonic distance detector. Basic measurements in optics (lenses, prism, polarization, diffraction). Measurement of submicron expansions (thermal expansion, magnetostriction) by Michelson interferometer. Measurement of specific heat and the heat of fusion in a stainless steel vacuum flask. Study of a solar collector model system. (1 credits)

Methods of Engineering Analysis

BMEEOHSMK51

The objective of the course is that the student shall understand and be aware of the principles and basis of methods of engineering analysis and assessments, statistics, probability theory, reliability analysis, numerical methods, risk analysis, optimization and digital sign processing. It also serves as the basis of the subsequent MSc subjects on modelling, design and programming. (3 credits)

Numerical Methods

BMEEOFTMK51

The aim of this course is that students learn and apply skill level at solving engineering problems numerically on computers, as well as to introduce the basics of Building Information Modelling (BIM). At the beginning of the semester BIM systems and their application opportunities are introduced, later the principles of the most relevant numerical techniques including their advantages, disadvantages and applicability are presented during laboratory practices. Students may learn and apply mathematical procedures suitable for solving and visualizing technical problems on computer practices. A further purpose of this course is to prepare the students for later independent research. (4 credits)

Building Physics

BMEEOEMMS51

The aim of the subject is that the students get to know the basics of modern building physics, the theory of the heat conduction, convection, heat radiation, heat transport processes, the tech-nical alternatives of the heat loss reduction of buildings and building constructions, the role of outdoor and indoor environment-related boundary conditions in building physical calculations and the method of determining these parameters, the analytical calculations of the of heat transport, the theory and practical application of non-steady-state, transient, non-linear and multi-dimensional heat transport processes, as well as conjugated heat-moisture and air transport simulations, and basics of city-scale building-physics. (3 credits)

Geodynamics

BMEEOGMMS51

The subject focuses on the understanding of dynamic effects that are transferred from the geological environment to the engineering structures. The students are getting familiar with geophysics, rock stress and its interpretation and graphic representation, local and world-scale (Word Stress Map). The deformations caused by seismic waves in igneous, metamorphic and sedimentary rocks also form part of the subject, as well as deformations caused by historic earthquakes. A main topic is the understanding of the Earth's structural geology and seismicity with special emphasis on the Carpathian basin. The lectures will help in learning the detection methods of seismic waves and acquire the information content of the seismograms. By completing the course the students will able to determine the parameters that are necessary for appropriate seismic design. Engineering seismological approach will help the students to place the structures in the geological environment allowing the minimal risk and reducing the cost by proper seismic design. (3 credits)

Materials' science for civil engineers

BMEEOEMMS52

Main objective of this subject is to learn a wide range of special material properties used for structural design. Within this subject special material properties and material processes are taught including: definition of performance based material properties, role of micro-structure of materials to their properties, related physical-chemical processes, possibilities in modelling, re-lationship of sustainability – durability – service life, possibilities of nanotechnology in civil en-gineering, possibilities in reuse and recycling in civil engineering. (3 credits)

FEM for Civil Engineers

BMEEOTMMS51

The goal of the subject is to present the theoretical bases of the finite element method and its practical application to typical structural engineering problems. The classic approach to the finite element method will be followed in presenting the basic idea of the method, the element types, the applied interpolation functions, the various matrices and the basic steps of their construction, the resulting system of equation and the solution techniques of it. All these will be demonstrated and practiced through examples, showing how the various structure types (trusses, beams, frames, plates, shells, 3D solids) can be analysed. An introduction to nonlinearities from various sources will be given, with special focus on the effect and handling of geometric nonlinearity. Beside the static problems, the application of the finite element method to some heat transfer problems of the structural engineering practice will also be discussed. (5 credits)

Soil-structure interaction

BMEEOGMMS52

The scope of the subject is to teach the students the fundamentals of geotechnics required for structural design, such as familiarity with and use of EC7. These include geotechnical categorization; types and contents of geotechnical documentations; geotechnical and structural design of piles for different loading types, design of soil-supported ground slabs along with the determination of the values of subgrade reaction modulus; design of pile-supported ground slabs and "rigid inclusion" slabs; structural design of excavation support structures, determination of soil reaction moduli along with their effect on deformations and internal forces; design of ground anchors; geotechnical questions of bridge abutments; and the basics of soil dynamics and geotechnical earthquake engineering. (5 credits)

Structures 1

BMEEOHSMS51

The objective of the subject is the modelling of beams, membrans, plates and the simplest circular shell structures. The most important analytical solutions, the basics and assumptions of numerical solutions are introduced. It's presented that the different structural considerations can be implemented in the design codes and regulations. The fundamental membrane solutions, shear lag effect, effective width, shear deformation, second-order effects and large deformations, anisotropy and the vibration of floors are also analysed. The main focus of the subject is the analysis of plates and slabs. (5 credits)

Numerical modeling project

BMEEOTMMS5P

The goal of the subject is that the students solve a civil engineering problem the complexity of which is in accordance with the level of the MSc course and with the credit and time-frame of the subject. The problem should be solved by high level application of some analytical or numerical method (e.g., finite element method). The problem is solved by the individual work of the student, helped by a tutor. (5 credits)

Structures project

BMEEOHSMS5P

The objective of the course is that the student shall solve a structure-specific problem, by which his/her problem solving skills are improved, gains the skill of literature review, aims the comprehensive thinking. Aim is that the student becomes able to efficiently solve problems arising during design or research tasks. The subject of the study can be any structure-related problem discussed and agreed with the supervisor; not exclusively: modelling, analysis and/or design of part of or whole structural system, experimental analysis; research, research and development or expert design task; based on individual problem statement or joining to ongoing research program. (5 credits)

Geotechnical and engineering geological project

BMEEOGMMS5P

The goal of the subject, that the students are getting familiar with the geotechnical and engineering geological design process. The students get to know through a project work the geotechnical, engineering geological data collection, modelling, design and calculation tasks. Furthermore, they get familiar with practical application of analytical and numerical design methods. (5 credits)

Decision Supporting Methods

BMEEPEKMST4

The aim of the course is to familiarize students with some practically used or usable mathematical models in the field of construction management, scheduling and tendering process. The course covers a wide variety of topics dealing with least cost scheduling problems, multi attribute decision models, learning curves. There are two computational modeling tasks as homework assignments. Final grades will be based on the two assigned tasks 15-15% and test 70%. (2 credits)

Accounting, Controlling, Taxation

BMEGT35M014

The main issues of 'window dressing' and their interpretation through financial ratio analysis and interpretation. The cost volume profit analysis and its relationship with costing and pricing decision-making. The operational and capital budgetary process in an international context and its advisory role through the process of variance analysis. The best international accounting practice both at the functional, planning and strategic stages. The wider developmental strategic and ethical international issues concerned with managerial accounting. (2 credits)

Engineering Ethics

BMEGT41M004

The purpose of this course is to help future engineers be prepared for confronting and resolving ethical issues that they might encounter during their professional careers. It gives an overview of the moral problems engineers face in their different social roles, and it provides conceptual tools and methods necessary for pursuing those issues. Topics include engineering professionalism; social roles of engineers; ethical theories; ethical decision making techniques; social impacts of engineering, professional organizations; code of ethics of engineering societies. Case studies are discussed in a practice oriented approach. The primary goal is to stimulate critical and responsible reflection on moral issues surrounding engineering practice. (2 credits)

Structural Dynamics

BMEEOTMMN-1

The purpose of the course is that students become familiar with the dynamic tasks occurring in the structural engineering practice, and the mechanical-mathematical background of their solution methods. There will be emphasized: the differential equations used to describe the continuum of mechanical vibration and their analytical and numerical solution methods, free vibration of multiple degrees of freedom systems and its approximate solutions, computation methods of mass and stiffness matrix of the (finite element method) discretized structures, taking into account the damping, dynamic issues supporting effect of the soil, the mechanical background of earthquake analysis of structures and the efect of wind. (4 credits)

Stability of Structures

BMEEOHSMT-2

The objective of the subject is the presentation of the most important problems in the stability analysis and stability design of steel structures. The student will learn the terminology of theory of engineering stability and theory of torsion of thin-walled members, as well as their practical importance and applicability. The most relevant modes of instabilities of engineering steel structures will be presented (flexural buckling, flexural-torsional buckling, lateral-torsional buckling, plate buckling). To each instability mode the student will learn the background and mathematical bases, as well as the Eurocode design procedures and their practical applications. (4 credits)

Nonlinear Mechanics

BMEEOTMMN-2

The subject is the continuation of the Strength of Materials subjects taught in the Civil Engineering BSc programme on the expansion and the generalization of its linear models. Its two main goals are:

A./ the students will become acquainted with the approaches of nonlinear mechanics, its variables used in theoretical and numerical modeling, and the principal equations required for the formulation of nonlinear mechanical problems. The application of various nonlinear strain and stress tensors is analysed, furthermore the origination of the equations in the form of a general boundary and/or initial value problem or as a variational problem formthe most important types of engineering structures.

B./ The second important goal is to get to know the theoretical background required for the - primarly finite element - analysis of nonlinear problems, with an emphasis on the tehoretical and practical differences between the linear and nonlinear analysis. (4 credits)

Plasticity

BMEEOTMMN61

The purpose of the subject is, that the students acquire the basic concepts and methods of plasticity. In the frame of this they will get to know the material models, yield and hardening conditions of plasticity. The torsion problem of prismatic bars, and planar problems of solids will be learnt through examples and applications. There will be an emphasis given to the plastic load bearing capacity of elasto-plastic frame structure, and their limit states. (3 credits)

Nonlinear FEM

BMEEOTMMN62

The main goal in this subject is, that the students get to know the solution with the finite element method (FEM) of the nonlinear mechanical problems typical in engineering practice, alongside with the mathematical background of the solutions. The specialities of one- and multidimensional problems will be discussed. There will be interpreted the nonlinear behaviour of the most important stuctures (beams, frames, plates, shells) from the practical use, with a focus on the important questions about the effect of large displacements and plastic deformations. Beyond the general nonlinearity the students will learn the special techniques (finite strip method, finite volume method, boundary element method, meshfree methods, smooth and finite particle methods, etc.). As an organic part of the course, students will analyse case studies solved by computer simulation, in order to deeper understand the modeling techniques of various nonlinearities and connect theory and practice. (3 credits)

Analysis of Rods and Frames

BMEEOTMMN63

The goal of the subject is to get students to know the modeling possibilities of rod structures appearing in the structural engineering practice, the theoretical background of the models. Based on the linear mechanical model of the generalized beam element students will be acquainted with the calculation of the stiffness matrix and load vector of frame structures and their generalizations e.g. trusses, grids, and infilled frames. Higher-order analysis of kinematically indeterminate structures with high importance in engineering practice will be learnt. (3 credits)

Discrete Element Method

BMEEOTMMN64

The goal of the subject is to get students to know the basics of the concept and methodology of the discrete element methods (DEM) occurring in the structural engineering practice, and allow an insight to the operation of a discrete element software. Students will learn the most important variations DEM, th applied equations of motion, their numeric solution methods with the limits of applicability, advantages and disadvantages. Students will analyse the model of a simple engineering problem. (3 credits)

Structures 2

BMEEOHSMT-1

The objective of the subject is the presentation of the hazards, structural reliability and their role in structural design. The behaviour of complex structures, curved steel and concrete shells, 3D truss structures and their design are introduced. The most important analytical solutions and the basics and assumptions of numerical solutions are presented. Additionally, the design methods of cable and membrane structures are concluded in the subject. (4 credits)

Stability of Structures

BMEEOHSMT-2

The objective of the subject is the presentation of the most important problems in the stability analysis and stability design of steel structures. The student will learn the terminology of theory of engineering stability and theory of torsion of thin-walled members, as well as their practical importance and applicability. The most relevant modes of instabilities of engineering steel structures will be presented (flexural buckling, flexural-torsional buckling, lateral-torsional buckling, plate buckling). To each instability mode the student will learn the background and mathematical bases, as well as the Eurocode design procedures and their practical applications. (4 credits)

Seismic Design

BMEEOHSMT-3

The objective of the course is that the student shall understand the description and characterization of seismic effects and consequences, shall be aware of the basic principles of vibration analysis, behaviour, analysis and design of single and multi degree of freedom elastic or elasto-plastic structural systems, simplified modelling techniques of structures, principles of design regulations and codes, behaviour and design methods of quasi-elastic and dissipative structures. (4 credits)

Applied Fracture Mechanics

BMEEOHSMT61

The objective of the subject is the presentation of the basic theories and methods of fracture mechanics,and their application in the field of civil engineering. The basic definitions of fracture mechanics and their mathematical representation, and the basic calculation methods are also introduced. The design methods in Eurocode based on fracture mechanics are presented. (4 credits)

Prestressing Technologies

BMEEOHSMT62

The objective of the subject is the presentation of the prestressed structures and its design procedures. The main types of prestressed structures, applied materials and prestressing technologies are introduced. The effect of prestressing for the design procedures is discussed. Special prestressed structural systems and prestressing technologies for bridges are also presented. The Eurocode based design procedures and their practical application are showed. (3 credits)

Strengthening of Structures

BMEEOHSMT63

The objective of the subject is the presentation of the diagnostic of existing structures with different materials and structural systems, the possible causes of structural damages, methods of reinforcement and the most common building materials. According to this, the tools and steps of the diagnostic of existing structures, the verification of the structure's load bearing capacity, the basic principles of qualification, the required content of expertise, the methods of reconstruction and reinforcement, the most common ways of structural damages (direct and indirect) and the different structural systems of existing residential buildings are presented during the semester. Case studies are also introduced. (3 credits)

Engineering Geology MSc

BMEEOGMMG-1

The goal of the subject, that the studnets get familiar with the physical properties of the main type of rocks. It is introducing to the students the most common types of landslide problems, their solutions, the risk analysis in the field of engineering geology, the importance of the in-situ stresses in the rock mechanical design. The students get to know the theoretical background of the rock mass classification systems, the relations between the different rock mass classification systems. They learn to use these systems for rock engineering design in normal and weak rock masses. With the completion of the subject they learn to use the introduced design methods and monitoring through examples. (4 credits)

Environmental Geology

BMEEOGMMG-2

The students are getting familiar with the pollution sources that endanger environment and understand the mitigation methods. The subject provides information on the transport mechanism of pollutants in subsurface area and the conditions that influence their dispersion. The studied topics include the legal regulation of environmental geological surveys and the geological constrains of environmental impact assessment of existing and planned engineering structures. By studying remediation techniques the course leads a better understanding of various methods of pollutant removal from the geological environment. Special focus area is mining related pollution and site remediation. Waste disposal and pollution control also form important parts of the course. The exercise classes help students to learn environmental geological practice that helps in the sustainable operation and design of engineering structures. The course provides perspectives in environmental pollution reduction and in cost effective mitigation of polluted sites. (4 credits)

Geotechnical Design

BMEEOGMMG-3

The goal of this course is to acquire knowledge of the basics of geotechnical design, geotechnical approaches according to Eurocode 7, requirements of the contents of infrastructural and structural plans, methodology of soil borings and complex laboratory tests, evaluation of in-situ tests results, design optimization of large-scale geotechnical projects, soil anchor and soil nail design, jet-grouting technology and its design, design and qualification of subgrades and subbases, design of monitoring systems and design based on observation. (4 credits)

Earthworks of Infrastructures

BMEEOGMMG-4

The aim of the course is that the students understand the geotechnical aspects of infrastructures' earthworks. In this course the student gets to know the effect of earthquakes on subsoil and earthworks (damages, stability calculation, liquefaction, case studies, failures), the concepts of embankment construction on soft soils (primary consolidation, secondary compression, wick drains, vibroflotation, dynamic compaction, dynamic replacement, staged construction), design, construction and control of soil and rock dams and flood protection dikes, and calculation of quick condition and sandpiping. (4 credits)

Tunneling

BMEEOGMMG61

The goal of this course is to teach the most important segments of the tunnel design and the construction. The course is focus on the frequently used tunneling technics and calculation methods in both soil and rock environment. During the semester the student calculates the most important stresses on the tunnel, using both numerical and analytical methods. The tunnel designs are shown in a detailed both the construction and operation system, as well. (3 credits)

Hydrogeology

BMEEOGMMG62

The goal of the subject, that the students getting familiar with the geological, geophysical methods of water exploration, the stratigraphy of ground, karstic and fissure water, the origin and properties of ground water (temperature, chemical nature). The students acquire the methodology for recharge, water flow, infiltration calculations, furthermore the water level and discharge measurements, water tracing and modelling the water flow in karstic and jointed rock mass. They learn the properties, classification and usage of thermal water. The subject introduce to the students the regional water management, the hydrogeological effect of mining and civil engineering, protecting of water resources through case studies. They get information about the dewatering methods and learn the usage of hydrogeological models for civil engineering works. (3 credits)

Numerical Methods in Geotechnics

BMEEOGMMG63

The aim of the course is that the students get to know the use of numerical methods that aid the geotechnical and engineering geological design. The students get familiar with the advantages and disadvantages of analytical methods and applications of finite element methods to geotechnical and engineering geological problems by using different commercially available software. The students get to know the special elements and material models that are typically used in case of FE modelling of geotechnical problems. The students get to know the most frequently used rock mechanical methods for modelling fractured rocks. (3 credits)

Engineering Geology of Hungary

BMEEOGMMG64

The goal of the subject, that the students getting familiar with the main geological regions of Hungary and gain the required regional and local geological knowledge for engineering design and operate of facilities. Furthermore it is also an important additional part of the course to present knowledge about the main geological structures of Hungary, the location of the most important soils and rocks, the surface-forming processes with anthropogenic effects, the most important relief forms caused by flowing water, wind. Introduces to the students the karstic landforms, and the surface forming effect of mining, road, railway and other civil engineering constructions. Furthermore the subject give comparison between the Hungarian and well-known international geological units and landforms. (3 credits)

Faculty of Electrical Engineering and Informatics

The Faculty of Electrical Engineering founded in 1949 has been renowned for excellence in research and education throughout the years of changes in the scope of engineering. Over this period, the faculty has earned a wide-spread international reputation for its high academic standards and scientific achievements. Spearheading the movement to establish a modern education system, it has offered a comprehensive English curriculum since 1984. In 1992 the name of the faculty was changed to Faculty of Electrical Engineering and Informatics in order to give recognition to the growing importance of computer science. The education programmes in English include a 3.5-year BSc, a 2-year MSc and a 4-year PhD programme in the fields of electrical engineering and computer engineering.

This Bulletin describes the curricula and the subjects being available for the 2018/2019 academic year, regarding the BSc, MSc and PhD programmes, respectively.

The undergraduate **BSc programme** (7 semesters) aims at providing a comprehensive knowledge with sound theoretical foundations in two areas: (1) Electrical Engineering including more specific studies in electronics, controll engineering and power engineering; and (2) Computer Engineering dedicated to the major domains of computer science. The major specializations in Electrical Engineering are infocommunication systems, embedded and controller systems and sustainable electric energetics. Studies in Computer Engineering include specialization in infocommunications and software engineering. Each specialization contains four courses focusing on the field of interest followed by a laboratory course and a project laboratory. In order to pursue studies in a given specialization the number of students must exceed a certain threshold, otherwise the interested students are kindly directed to another specialization.

The **MSc programme** (4 semesters) advances the knowledge in the following fields: (1) Electrical Engineering, offering specializations in (i) embedded systems, (ii) multimedia systems and services, and (iii) electric power systems; and (2) Computer Engineering, offering specializations in (i) applied informatics, and (ii) internet architecture and services.

The post-graduate **PhD programme** is available in all domains offered in the MSc programme.

Since research and development requires innovative engineering expertise, one of the major concerns of the faculty is to endow students with high level mathematical skills in modeling complex engineering systems. This objective implies the use of system and algorithmic theory in addition to a thorough knowledge in physics. The search for optimal solutions in the highly complex architectures of Electrical Engineering and Computer Engineering necessitates not only engineering but economical considerations, as well. As a result, the scope of the programme must include design, research and management expertise at the same time.

Several strategies have been designed to help students develop high level skills in mathematics, physics, and computation. Besides theoretical knowledge they need to carry out design and development activities in the field of communication, instrumentation, and power industries to further perfect their practical skills. The curriculum also includes solving tasks in the fields of production and operation.

Scientific groups are formed to encourage the students to do independent but supervised laboratory work. Project laboratory is one of the core parts of the studies which are dedicated to independent problem solving with the armoury of modern work stations and software packages. The expertise of handling these tools are inevitable in pursuing an engineering career.

In order to strengthen the transfer of knowledge and know-how between the university and industry, the faculty maintains close contact with well known multinational companies in the field of communication and computer industry. As a result, many industrial experts offer their experience and knowledge as part-time lecturers, project supervisors, members of examination committees.

Admission policy

To maintain a high educational standard is the basic interest of both the university and the students. Only a constant guard of quality can ensure that tuition fee is traded for a degree of high reputation bearing a competitive value in the global market. Therefore, the priority of our acceptance policy is sustaining the quality of education by selecting those students whose knowledge and previous qualifications are in match with the expertise required by the courses. This rule holds for all applicants, no matter the country or the educational institutions they came from. Only the implementation of this acceptance policy helps us to preserve the value of the degree, which the students rightly deserve in exchange of their tuition fee and in exchange of their continuous effort committed during the course. In order to implement the principles, our faculty has adopted the following terms of acceptance:

Practical guidelines for acceptance to the MSc programme

1. Applicants with BSc studies having a WGAP (Weighted Grade Average Point) equal or better than ‘good’ (more than 3.51 out of 5.00) will receive acceptance to the MSc course.

2. Applicants with a BSc qualification less than ‘good’ (less than 3.50 out of 5.00) are regretfully rejected to enter the MSc program.

3. Applicants should also submit two recommendations given by renowned academic personnel.

Practical guidelines for acceptance to the PhD programme

1. The primary condition of admission to postgraduate studies is that the applicant must hold a Master of Science (or Engineering) degree in Electrical and Electronic Engineering (or in some closely related fields) or Informatics. Admission to postgraduate studies will be considered if the qualification of previous studies is at least of level “good” (more than 3.51 out of 5.00) or equivalent.

2. Applicants are expected to have a definite scope of research in electrical engineering or computer science, where they would like to advance their knowledge. They are requested to present a proposal, specifying a domain of interest with some research objectives, milestones and deliverables during the postgraduate studies. The suggested topic should have sufficient preliminaries in their university studies.

3. Applicants with experience and initial results in the suggested research topic will have preference. A short summary of preliminary research activities together with relevant reports, published papers ... etc. would be of help in the admission process.

4. Applicants should also submit two recommendations given by renowned academic personnel

Each admission is valid only for the forthcoming academic year (starting right after the letter of acceptance). In the case of commencing studies later than the semester indicated in the letter of acceptance, or returning to studies after a passive semester, the faculty does not take responsibility for ensuring that the students can follow the same specialization which he or she studied prior to the passive semester, and reserves the right to direct the student to other specialization depending on the changes in the number applicants for specializations.

Departments

Automation and Applied Informatics
Electronics Technology
Electron Devices
Networked Systems and Services
Control Engineering and Information Technology
Measurement and Information Systems
Computer Science and Information Theory
Broadband Infocommunications and Electromagnetic Theory
Telecommunications and Media Informatics
Electric Power Engineering

Budapest University of Technology and Economics
Faculty of Electrical Engineering and Informatics
International Office:
Building Q, wing B, ground floor, room No. BF05
Mailing Address: Magyar tudósok körútja 2.
H-1117 Budapest, Hungary
Phone: (+36-1) 463-1608
Fax: (+36-1) 463-2551
E-mail: english_program_info@vik-dh.bme.hu

Dean of the Faculty: Dr. László Jakab
Vice-Dean for BSc and MSc Education: Dr. Gábor Tevesz
Director of BSc and MSc programmes: Dr. Eszter Udvary
Vice-Dean for Scientific Matters and PhD Education: Dr. József Bíró
Acting International Director: Dr. Balázs Illés
International coordinators: Ms. Nóra Demeter and Ms. Kata Jármi

Curriculum of BSc Subjects in Electrical Engineering

Subject			lectures/practical lectures/laboratory						
Name	**Code**	**Cre-dits**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Fundametals in Natural Sciences (48 credits)									
Mathematics A1	TE90AX00	6	4/2/0/e						
Mathematics A2	TE90AX26	6		4/2/0/m					
Comprehensive Exam on Mathematics A1&A2	TE90AX16	0		0/0/0/ce					
Mathematics A3	TE90AX09	4			2/1/0/e				
Mathematics A4	TE90AX51	4			2/2/0/e				
Physics 1	TE11AX21	4	3/1/0/e						
Physics 2	TE11AX22	4		2/1/0/e					
Foundation of Computer Science	VISZAA05	5	2/2/0/e						
Informatics 1	VIIIAB08	4				4/0/0/m			
Informatics 2	VIAUAB01	5				3/0/1/e			
Electronics Technology and Materials	VIETAB00	6			3/0/2/m				
Economics and Humanities (20 credits)									
English		2	2/0/0/m						
Micro- and Macroeconomics	GT30A001	4						4/0/0/e	
Management and Business Economics	GT20A001	4					4/0/0/m		
Business Law	GT55A001	2						2/0/0/m	
Mandatory Humanities & Economics 1, 2		2		2/0/0/m					2/0/0/m
Mandatory Humanities & Economics 3, 4		2		2/0/0/m					2/0/0/m
Core Electrical Engineering Knowledge (89 Credits)									
Basics of Programming 1	VIHIAA01	7	2/2/2/m						
Basics of Programming 2	VIAUAA01	6		2/0/2/m					
Digital Design 1	VIIIAA04	6	3/1/1/e						
Digital Design 2	VIIIAA02	5		3/1/0/e					
Signals and Systems 1	VIHVAA00	6		3/2/0/e					
Signals and Systems 2	VIHVAB01	6			3/3/0/e				
Electrotechnics	VIVEAB00	5			3/0/1/m				
Introduction to Electromagnetic Fields	VIHVAC03	4					2/1/0/e		
Electronics 1	VIHIAB02	5			2/2/0/e				
Electronics 2	VIAUAC05	5					4/1/0/m		
Measurement Technology	VIMIAB01	5				3/2/0/m			
Control Engineering	VIIIAB05	5				2/1/1/e/5			
Infocommunication	VITMAB03	5				2/2/0/e/5			
Power Engineering	VIVEAB01	5				2/1/1/e/5			
Microelectronics	VIEEAB00	5						2/0/2/e/5	
Laboratory 1	VIMIAC12	4					0/0/3/m		
Laboratory 2	VIMIAC13	5						0/0/4/m	
Study Specialization Blocks (43 Credits)									
Specialization subject 1		4					2/1/0/e		
Specialization subject 2		4					2/1/0/e		
Specialization subject 3		4					2/1/0/e		
Specialization subject 4		4						2/1/0/e	
Specialization laboratory		4						0/0/3/m	
Training project laboratory	VI**AL02	3					0/0/2/m		
Project Laboratory	VI**AL03	5						0/0/4/m	
Bsc Thesis Work	VI**AT01	15							0/10/0/m
Free electives (10 credits)[1]									
Free elective 1, 2		2						2/0/0/e	2/0/0/m
Free elective 3		2							2/0/0/m
Free elective 4		2							2/0/0/m
Free elective 5		2							2/0/0/m
Totals									
Sum of hours per week			15/8/3	18/6/2	15/8/3	16/5/4	16/5/5	12/2/12	12/10/0
Sum of credits per semester			30	31	30	29	32	31	27
Number of exams[2]			4	4	4	4	4	4	0

x/y/z/[e,ce,m,s]: x: contact hours of lectures per week, y: contact hours of classroom practices per week, z: contact hours of laboratory exercises per week, e: examination, ce: comprehensive exam, m: mid-semester mark, s: signature; credit: credit value according to ECTS – 1 credit represents 30 work hours (on average)

[1]10 credits of free electives could be substituted by any subjects available

[2]Students should note that due to the early scheduling of the thesis defense session for students applying to MSc studies, the period for examination could be rather limited in the 7th semester

Specializations

List of available specialization blocks depends on the number of students wanting to join. In order to pursue studies in a given specialization the number of students must exceed a certain threshold, otherwise the interested students are kindly directed to another specialization.

Subject			lectures/practical lectures/laboratory						
Name	Code	Cre-dits	1	2	3	4	5	6	7
SUSTAINABLE ELECTRIC ENERGETICS specialization									
Electric Power Transmission	VIVEAC00	4					2/1/0/e		
Electrical Machines and Applications	VIVEAC01	4					2/1/0/e		
Electrical Equipment and Insulations	VIVEAC02	4					2/1/0/e		
Control of Electric Drives	VIVEAC04	4						2/1/0/e	
Sustainable Electric Energetics Laboratory	VIVEAC07	4						0/0/3/m	
EMBEDDED AND CONTROL SYSTEMS specialization									
Embedded And Ambient Systems	VIMIAC06	4					2/1/0/e		
Industrial Control	VIIIAC03	4					2/1/0/e		
Microcontroller Based Systems	VIAUAC06	4					2/1/0/e		
Embedded Operating Systems and Client	VIAUAC07	4						2/1/0/e	
Embedded and Control Systems Lab.	VIAUAC08	4						0/0/3/m	
INFOCOMMUNIATION SYSTEMS specialization									
Space Technology	VIHVC05	4					2/1/0/e		
Network Technologies and Applications	VITMAC05	4					2/1/0/e		
Mobile Comm. Systems	VIHIC04	4					2/1/0/e		
High Frequency System Techniques	VIHVAC04	4						2/1/0/e	
Radio Systems and Applications Lab	VIHVAC06	4						0/0/3/m	

Curriculum of BSc Subjects in Computer Engineering

Subject			lectures/practical lectures/laboratory						
Name	**Code**	**Cre-dits**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Fundametals in Natural Sciences (44 credits)									
Calculus 1 for Informaticians	TE90AX21	6	4/2/0/e						
Calculus 2 for Informaticians	TE90AX22	6		4/2/0/m					
Comprehensive Examination in Calculus	TE90AX20	0		0/0/0/ce					
Probability Theory	VISZAB02	5			2/2/0/e				
Introduction to the Theory of Computing 1	VISZAA03	5	2/2/0/e						
Introduction to the Theory of Computing 2	VISZAA04	5		2/2/0/e					
Coding Technology	VIHIAB00	4			3/0/0/e				
Theory of Algorithms	VISZAB03	5				2/2/0/e			
Physics 1i	TE11AX23	4	2/1/0/e						
Physics 2i	TE11AX24	4		2/1/0/e					
Economics and Humanities (20 Credits)									
English		2	2/0/0/m						
Micro- and Macroeconomics	GT30A001	4					4/0/0/e		
Management and Business Economics	GT20A001	4				4/0/0/m			
Business Law	GT55A001	2					2/0/0/m		
Mandatory human & economic science elective 1		2						2/0/0/m	
Mandatory human & economic science elective 2		2						2/0/0/m	
Mandatory human & economic science elective 3		2							2/0/0/m
Mandatory human & economic science elective 4		2							2/0/0/m
Core Engineering Knowledge (91 Credits)									
System Theory	VIHVAB00	4			2/2/0/m				
Technology of IT Devices	VIEEAC00	4					2/0/1/m		
Digital Design	VIMIAA02	6	2/1/2/e						
System Modelling	VIMIAA00	4		2/1/0/m					
Computer Architectures	VIHIAA02	4		2/1/0/e					
Communication Networks 1	VIHIAB01	4			2/0/1/m				
Communication Networks 2	VITMAB01	4				2/0/1/e			
Operating Systems	VIMIAB00	5				3/0/1/e			
Basics of Programming 1	VIEEAA00	7	2/2/2/m						
Basics of Programming 2	VIIIAA03	6		2/0/2/m					
Basics of Programming 3	VIIIAB00	5			2/0/2/m				
Databases	VITMAB04	5			2/1/1/e				
Software Technology	VIIIAB01	4			3/0/0/e				
Software Techniques	VIAUAB00	5				2/0/2/e			
Software Project Laboratory	VIIIAB06	3				0/0/2/m			
Web And Mobile Software	VIAUAC00	5					2/0/2/e		
Computer Graphics	VIIIAB07	3				3/0/0/m			
Artificial Intelligence	VIMIAC10	3					3/0/0/m		
IT Security	VIHIAC01	3						3/0/0/m	
Management of Information Systems	VITMAC02	4						2/1/0/m	
Embedded Information Systems	VIMIAD00	3							2/0/1/m
Study specialization blocks (45 credits)									
Specialization subject 1		4					2/1/0/e		
Specialization subject 2		4					2/1/0/e		
Specialization subject 3		4						2/1/0/e	
Specialization subject 4		4						2/1/0/e	
Specialization laboratory 1, 2		3						0/0/2/m	0/0/2/m
Training project laboratory	VI**AL00	3					0/0/3/m		
Project laboratory	VI**AL01	5						0/0/4/m	
BSc thesis work	VI**AT00	15							0/10/0/m
Free electives (10 credits)[2]									
Free elective 1, 2		4						4/0/0/e	2/0/0/m
Free elective 3		2							2/0/0/m
Free elective 4		2							2/0/0/m
Totals									
Sum of hours per week			13/8/4	14/7/2	16/5/4	16/2/6	17/2/6	17/2/7	12/11/2
Sum of credits per semester			30	29	31	29	29	31	31
Number of exams[4]			4	4	4	4	4	3	0

x/y/z/[e,ce,m,s]: x: contact hours of lectures per week, y: contact hours of classroom practices per week, z: contact hours of laboratory exercises per week, e: examination, ce: comprehensive exam, m: mid-semester mark, s: signature; credit: credit value according to ECTS – 1 credit represents 30 work hours (on average)

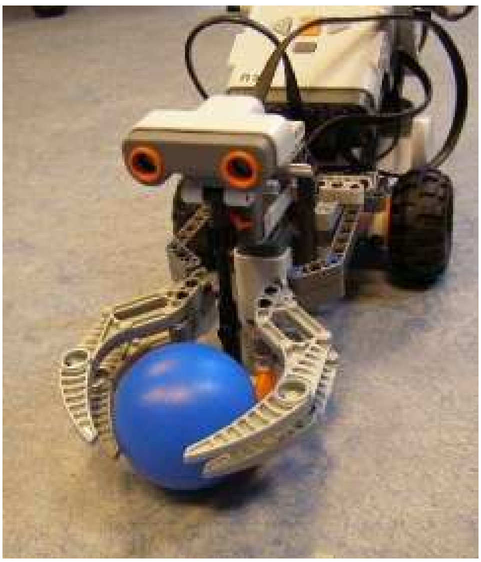
[2]10 credits of free electives could be substituted by any subjects available

[3]Students should note that due to the early scheduling of the thesis defense session for students applying to MSc studies, the period for examination could be rather limited in the 7th semester

Specializations

List of available specialization blocks depends on the number of students. In order to pursue studies in a given specialization the number of students must exceed a certain threshold, otherwise the interested students are kindly directed to another specialization.

Subject			lectures/practical lectures/laboratory						
Name	**Code**	**Credits**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
SOFTWARE ENGINEERING specialization									
Data-Driven Systems	VIAUAC01	4					2/1/0/e		
Object-Oriented Software Design	VIIIAC00	4					2/1/0/e		
Integration & Verification Techniques	VIMIAC04	4						2/1/0/e	
Client Side Technologies	VIAUAC02	4						2/1/0/e	
Software Development Laboratory 1	VIAUAC09	3						0/0/2/m	
Software Development Laboratory 2	VIAUAD01	3							0/0/2/m
INFOCOMMUNICATIONS specialization									
Mobile Communication Networks	VIHIAC00	4					2/1/0/e		
Building and Operation of Networks	VITMAC00	4					2/1/0/e		
Media Applications & Networks in Practice	VIHIAC02	4						2/1/0/e	
Networked Resource Platforms & Apps	VITMAC03	4						2/1/0/e	
Infocommunication Laboratory 1	VITMAC08	3						0/0/2/m	
Infocommunication Laboratory 2	VIHIAD02	3							0/0/2/m



Curriculum of MSc Subjects in Computer Engineering
Applied Informatics Main Specialization

Subject			lectures/practical lectures/ laboratory			
Name	**Code**	**Cre-dits**	**1**	**2**	**3**	**4**
Fundamentals in Natural Sciences (20 credits)						
System Optimization	BMEVISZMA02	4	4/0/0/e			
Applied Algebra and Mathematical Logic	BMETE90MX57	4		4/0/0/e		
Formal Methods	BMEVIMIMA07	4	3/0/0/m			
Information Theory	BMEVISZMA03	4		3/0/0/m		
Languages and Automata	BMEVISZMA04	4		3/0/0/m		
Subjects from Economic and Human Sciences (10 credits)						
Elective Subject 1	BMEGTxxMxxx	2			2/0/0/m	
Elective Subject 2	BMEGTxxMxxx	2				2/0/0/m
Elective Subject 3	BMEGTxxMxxx	2				2/0/0/m
Engineering Management	BMEVITMMB03	4				4/0/0/e
Basic Obligatory Subjects for the Specialization (28 credits)						
Software Development Methods and Paradigms	BMEVIAUMA00	4	2/1/0/e			
Distributed Systems and Domain-Specific Modeling	BMEVIAUMA01	4	2/1/0/e			
Service Oriented System Integration	BMEVIIIMA04	4	2/1/0/e			
Business Intelligence	BMEVIAUMA02	4		2/1/0/e		
Software and Systems Verification	BMEVIMIMA01	4		2/1/0/e		
Distributed Systems Laboratory	BMEVIAUMA03	4		0/0/3/m		
Business Intelligence Laboratory	BMEVIAUMB00	4			0/0/3/m	
Basic Compulsory Elective Subjects for the Specialization (56 credits)						
Basic Obligatory Subjects for the Secondary Specialization (Smart City or Cloud and Parallel Systems)		16				
Project Laboratory 1	BMEVIxxML00	5	0/0/3/m			
Project Laboratory 2	BMEVIxxML01	5		0/0/3/m		
Diploma Thesis Design 1	BMEVIxxMT00	10			0/5/0/m	
Diploma Thesis Design 2	BMEVIxxMT01	20				0/10/0/m
Free Electives (6 credits)						
Free Elective Subject 1	BMExxxxxxxx	2			2/0/0/m	
Free Elective Subject 2	BMExxxxxxxx	2			2/0/0/m	
Free Elective Subject 3	BMExxxxxxxx	2			2/0/0/m	
Smart City Secondary Specialization (16 credits)						
Sensor Networks and Applications	BMEVITMMA09	4	2/1/0/e			
Intelligent Traffic Systems	BMEVITMMA10	4		2/1/0/e		
Human-Machine Interface	BMEVITMMA11	4			2/1/0/e	
Smart City Laboratory	BMEVITMMB04	2			0/0/2/m	
Free Elective Subject 4	BMExxxxxxxx	2			2/0/0/m	
Cloud and parallel systems Secondary Specialization (16 credits)						
Cloud Computing	BMEVIIIMA05	4	2/1/0/e			
High Performance Parallel Computing	BMEVIIIMA06	4		2/1/0/e		
GPGPU Applications	BMEVIIIMB01	4			2/1/0/e	
Parallel Programming Laboratory	BMEVIIIMB02	4			0/0/3/m	

Free Elective Subjects: *a list of these subjects is published on the website.*

Notation: working hours/week: x/y/z/r

x = lecture hours

y = practice hours

z = laboratory hours

r = requirement (e = exam, m=mid-semester mark)

Curriculum of MSc Subjects in Computer Engineering
Internet Architecture and Services Main Specialization

Subject			lectures/practical lectures/ laboratory			
Name	**Code**	**Cre-dits**	**1**	**2**	**3**	**4**
Fundamentals in Natural Sciences (20 credits)						
System Optimization	BMEVISZMA02	4	4/0/0/e			
Applied Algebra and Mathematical Logic	BMETE90MX57	4		4/0/0/e		
Formal Methods	BMEVIMIMA07	4	3/0/0/m			
Information Theory	BMEVISZMA03	4		3/0/0/m		
Languages and automata	BMEVISZMA04	4		3/0/0/m		
Subjects from Economic and Human Sciences (10 credits)						
Elective Subject 1	BMEGTxxMxxx	2			2/0/0/m	
Elective Subject 2	BMEGTxxMxxx	2				2/0/0/m
Elective Subject 3	BMEGTxxMxxx	2				2/0/0/m
Engineering Management	BMEVITMMB03	4				4/0/0/e
Basic Obligatory Subjects for the Specialization (28 credits)						
Internet Ecosystem and its Evolution	BMEVITMMA00	4	2/1/0/e			
Agile Network Service Development	BMEVITMMA01	4	2/1/0/e			
Cloud Networking	BMEVITMMA02	4	2/1/0/e			
Modeling Seminar for Engineers	BMEVITMMA03	4		2/1/0/e		
Internet Services and Applications	BMEVITMMA04	4		2/1/0/e		
Infocommunication Services Laboratory 1	BMEVIHIMA04	4		0/0/3/m		
Infocommunication Services Laboratory 2	BMEVITMMB00	4			0/0/3/m	
Basic Compulsory Elective Subjects for the Specialization (56 credits)						
Basic Obligatory Subjects for the Secondary Specialization (Smart City or Cloud and parallel systems) (see below)		16				
Project Laboratory 1	BMEVIxxML00	5	0/0/3/m			
Project Laboratory 2	BMEVIxxML01	5		0/0/3/m		
Diploma Thesis Design 1	BMEVIxxMT00	10			0/5/0/m	
Diploma Thesis Design 2	BMEVIxxMT01	20				0/10/0/m
Free Elective Subjects (6 credits)						
Free Elective Subject 1	BMExxxxxxxx	2			2/0/0/m	
Free Elective Subject 2	BMExxxxxxxx	2			2/0/0/m	
Free Elective Subject 3	BMExxxxxxxx	2			2/0/0/m	
Smart City Secondary Specialization (16 credits)						
Sensor Networks and Applications	BMEVITMMA09	4	2/1/0/e			
Intelligent Traffic Systems	BMEVITMMA10	4		2/1/0/e		
Human-Machine Interface	BMEVITMMA11	4			2/1/0/e	
Smart City Laboratory	BMEVITMMB04	2			0/0/2/m	
Free Elective Subject 4	BMExxxxxxxx	2			2/0/0/m	
Cloud and parallel systems Secondary Specialization (16 credits)						
Cloud Computing	BMEVIIIMA05	4	2/1/0/e			
High Performance Parallel Computing	BMEVIIIMA06	4		2/1/0/e		
GPGPU Applications	BMEVIIIMB01	4			2/1/0/e	
Parallel Programming Laboratory	BMEVIIIMB02	4			0/0/3/m	

Free Elective Subjects: *a list of these subjects is published on the website.*

Notation: working hours/week: x/y/z/r

x = lecture hours

y = practice hours

z = laboratory hours

r = requirement (e = exam, m=mid-semester mark)

Curriculum of MSc Subjects in Electrical Engineering
Embedded Systems Main Specialization

Subject			lectures/practical lectures/ laboratory			
Name	**Code**	**Cre-dits**	**1**	**2**	**3**	**4**
Fundamentals in Natural Sciences (22 credits)						
Advanced physic Electromagnetic Fields	BMEVIHVMA08	4		3/1/0/e		
or Physics 3	BMETE11MX33	4			3/1/0/e	
Stochastics (Advanced Mathematics for Electrical Engineers)	BMETE90MX55	3		2/1/0/m		
Measurement Theory	BMEVIMIMA17	4	3/0/0/m			
Linear Algebra (Advanced Mathematics for Electrical Engineers)	BMETE90MX54	3	2/1/0/m			
Photonic Devices	BMEVIETMA06	4		4/0/0/m		
Communication Theory	BMEVIHVMA07	4			3/0/0/m	
Subjects from Economic and Human Sciences (10 credits)						
Elective Subject 1	BMEGTxxMxxx	2			2/0/0/m	
Elective Subject 2	BMEGTxxMxxx	2				2/0/0/m
Elective Subject 3	BMEGTxxMxxx	2				2/0/0/m
Engineering Management	BMEVITMMB03	4			4/0/0/e	
Basic Obligatory Subjects for the Specialization (28 credits)						
Artifical Intelligence Based Control	BMEVIIIMA09	4	2/1/0/e			
SW Technology for Embedded Systems	BMEVIMIMA09	4	2/1/0/e			
Computer Vision Systems	BMEVIIIMA07	4	2/1/0/e			
Development of SW Applications	BMEVIAUMA09	4		2/1/0/e		
Design & Integration of Embedded Systems	BMEVIMIMA11	4		2/1/0/e		
Control Engineering & Image Processing Labratory	BMEVIIIMA11	4		0/0/3/m		
Applied Computer Systems Laboratory	BMEVIAUMB03	4			0/0/3/m	
Basic Compulsory Elective Subjects for the Specialization (54 credits)						
Basic Obligatory Subjects for the Secondary Specialization (Smart City or Smart System Integration or Optical Communication))		14				
Project Laboratory 1	BMEVIxxML02	5	0/0/3/m			
Project Laboratory 2	BMEVIxxML03	5		0/0/3/m		
Diploma Thesis Design 1	BMEVIxxMT02	10			0/5/0/m	
Diploma Thesis Design 2	BMEVIxxMT03	20				0/10/0/m
Free Elective Subjects (6 credits)						
Free Elective Subject 1	BMExxxxxxxx	2				2/0/0/m
Free Elective Subject 2	BMExxxxxxxx	2				2/0/0/m
Free Elective Subject 3	BMExxxxxxxx	2				2/0/0/m
Smart City Secondary Specialization (14 credits)						
Sensor Networks and Applications	BMEVITMMA09	4	2/1/0/e			
Intelligent Traffic Systems	BMEVITMMA10	4		2/1/0/e		
Human-Machine Interface	BMEVITMMA11	4			2/1/0/e	
Smart City Laboratory	BMEVITMMB04	2			0/0/2/m	
Smart Systems Integration Secondary Specialization (14 credits)						
Fundamentals of Smart Systems	BMEVIEEMA04	4	2/1/0/e			
System Level Design	BMEVIEEMA05	4		2/1/0/e		
Circuit Environment	BMEVIEEMA06	4		2/1/0/e		
Smart Systems Design Laboratory	BMEVIEEMB00	2			0/0/2/m	
Optical Communication Seondary Scpecialization (14 credits)						
Optical Network Elements	BMEVIHVMA05	4	2/1/0/e			
Optical Systems and Applications	BMEVIHVMA06	4		2/1/0/e		
Optical Networking Architectures	BMEVITMMA12	4		2/1/0/e		
Optical Networks Laboratory	BMEVIHVMB03	2			0/0/2/m	

Free Elective Subjects: *a list of these subjects is published on the website.*

Notation: working hours/week: x/y/z/r

x = lecture hours

y = practice hours

z = laboratory hours

r = requirement (e = exam, m=mid-semester mark)

Curriculum of MSc Subjects in Electrical Engineering
Multimedia Systems and Services Main Specialization

Subject			lectures/practical lectures/ laboratory			
Name	**Code**	**Cre-dits**	**1**	**2**	**3**	**4**
Fundamentals in Natural Sciences (22 credits)						
Advanced physic Electromagnetic Fields	BMEVIHVMA08	4		3/1/0/e		
or Physics 3	BMETE11MX33	4			3/1/0/e	
Stochastics (Advanced Mathematics for Electrical Engineers)	BMETE90MX55	3		2/1/0/m		
Measurement Theory	BMEVIMIMA17	4	3/0/0/m			
Combinatorial Optimization (Advanced Mathematics for Electrical Engineers)	BMEVISZMA06	3	2/1/0/m			
Photonic Devices	BMEVIETMA06	4		4/0/0/m		
Communication Theory	BMEVIHVMA07	4			3/0/0/m	
Subjects from Economic and Human Sciences (10 credits)						
Elective Subject 1	BMEGTxxMxxx	2			2/0/0/m	
Elective Subject 2	BMEGTxxMxxx	2				2/0/0/m
Elective Subject 3	BMEGTxxMxxx	2				2/0/0/m
Engineering Management	BMEVITMMB03	4			4/0/0/e	
Basic Obligatory Subjects for the Specialization (28 credits)						
Mobile And Wireless Networks	BMEVIHIMA07	4	2/1/0/e			
Broadband Wireless Telecommunication and Broadcasting Systems	BMEVIHVMA01	4	2/1/0/e			
Foundations of Multimedia Technologies	BMEVIHIMA08	4	2/1/0/e			
Networked Multimedia Systems and Services	BMEVIHIMA09	4		2/1/0/e		
Media Informatics Systems	BMEVITMMA08	4		2/1/0/e		
Laboratory on Multimedia Systems and Services 1	BMEVIHIMA10	4		0/0/3/m		
Laboratory on Multimedia Systems and Services 2	BMEVIHIMB02	4			0/0/3/m	
Basic Compulsory Elective Subjects for the Specialization (54 credits)						
Basic Obligatory Subjects for the Secondary Specialization (Smart City or Smart System Integration or Optical Communication)		14				
Project Laboratory 1	BMEVIxxML02	5	0/0/3/m			
Project Laboratory 2	BMEVIxxML03	5		0/0/3/m		
Diploma Thesis Design 1	BMEVIxxMT02	10			0/5/0/m	
Diploma Thesis Design 2	BMEVIxxMT03	20				0/10/0/m
Free Elective Subjects (6 credits)						
Free Elective Subject 1	BMExxxxxxxx	2				2/0/0/m
Free Elective Subject 2	BMExxxxxxxx	2				2/0/0/m
Free Elective Subject 3	BMExxxxxxxx	2				2/0/0/m
Smart City Secondary Specialization (14 credits)						
Sensor Networks and Applications	BMEVITMMA09	4	2/1/0/e			
Intelligent Traffic Systems	BMEVITMMA10	4		2/1/0/e		
Human-Machine Interface	BMEVITMMA11	4			2/1/0/e	
Smart City Laboratory	BMEVITMMB04	2			0/0/2/m	
Smart Systems Integration Secondary Specialization (14 credits)						
Fundamentals of Smart Systems	BMEVIEEMA04	4	2/1/0/e			
System Level Design	BMEVIEEMA05	4		2/1/0/e		
Circuit Environment	BMEVIEEMA06	4		2/1/0/e		
Smart Systems Design Laboratory	BMEVIEEMB00	2			0/0/2/m	
Optical Communication Seondary Scpecialization (14 credits)						
Optical Network Elements	BMEVIHVMA05	4	2/1/0/e			
Optical Systems and Applications	BMEVIHVMA06	4		2/1/0/e		
Optical Networking Architectures	BMEVITMMA12	4		2/1/0/e		
Optical Networks Laboratory	BMEVIHVMB03	2			0/0/2/m	

Free Elective Subjects: *a list of these subjects is published on the website.*

Notation: working hours/week: x/y/z/r

x = lecture hours

y = practice hours

z = laboratory hours

r = requirement (e = exam, m=mid-semester mark)

Curriculum of MSc Subjects in Electrical Engineering
Electric Power Systems Main Specialization

Subject			lectures/practical lectures/ laboratory			
Name	**Code**	**Cre-dits**	**1**	**2**	**3**	**4**
Fundamentals in Natural Sciences (22 credits)						
Advanced physic Electromagnetic Fields	BMEVIHVMA08	4		3/1/0/e		
or Physics 3	BMETE11MX33	4			3/1/0/e	
Stochastics (Advanced Mathematics for Electrical Engineers)	BMETE90MX55	3		2/1/0/m		
Alternating Current Systems	BMEVIVEMA13	4	3/0/0/m			
Combinatorial Optimization (Advanced Mathematics for Electrical Engineers)	BMEVISZMA06	3	2/1/0/m			
Electrical Insulations and Discharges	BMEVIVEMA14	4		4/0/0/m		
Communication Theory	BMEVIHVMA07	4			3/0/0/m	
Subjects from Economic and Human Sciences (10 credits)						
Elective Subject 1	BMEGTxxMxxx	2			2/0/0/m	
Elective Subject 2	BMEGTxxMxxx	2				2/0/0/m
Elective Subject 3	BMEGTxxMxxx	2				2/0/0/m
Engineering Management	BMEVITMMB03	4			4/0/0/e	
Basic Obligatory Subjects for the Specialization (28 credits)						
Power System Operation and Control	BMEVIVEMA01	4	2/1/0/e			
Electrical Systems of Sustainable Energetic	BMEVIVEMA02	4	2/1/0/e			
Power System Transients	BMEVIVEMA03	4	2/1/0/e			
Protection Systems and Measurement Technology	BMEVIVEMA04	4		2/1/0/e		
Electric Energy Market	BMEVIVEMA05	4		2/1/0/e		
Electric Power Systems laboratory 1	BMEVIVEMA06	4		0/0/3/m		
Electric Power Systems laboratory 2	BMEVIVEMB00	4			0/0/3/m	
Basic Compulsory Elective Subjects for the Specialization (54 credits)						
Basic Obligatory Subjects for the Secondary Specialization (Smart City or Smart System Integration or Optical Communication)		14				
Project Laboratory 1	BMEVIxxML02	5	0/0/3/m			
Project Laboratory 2	BMEVIxxML03	5		0/0/3/m		
Diploma Thesis Design 1	BMEVIxxMT02	10			0/5/0/m	
Diploma Thesis Design 2	BMEVIxxMT03	20				0/10/0/m
Free Elective Subjects (6 credits)						
Free Elective Subject 1	BMExxxxxxxx	2				2/0/0/m
Free Elective Subject 2	BMExxxxxxxx	2				2/0/0/m
Free Elective Subject 3	BMExxxxxxxx	2				2/0/0/m
Smart City Secondary Specialization (14 credits)						
Sensor Networks and Applications	BMEVITMMA09	4	2/1/0/e			
Intelligent Traffic Systems	BMEVITMMA10	4		2/1/0/e		
Human-Machine Interface	BMEVITMMA11	4			2/1/0/e	
Smart City Laboratory	BMEVITMMB04	2			0/0/2/m	
Smart Systems Integration Secondary Specialization (14 credits)						
Fundamentals of Smart Systems	BMEVIEEMA04	4	2/1/0/e			
System Level Design	BMEVIEEMA05	4		2/1/0/e		
Circuit Environment	BMEVIEEMA06	4		2/1/0/e		
Smart Systems Design Laboratory	BMEVIEEMB00	2			0/0/2/m	
Optical Communication Seondary Scpecialization (14 credits)						
Optical Network Elements	BMEVIHVMA05	4	2/1/0/e			
Optical Systems and Applications	BMEVIHVMA06	4		2/1/0/e		
Optical Networking Architectures	BMEVITMMA12	4		2/1/0/e		
Optical Networks Laboratory	BMEVIHVMB03	2			0/0/2/m	

Free Elective Subjects: *a list of these subjects is published on the website.*

Notation: working hours/week: x/y/z/r

x = lecture hours y = practice hours z = laboratory hours

r = requirement (e = exam, m=mid-semester mark)

Description of BSc Courses in Electrical Engineering

Mathematics A1

BMETE90AX00

Algebra of vectors in plane and in space. Arithmetic of complex numbers. Infinite sequences. Limit of a function, some important limits. Continuity. Differentiation: rules, derivatives of elementary functions. Mean value theorems, l'Hospital's rule, Taylor theorem. Curve sketchig for a function, local and absolute extrema. Integration: properties of the Riemann integral, Newton-Leibniz theorem, antiderivatives, integration by parts, integration by substitution. Integration in special classes of functions. Improper integrals. Applications of the integral. (6 credits)

Mathematics A2

BMETE90AX26

Solving systems of linear equations: elementary row operations, Gauss-Jordan- and Gaussian elimination. Homogeneous systems of linear equations. Arithmetic and rank of matrices. Determinant: geometric interpretation, expansion of determinants. Cramer's rule, interpolation, Vandermonde determinant. Linear space, subspace, generating system, basis, orthogonal and orthonormal basis. Linear maps, linear transformations and their matrices. Kernel, image, dimension theorem. Linear transformations and systems of linear equations. Eigenvalues, eigenvectors, similarity, diagonalizability. Infinite series: convergence, divergence, absolute convergence. Sewuences and series of functions, convergence criteria, power series, Taylor series. Fourier series: axpansion, odd and even functions. Functions in several variables: continuity, differential and integral calculus, partial derivatives, Young's theorem. Local and global maxima / minima. Vector-vector functions, their derivatives, Jacobi matrix. Integrals: area and volume integrals. (6 credits)

Mathematics A3

BMETE90AX09

Differential geometry of curves and surfaces. Tangent and normal vector, curvature. Length of curves. Tangent plane, surface measure. Scalar and vector fields. Differentiation of vector fields, divergence and curl. Line and surface integrals. Potential theory. Conservative fields, potential. Independence of line integrals of the path. Theorems of Gauss and Stokes, the Green formulae. Examples and applications. Complex functions. Elementary functions, limit and continuity. Differentiation of complex functions, Cauchy-Riemann equations, harmonic functions. Complex line integrals. The fundamental theorem of function theory. Regular functions, independence of line integrals of the path. Cauchy's formulae, Liouville's theorem. Complex power series. Analytic functions, Taylor expansion. Classification of singularities, meromorphic functions, Laurent series. Residual calculation of selected integrals. Laplace transform. Definition and elementary rules. The Laplace transform of derivatives. Transforms of elementary functions. The inversion formula. Transfer function. Classification of differential equations. Existence and uniqueness of solutions. The homogeneous linear equation of first order. Problems leading to ordinary differential equations. Electrical networks, reduction of higher order equations and systems to first order systems.The linear equation of second order. Harmonic oscillators. Damped and forced oscillations. Variation of constants, the in-homogeneous equation. General solution via convolution, the method of Laplace transform. Nonlinear differential equations. Autonomous equations, separation of variables. Nonlinear vibrations, solution by expansion. Numerical solution. Linear differential equations. Solving linear systems with constant coefficients in the case of different eigenvalues. The inhomogeneous problem, Laplace transform. Stability. (4 credits)

Mathematics A4

BMETE90AX51

Notion of probability. Conditional probability. Independence of events. Discrete random variables and their distributions (discrete uniform distribution, classical problems, combinatorial methods, indicator distribution, binomial distribution, sampling with/without replacement, hypergeometrical distribution, Poisson distribution as limit of binomial distributions, geometric distribution as model of a discrete memoryless waiting time). Continuous random variables and their distributions (uniform distribution on an interval, exponential distribution as model of a continuous memoryless waiting time, standard normal distribution). Parameters of distributions (expected value, median, mode, moments, variance, standard deviation). Two-dimensional distributions. Conditional distributions, independent random variables. Covariance, correlation coefficient. Regression. Transformations of distributions. One- and two-dimensional normal distributions. Laws of large numbers, DeMoivre-Laplace limit theorem, central limit theorem. Some statistical notions. Computer simulation, applications. (4 credits)

Physics 1

BMETE11AX21

Mechanics: Measurements, units, models in physics. Space, time, different frames of references. Motion of a particle in 3D. Newton's laws. Work, kinetic energy, potential energy. Work-energy theorem. Conservation laws in mechanics. Motion in accelerated frames, inertial forces. Newton's law of gravitation. Basics of the theory of special relativity. System of particles, conservation laws. Kinematics and dynamics of a rigid body. Oscillatory motion, resonance. Wave propagation, wave equation, dispersion, the Doppler effect. Thermodynamics: Heat and temperature. Heat propagation. Kinetic theory of gases. Laws of thermodynamics. Reversible and irreversible processes, phase transitions. Entropy, microscopic interpretation of entropy. Elements of statistical physics. Static electric and magnetic fields: Electric charge. Electric field, electric flux, electric potential. Basic equations of electrostatics. Applications of Gauss's law. Capacitors, energy of the static electric field. Dielectrics, boundary conditions. Electric current. Magnetic field. Current carrying wire in magnetic field. Magnetic field produced by an electric current, the Biot-Savart law. (4 credits)

Physics 2

BMETE11AX22

Elektrodynamics: Faraday's law. Self induction, mutual induction. Magnetic properties of materials. Magnetic data storage. Maxwell equations. Generation, propagation and reflection of electromagnetic waves. Basics of geometrical optics. Wave optics, interference, diffraction. Polarized light. Basics of atomic Physics: Natural and coherent light sources. Physical foundations of optical communication. Matter waves of de Broglie. The Schrödinger equation. The electron structure of atoms. Electron spin. Free-electron theory of metals. Band structure of solids. Superconduction.

Quantum-mechanical phenomena in modern electronics. Basics of nuclear physics. Nuclear reactors. Elementary particles. Curiosities in cosmology. Fundamentals of the physics of the atomic kernel, elementary particles, selected topics in cosmology. (4 credits)

Foundation of Computer Science

BMEVISZAA05

The objective of the subject is to provide the students with the required theoretical background in combinatorics, algorithmics, elementary cryptography, and graph theory for further studies in electrical engineering. Within the subject the students learn about the basic concepts of combinatorics and of graph theory (trees, planar graphs, Euler circuits and Hamilton cycles, colorings of graphs, matchings and some basic algorithms like BFS, shortest path algorithms, maximal flow algorithm, DFS and the PERT method. We also discuss the basic concepts of complexity theory, NP completeness as well as fundamentals of number theory, leading to the concept of public key cryptography and RSA encoding. (5 credits)

Informatics 1

BMEVIIIAB08

This course (as a continuation of Digital Design 1 and 2) provides the students with comprehensive knowledge related to the architecture and functioning principles of modern computers and their operating systems. The basic principles and the evolution of most hardware and software concepts used in today's computer systems are presented through case studies of existing systems and through quantitative example problems. tudents successfully satisfying the course requirements will be able to understand the documentation and the functioning of modern computers and operating systems. They will also be able to easily learn the installation, configuration and maintenance tasks of such systems. (4 credits)

Informatics 2

BMEVIAUAB01

Computer networks: Basic concepts, network topologies, network structures, network architectures (OSI and TCP/IP models). Communication channel. Error-correction and error-control coding. End-to-end connection. Connection-based and connection lost data transmission. Services. IEEE 802.3 and Ethernet. TCP/IP protocol. Database design: Basic concepts. Architecture of a database management system. Logical databases. Relational data model. Key, functional dependencies, normal forms, relational algebra. Physical databases, indexing techniques. Logical planning of relational databases. The SQL language. Formal languages: Basic concepts, languages, automata, Chomsky hierarchy. Finite state machines and regular languages. Context-free and LL(k) languages. Compilers. (5 credits)

Electronics Technology and Materials

BMEVIETAB00

The primarily objective of the course is to provide the students with knowledge and practical skills related to circuit modules and systems. The course provides a comprehensive overview of microelectronic devices, components, mechatronic, optoelectronic and other modules and about the structure of electronic equipments including their manufacturing, maintenance and assembly technologies. (6 credits)

Basics of Programming 1

BMEVIHIAA01

The main objective of the course is to provide students with appropriate skills in computerized problem-solving and basic use of tools that can be effectively applied during their further studies. A further goal of the course is to teach writing portable programs. Learning a high-level programming language the C language allows students to reach these goals in practice. The classroom practice follows the syllabus of lectures; helps better understand the topics of the lecture through detailed examination of the algorithms. (7 credits)

Basics of Programming 2

BMEVIAUAA01

This course, as a basic BSc course based on the previous term, continues the exposition of methods and tools of computational problems. The main goal is an introduction of object-oriented programming. Based on the C programming language skills, the object-oriented techniques are introduced with the help of C++ programming language. The curriculum of computer laboratories continuously follows the lectures. (6 credits)

Digital Design 1

BMEVIIIAA04

The course (together with the course entitled Digital Design 2) provides the students with all system level hardware knowledge required to the logical level design of digital equipment. The theoretical background is also widened through the solution of design problems during the classroom practices. Obtained skills and expertise: The knowledge acquired in the framework of the course (together with the course entitled Digital Design 2) allows students to solve any logical design problems they may encounter in electrical engineering. (6 credits)

Digital Design 2

BMEVIIIAA02

The course (together with the course entitled Digital Design 1) provides the students with all system level hardware knowledge required to the logical level design of digital equipment. The theoretical background is also widened through the solution of design problems during the classroom practices. Obtained skills and expertise: The knowledge acquired in the framework of the course (together with the course entitled Digital Design 1) allows students to solve any logical design problems they may encounter in electrical engineering. (5 credits)

Signals and Systems 1

BMEVIHVAA00

The objective of this class is to introduce the basic concepts of signal and system, and to provide computational methodologies applicable to continuous systems. It presents the time domain and the sinusoidal steady state analysis. The practical examples refer to continuous systems represented by Kirchoff type electric circuits. The principles to formulate the models and the methods to solve the resulting equations are discussed. The students fulfilling the requirements of this class will be able to apply the methodologies of system and network analysis in the time domain and in the frequency domain in case of sinusoidal excitation
(6 credits)

Signals and Systems 2

BMEVIHVAB01

The course is a follow-up of Signals and Systems I. It provides the foundations of analysis methods for continuous time systems in the frequency and complex frequency domains. Furthermore, it presents various system description methods and establishes the connections between these representations. It also deals with analysis methods of discrete time signals and systems both in time, frequency and z domains. The link between continuous and discrete systems is presented by dealing with discrete approximation of continuous time systems, and the basics of signal sampling and reconstruction are shown. The last part introduces analysis techniques for continuous time nonlinear circuits and systems. (6 credits)

Electrotechnics

BMEVIVEAB00

Basic things about Electritechnics. Practical circuit calculation methods: Definition of the active, reactive power in single phase and 3-phase systems. Calculations with instantaneous values and phasors. Positive directions. Definition of the power sign. Y-D conversion. Nominal values. Per-unit system. Practical calculation methods of energy converters. Calculation methods of magnetic circuits. Symmetrical components method. Three-phase vectors. Transformers. Magnetic materials. Hysteresis and eddy-current losses. Induced voltage. Excitation balance law. Equivalent circuit and its parameters. Phasor diagram. No-load and short-circuit. Definition of the DROP. 3-phase transformers, connections, phase-shift, parallel connection. Magnetic field of the electromechanical energy converters. Magnetic fields of the electrical machines. Generation of the rotating field. Torque development. Frequency condition. Operation principles of the basic electromechanical energy converters. 3-phase synchronous machine. Condition of the steady-state torque. Synchronous speed. Equivalent circuit. Pole-voltage, armature voltage, synchronous reactance. 3-phase induction machine. Condition of the steady-state torque. Slip-ring and squirrel-cage rotor. The slip. Equivalent circuit. The DC machine. The commutation. Power electronics, electrical drives. Electrical drives: starting, braking, speed modification. Electrotechnical environment protection. Electromagnetic compatibility (EMC). Low and high frequency effects. Electrostatic discharge. Electromagnetic impulses. Electrical safety regulations. Basics, methods, limits, measurements. Electrical energy storage. Chemical, electrical, magnetic, mechanical energy storage. Fuel-cells. Electrotechnical applications, trends. Requirements of sustainable development. Application of alternative energy sources. Alternative electrical vehicles. New materials and technologies. Superconductivity. (5 credits)

Introduction to Electromagnetic Fields

BMEVIHVAC03

The course teaches the fundamentals of classical electrodynamics in an engineering approach. Besides the main principles, the most important fields of engineering applications as well as some analysis methods are discussed. The lectures are complemented with classroom practices. Topics covered: Part I. Fundamental laws: measurable quantities, scalar and vector fields, Maxwell's equations, fields in materials, interface conditions, Poynting's theorem, forces, classification. Part II. Static fields: scalar electric potential, Laplace-Poisson-equation, electrodes, capacitance, electric dipole, method of images, finite difference method; current flow problems, grounding, step voltage; static magnetic fields, Biot-Savart law, self and mutual inductance, induction phenomena. Part III. Transmission lines: telegraph equations, Helmholtz-equation, specific loads, matching, standing wave ration, two-port equivalent. Part IV. Wave phenomena: wave equation, plane waves, transmission line analogy, reflection and refraction, polarised waves, waves in dielectrics and conductors, skin effect, elementary electric dipole antenna, rectangular waveguides. (4 credits)

Electronics 1

BMEVIHIAB02

Virtually every electronic equipment used today is constructed on the basis of high complexity circuits. All electrical engineers must know the construction and functioning principles of such devices. In order to understand the behavior of complex systems, the elementary design principles and dimensioning procedures should be presented which is the objective of this course. Obtained skills and expertise: The students get acquainted with the definitions and management of the parameters of electrical components and will understand the calculations of the properties of electronic circuits built up of such components. The skills obtained in the framework of this course (together with the course entitled Electronics 2) empowers students with the necessary expertise to understand the courses of the related study specialization blocks. (5 credits)

Electronics 2

BMEVIAUAC05

The goal of the course is to lay down the basis of the aspects of more complex electronic systems, including their functions, their operation and their structure. This formed basis can be built upon by later specialization courses. The course discusses two main areas of electronics: power electronics and signal level electronics.

During the discussion of power electronics, the design and usage of basic power semiconductors (PN junction, diode, BJT, Darlington, MOSFET, SCR, GTO, IGBT) are covered. Diodes and thyristors in rectifiers, grid commutation based converters and AC choppers are also covered. The material includes basic DC-DC converter topologies (buck, boost, buck-boost) and single phase inverters as well.

The second part of the course provides a brief introduction into several topics of signal level electronics, including nonlinear circuits, phase locked loops (containing voltage controlled oscillators, phase detectors, analog PI controllers), passive and active filters, and analog modulation techniques. (5 credits)

Measurement Technology

BMEVIMIAB01

The aim of the subject is to give insight into metrology, measurement theory, measurement technology and instrumentation. Besides the theoretical aspects, the course also prepares students for laboratory practices. Model building and problem solving skills of the students are developed. The subject focuses on the measurement of electrical quantities but also emphasizes the analogies with non-electrical problems. (5 credits)

Laboratory 1

BMEVIMIAC12

The primary aim of this laboratory course is to improve the skills of the students in the following areas: to get acquainted with the materials, components and instruments in the area of electrical engineering and to practice the designing of measurement setups, setting up the measurement, measuring and using the infrastructure of the laboratory; furthermore, to practice the evaluation and documentation of the measurement results. By the end of the course, the students acquire practical competence and skills at the selected fields of electrical engineering, and become experienced with up-to-date measurement equipment. (4 credits)

Laboratory 2

BMEVIMIAC13

This subject is based on the "Laboratory 1" subject and enables the students to gain deeper knowledge more experience along to further improving their skills in the following areas: the materials, components and instruments in the area of electrical engineering; the designing of measurement setups, setting up the measurement, measuring and using the infrastructure of the laboratory; and to evaluate and document the measurement results. These practical competences and skills in the selected fields of electrical engineering are acquired by using up-to-date measurement equipment. (4 credits)

Space Technology

BMEVIHVC05

This subject is an overview of engineering, design, construction, testing and operation of electronic systems for space. Nevertheless, this knowledge is well applicable also in design of high reliability terrestrial equipments that are operating under extreme environmental conditions. System concepts of big space structures like satellites and probes and the problems of smaller units are also discussed. The theory and practice of space communications, the design and parts selection for high reliability electronics, the effects of interplanetary space and radiation, the mechanical construction problems and space related analogue and digital electronics are also highlighted. The lectures are extended with practice to deepen the knowledge and resolve practical problems. (4 credits)

Embedded and Ambient Systems

BMEVIMIAC06

The aim of the subject is to develop the ability to select components of embedded systems, to design the system and to integrate the components. This includes selection of communication interfaces and protocols, design of information processing algorithms and software structure. The subject presents the principal building blocks of embedded systems, their main requirements and properties. These topics cover (but are not limited to) analog signal processing and signal conditioning, operation and features of processing units (DSP), digital signal processing, basic software architectures and their analyses, signal converters (AD/DA) and the popular communication systems used in embedded systems. (4 credits)

Power Engineering

BMEVIVEAB01

The aim of the course is to lecture basic knowledge of power systems, which are necessary for all electrical engineers, and are also a foundation for students taking power system engineering major. Introduction of the structure and operation of power systems, organised along the operation principles of elements and subsystems of the network. Representation of power systems, basic methods of examination of symmetrical operation. Detailing of the most important questions of asymmetrical operation from the aspect of distribution and consumer networks. Requirements of power quality and security of supply. Health effects and EMC aspects of electric and magnetic fields of the power system. Overview on the paradigm shift of different fields of power system engineering (production, transmission, service, environmental effects), the smart grid concept and other actual trends. (5 credits)

Electric Power Transmission

BMEVIVEAC00

The course is intended to provide theoretical knowledge and practical skills in the following fields: structure of the power system, network transformations, process of power transmission and distribution, network elements used for transmission and distribution tasks, interpretation and determination of parameters of transmission network elements used for calculations, representation of the elements, power line and transformer operations, power and voltage conditions of steady state operation, power losses, application of symmetrical components, fundamental effects of short-circuits and switches, calculation, principles of star point earthing, related phemomena, Substation and busbar topologies. (4 credits)

Electrical Machines and Applications

BMEVIVEAC01

Transformers: Single-phase and 3-phase transformers. Steady-state and transient operation. Unbalanced load of the 3-phase transformers. Windings of the rotation machines, torque development: Concentrated and distributed winding (slots). The induced voltage, the developed air-gap filed, the stray field. Force and torque development and calculation. Induction machines: Equivalent circuit and torque development. Deep-slot and double-slot rotors. Effect of the spatial harmonics. Asymmetric operation, stator and rotor asymmetry. Single-phase and auxiliary-phase machines. Synchronous machines: Cylindrical rotor case: Equivalent circuit and torque development. Motor and generator operation. Stability. Effect of the salient-pole. Reluctance machines. Permanent-magnet machines. DC machines: Armature windings. The role of the auxiliary and compensating windings. Separate, parallel and mixed excitation, characteristics. Modern calculation methods: Finite element method (FEM). Poisson equation. Lagrange interpolation polynom. Dirichlet and Neumann conditions. Simple 2D promlem. Presentation of the QuickField, Flux2D and Motorpro, MotorCad software. Applications of electrical machines: Electrical machines in consumer electronics. Electrical machines in vehicles. Magnetically levitated trains. Superconducting generators and motors. Servo motors. Kinetics of electrical drives: Reduction of torques and masses to common shaft. Motion equation of the electrical drives. Stability criterion of drives. Definition of time constants. Design of electrical drive: Protection levels. Operation condition of electrical motors. Selection of electrical motors. Applications of electrical drives: Speed modification and braking methods of DC urban electrical vehicles. Voltage source inverter-fed induction machine driven trolley-bus. Semiconductor-based DC drive driven trains. Inverter-fed trains. Wind generators. (4 credits)

Control of Electric Drives

BMEVIVEAC04

Drive specific and task specific drive controls. Subordinated control structure. Transient equations and block schemes of DC machines. Line-commutated converter-fed DC drives: block schemes for continuous and discontinuous conduction, circulating current and non-circulating current control for quadrant and 2/4 quadrant operation. Adaptive current control. Control in field-weakening. 4/4 quadrant DC chopper-fed DC drive with hysteresis and PWM modulator based current control. Park-vector transient equations of the 3-phase synchronous and induction machines in natural and arbitrary coordinate systems. Equivalent circuits for fluxes and voltages. Torque expressions wit Park-vectors. Properties of the field-oriented controlled cage rotor induction machine with voltage-source and current-source supply. Dynamic and energy-saving operation. Direct and indirect rotor flux control. Machine models to provide the rotor flux and speed. Voltage source inverter-fed (VSI) cage rotor induction machine with field oriented control: hysteresis and PWM modulator based control. VSI type grid-side converter: grid-oriented current vector control. Current source inverter-fed induction motor drive: field oriented control in traditional and PWM operation. Permanent magnet sinusoidal field synchronous machine drive: normal and field-weakening operation. VSI-fed hysteresis and PWM modulator based current vector control. Subordinated speed and position control. Selection of control types, their optimal design. Practical applications of controlled drives: flywheel energy storage drive, electrical drives of vehicles, wind turbines, starting of gas-turbine-synchronous generator set. Calculation practices: Optimal controller setting. Per-unit systems. (4 credits)

Microelectronics

BMEVIEEAB00

The basic goal of the course is to deepen the already acquired knowledge in the field of digital electronics through presenting the latest implementation techniques of digital integrated circuits. Further goals of the subject are to provide information on the basics of analogue integrated circuits, components of power electronics and solid-state lightning. Today's electronics and IT devices are all based on different special discrete semiconductors and complex integrated circuits. Solid knowledge regarding the structure, operation and manufacturing of these devices is among the necessary skills of today's electrical engineers including basics of IC design at least on the level which allows effective communication with IC design specialists. They have to know how system level design connects with the IC design as well. Special emphasis is put on the corresponding practical skills through simple case studies (calculation examples) as well as computer laboratory practices where the students get acquainted with the basic steps IC design. An important aspect of the course is to bridge the gap between the operation of abstract electronics components and the physical reality: the major components used in ICs (diodes, transistors, etc.) are discussed in detail. A detour is made towards the MEMS and MOEMS, where electrical operation is combined with mechanical and optical effects. (5 credits)

Microcontroller Based Systems

BMEVIAUAC06

The course describes the most widespread microcontroller architectures and gives guidance for their selection for the given application. The course provides competences to design and implement the hardware components of microcontroller based systems and to implement the associated low level software system. Design phases are demonstrated by case studies. (4 credits)

Embedded Operating Systems and Client Apps.

BMEVIAUAC07

The students will be able to understand and make use of the basic concepts of embedded operating systems. The objective of the course is to present platforms, techniques and tools which are required to create and run both application and system level software for embedded systems. After creating the hardware unit and embedded programs for it, the next natural step is the implementation of a desktop or web application that enables monitoring and parameterizing the hardware unit from a standard PC. Mobile applications are becoming more widely used as well. The course presents the programming of desktop and web based client applications, focusing on user interfaces, graphics drawing tools, multithreaded and network programming. Most modern development platforms follow object-oriented concepts. Consequently, the course provides introduction to object-oriented design, basic UML and a few architectural and design patterns.
Students will be able to develop desktop and thin client applications to access hardware units from PCs, and to create user friendly user interfaces for different client types. Network programming also gets an important role. The topics covered are illustrated by case studies and demo applications. (4 credits)

Network Technologies and Applications

BMEVITMAC05

The goal of this course is on one hand to present the basic principles of the currently used and emerging wired access network technologies, focusing mostly on the data link layer. On the other hand it aims to present the principles of network layer communication both in wired and wireless environments, focusing on routing algorithms in fixed and ad hoc networks, IP multicast technologies as well as mobility handling over IP networks. Then, the course presents different architectures of networking applications, the client-server and the peer-to-peer communication model, and the principles of cloud communications. Finally, the course presents some application scenarios, and touches briefly emerging topics such as the Future Internet and the Internet of Things. (4 credits)

Control Engineering

BMEVIIIAB05

The control of technological, economical, and environmental processes belongs to the electrical engineers' most important professional activities that require both abstract and applied knowledge and competences. Besides its contribution to form an engineering approach of problem solving, the course teaches the fundamentals of control engineering, the main principles of analysis and synthesis of control loops, and the use of the related computational tools. Students successfully satisfying the course requirements are prepared to analyze discrete and continuous time control loops, to design different types of compensators and to later engage courses in more advanced fields in control theory such as optimal control and identification of dynamical systems. Lectures are complemented with classroom and computer laboratory practices. (4 credits)

Description of BSc Courses in Computer Engineering

Calculus 1 for Informaticians

BMETE90AX21

Real sequences. Special limits, number e. Operations on convergent sequences. Monotonic and bounded sequences. Continuity and differentiability of real functions of a single variable. Elementary functions and their inverses, properties of differentiable functions, mean value theorems, L'Hospital rule, sketching graphs, parametric and polar curves. Integral of functions of a single variable. Methods of integration, the fundamental theorem of calculus (Newton-Leibniz formula), applications, improper integrals. (6 credits)

Calculus 2 for Informaticians

BMETE90AX22

Differential equations: Separable d.e., first order linear d.e., higher order linear d.e. of constant coefficients. Series: Tests for convergence of numerical series, power series, Taylor series.
Functions of several variables: Limits, continuity. Differentiability, directional derivatives, chain rule. Higher partial derivatives and higher differentials. Extreme value problems. Calculation of double and triple integrals. Transformations of integrals, Jacobi matrix.
Analysis of complex functions: Continuity, regularity, Cauchy - Riemann partial differential equations. Elementary functions of complex variable, computation of their values. Complex contour integral. Cauchy - Goursat basic theorem of integrals and its consequences. Integral representation of regular functions and their higher derivatives (Cauchy integral formulae). (6 credits)

Probability Theory

BMEVISZAB02

The objective of the subject is to learn the basics of stochastic modeling. Within the subject the students learn about the basic concepts of probability and random variables. They get acquainted with various discrete and continuous distributions. Students also learn the notion of expected value and higher moments. The course concludes with theorems of large numbers, the notion of regression and correlation. (5 credits)

Introduction to the Theory of Computing 1

BMEVISZAA03

The objective of the subject is to acquire the fundamental mathematical knowledge (in the area of linear algebra and number theory) necessary for software engineering studies. Within the subject the students learn about coordinate geometry in the space, the vector space Rn and its various properties, solving systems of linear equations with the Gaussian elimination, determinants and basic properties of linear mappings as well as fundamentals of number theory, leading to the concept of public key cryptography and RSA encoding. (~490) (5 credits)

Introduction to the Theory of Computing 2

BMEVISZAA04

The objective of the subject is to acquire the fundamental mathematical knowledge (in the area of graph theory) necessary for software engineering studies. Within the subject the students learn about the basic notions of graph theory, trees, planar graphs, Euler circuits and Hamilton cycles, vertex- and edge colorings of graphs, matchings and higher connectivity as well as some basic algorithms like BFS, shortest path algorithms, Kruskal's algorithm, maximal flow algorithm, DFS and the PERT method. (5 credits)

Coding Technology

BMEVIHIAB00

Clear understanding of the basic principles, notions, models, techniques in the field of data compression coding, error control coding, and cryptography security encoding, supported by solving a lot of numerical problems.
Obtained skills and expertise: Ability to apply basic techniques in communication technologies and solve standard design problems. (4 credits)

Theory of Algorithms

BMEVISZAB03

The objective of the subject is to learn the basic methods and skills in the design and analysis of algorithms and to study the most important models of computations. Within the subject the students learn about the basic types of automata (finite, pushdown and Turing machine, all deterministic and nondeterministic) and their relationship to formal languages. They get acquainted with the basic complexity classes. Further algorithmic tools include linear and integer programming, dynamical programming, and sorting and searching techniques. (5 credits)

Physics 1i

BMETE11AX23

kinematics, work and energy, potential energy, linear momentum and collisions, rotation of a rigid object about a fixed axis, angular momentum, kepler's laws of planetary motion, static equilibrium, accelerating frames, oscillatory motion, waves, special relativity, kinematics, special relativity, dynamics, temperature, heat and the 1st law of thermodynamics, the kinetic theory of gases, heat engines, entropy and the 2nd law of thermodynamics. (4 credits)

Physics 2i

BMETE11AX24

electric fields, electric potential, capacitance and dielectrics, current and resistance, direct current circuits, magnetic fields. sources of the magnetic field, faraday's law, inductance, light and optics, interference of light waves, diffraction and polarization, lasers and holography, introduction to quantum physics, quantum mechanics. (4 credits)

System Theory

BMEVIHVAB00

The main objective of the class is to introduce the basic concepts of signal and system theory, mathematical methods. It will be introduced the linear, time invariant system alalysis for time continuous and discrete cases. The analysis methods are introduced in time, frequency and complexe frequency domain. Examples for signal processing, telecommunications and also for business processes are discussed. The students fulfilling the requirements of this class will be able to apply the methodologies of system analysis and the basic elements of process control. (4 credits)

Technology of IT devices

BMEVIEEAC00

The goal of the subject is to present the students the operation of the most important hardware elements of IT devices, the fundamentals of electronics and its manufacturing technology. It is presented what opportunities modern microelectronics assures to computation, what are the physical limits and the trends of development. At the laboratory practices the students experience themselves that hardware and software development occurs with the help of similar methods and tools. (4 credits)

Digital Design

BMEVIMIAA02

Digital technology is an important core subject in the curriculum of the Engineering Information Technology. The most important objective of the course is to present the process of engineering and system-oriented approach of problems, and to acquire basic practical skills to for good problem solving. The following topics are discussed: computing systems, the basic elements of the operation of logic circuits, the digital abstraction of the simple tasks and the direct hardware or low-level software implementations of them. The course starts with the introduction of the binary arithmetic, the operations done by basic digital functional units and controllers, and ends by the presentation of the general-purpose microcontroller architectures and its design and applications. Lectures are completed with classroom and laboratory exercises, where the focus is on the mastering of modern computer design methods and on the direct design/development experience. (6 credits)

System Modelling

BMEVIMIAA00

The course overviews the design process of IT systems in a model based approach. The goal of this course is to provide solid understanding on the basic modeling tasks and tools, which are important prerequisite for other courses including application specific modeling. (e.g.) Additionally, the course provides opportunity to experiment with conceptually straightforward and easy to learn tools, which can be used for simple application logic development. The participants of the course will learn the basic concepts and modeling aspects of high level, graphical tool supported, process centric modeling, verification, performance analysis and service quality assurance. The course builds on learning experience at digital technology course and you can build competence in systematic system design process. Participants will also gain experience in the process of implementing IT system through the steps of modelling exercises. Finally, they get an overview of simulation based system analysis and visual data analysis of measurement results. The didactical goal of the course is to improve the abstraction skill of the participants and lay the foundations of the upcoming courses on conceptual and motivational level. (4 credits)

Computer Architectures

BMEVIHIAA02

The course objective is to present the basic notions of computer architectures and the related application and design methods such that the student can formally solve fundamental software and hardware problems.
Obtained skills and expertise: Understand and solve computer architecture related hardware and software problems. (4 credits)

Communication Networks 1

BMEVIHIAB01

The course objective is to present the fundamental principles of the construction, architecture and protocols of computer network.
Obtained skills and expertise: Understanding the operating principles, architecture and protocols in computer networks as a basis for later specialized studies. (4 credits)

Communication Networks 2

BMEVITMAB01

The aim of this course is to provide both theoretical and practical knowledge about communication networks, and about telecommunication networks in particular. The course starts from the classical wireline telephony networks, including the speech digitalization, and the architecture of telephony exchanges. The next major part is wired IP access networks, including digital subscriber loops (especially ADSL and its variants), cable television-based Internet access, and optical access networks with the focus on GPON systems. Triple-play services, including IP television and Voice over IP (VoIP), are certainly part of this subject, including an introduction to speech codecs. A whole range of mobile cellphone networks are also covered from GSM to LTE. Introduction to backbone transport network technologies (including MPLS and its extensions, optical wavelength- and waveband switching) concludes the course. (4 credits)

Operating Systems

BMEVIMIAB00

The subject introduces students to the functions, internal operation, and types of operating systems, and in addition, to the programming model of concurrent, distributed systems. It also demonstrates these concepts using examples, including the task of operating system selection. The lectures and the laboratories, which are inherent part of the subject, concentrate on the relationship of the hardware and the operating system, making it possible for students to use operating systems in practical applications. (5 credits)

Basics of Programming 1

BMEVIEEAA00

The main objective of this course is to provide students with appropriate skills in computer-based problem solving and basic use of program development tools. These skills are to be effectively applied during further studies. The C language is selected as working language to illustrate how portable programs can be developed and to allow students to gain practice in actual coding. The classroom practice follows the syllabus of lectures; helps better understand the topics of the lecture through detailed examination of the algorithms. The classes are completed with a long-term individual homework assignment to help improve the students' skills. (7 credits)

Basics of Programming 2

BMEVIIIAA03

This semester focuses on leading the students to a deeper understanding of C language, and a special emphasis is also put on the steps of solving very complex programming tasks using an object-oriented approach. The latter is achieved via learning the C++ language, assuming a reliable knowledge of C. The practice classes follow the topics of the lectures and discuss further details of the object-oriented concept and the language elements. First the students learn how the C++ language derives from C. Inline macros, prototypes, default arguments and function overloading are explained. Dynamic memory allocation process of C++, reference type, visibility and scope of data are discussed. Next the object-oriented concept is introduced via the C++ language. The principles and concepts behind the object oriented programming paradigm are shown with the corresponding C++ syntax. Topics include classes, encapsulation, protection; member functions, constructor/destructor, friend mechanism; operator overloading; inheritance, virtual functions; generic classes. Last the students are introduced to essential operating system functions and to development and documenting tools. (6 credits)

Basics of Programming 3

BMEVIIIAB00

The course, as a continuation of Basics of Programming 1 and 2, aims at further enhancing skills in object-oriented techniques and algorithmic solutions. The course introduces Java syntax and the basic Java class libraries, like IO, utilities, generics, collections. Special topics, like thread handling with synchronization and signaling, GUI concepts and implementation using Swing, unit testing with JUnit, XML handling in SAX and JDOM, and logging via log4j are also covered. The connections between UML and OO implementations, especially in C++ and Java are introduced. The course relies on skills and knowledge of C and C++, that are mandatory for successfully finishing the semester. (5 credits)

Databases

BMEVITMAB04

Data, information, knowledge. Structured, non-structured and semistructured data. Database management systems, components, operation. Data Definition Language, Data Manipulation Language, Host language. Layered model of DBMS, principle of data independence. Data models, data modelling. Entity-relationship model/diagram, attributes, relationship-types, constraints, specialization, weak entity sets. Relational data model, relational algebra. Design of relational schemes from E/R diagram. Tuple relational calculus, domain relational calculus, safe expressions. Functional dependencies, determinant, key, superkey, candidate key. Armstrong axioms, soundness and completeness. Normal forms of 0NF, 1NF, 2NF, 3NF, BCNF. Closure of dependency sets, closure of attribute sets. Decomposition of relational schemes. Lossless and dependency preserving decompositions. Decomposition in a given normal form. Fundamentals of transaction management. (5 credits)

Software Engineering

BMEVIIIAB01

The aim of the course is to examine the overall process of software development, including the analysis and design of information systems and the project management issues. On completion of this course students will be able to understand the economic and managerial implications of software projects, have a global view and understanding of the software development, describe the static and dynamic aspects of a real-world system using appropriate modelling techniques, advise on the selection of an appropriate software architecture for a problem, describe the concepts underlying object orientation, use and create UML models, demonstrate the quality of software products created at different stages of the lifecycle. (4 credits)

Software Techniques

BMEVIAUAB00

The objective of the course is to present up-to-date techniques used in object oriented and event-based software development. The concepts, the structures and the programming of GUI (graphical user interface) and RAD (Rapid Application Development) are presented together with the most important features of modern supervised execution environments and class libraries (reflection techniques, data binding, displaying figures and text, parallel computing basics with related synchronization techniques, etc.). The widely used architectural and design patterns for software development are also covered.
Students satisfying the course requirements will be able to develop software on the most widely used platforms with up-to-date tools and technology, having design patterns incorporated. (5 credits)

Software Project Laboratory

BMEVIIIAB06

The aim of the course is gaining first-hand experience of working in software projects. The goal is to create an object oriented application with full UML (Unified Modeling Language) description, Java implementation, according to RUP (Rational Unified Process) concepts. The students are working on the project in groups of 3 or 4 that are formed by the supervisor. The students are preparing the documentations and program of the game according to the predefined schedule specified at first week. Documentations must be submitted in a predefined format, usually printed. Good understanding of Java and UML are required for successfully finishing the course. (3 credits)

Web and Mobile Software

BMEVIAUAC00

During the course, students get an overview of the latest model platforms and its capabilities. The course teaches the student to be able to choose the most suitable tool and platform for solving a given problem and give the knowledge to estimate the complexity of a project. Furthermore, the method of developing small application for Java Me platform is presented, as well as the basics of Android platform and usage of the Android emulator. The course also presents the method of quick prototype- development method in Python environment. The following techniques will be described: application structure, basic UI, development compiling and installing.
Besides the mobile platform, modern client based web technologies are also presented with the method of developing web applications for devices with small screen and using development tools for multiplatform. (5 credits)

Computer Graphics

BMEVIIIAB07

Fundamental concepts: tasks of the computer graphics and image processing, synthetic camera, image synthesis. Graphical hardware. Analytical geometry: vectors, coordinate frames, points. Implementation of operations on vectors. The equation of lines and planes. Geometrical modeling, Lagrange interpolation, Bezier approximation, B-Splines, NOBS and NORBS. Areas, quadratic and parametric surfaces, polygon modeling, body models. Colors: the light as electromagnetic wave, the model of color perception, color fitting, color systems. Geometric transformation. Virtual world models: hierarchical model, VRML, color space graphs. 2D image synthesis: vectorization. Modeling transformation, view transformation. Split of sections and area. 2D graphical systems: OpenGL, GLUT, color tactics, link with the windowing environment, open of the graphical window, registration of callback functions. Fundamental optical model for 3D image synthesis: flux, radiance, BRDF, shading equation. Recursive ray tracing: intersection calculation and its acceleration. Incremental 3D image synthesis. OpenGL and graphical hardware, OpenGL primitives, transformations, shading, light sources. Textures in OpenGL, control of the OpenGL pipeline. The architecture of the graphical hardware and its direct programming. Cg language, GPUGPU, CUDA. Computer animation: definition of motion, Spline, key-frame, path, physical and motion capture based animation. Forward and inverse kinemtaics. Augmented reality. Computer games: virtual worlds and the architectural concepts of games. The game engine. Realistic effects: physics of the games, terrain modeling, MD2 format, artificial intelligence of the opponents. Scientific and medical visualization (CT, MRI, PET). Direct and indirect methods. (3 credits)

Artificial Intelligence

BMEVIMIAC10

The aim of the subject is a short, yet substantial presentation of the field of artificial intelligence. The principal presented topics are expressing intelligent behavior with computational models, analysis and application of the formal and heuristic methods of artificial intelligence, and methods and problems of practical implementations. The subject is intended to develop the abilities and skills of the students of informatics in the area of studying novel applications of the computing, developing effective methods to solve computational problems, understanding the technological and conceptual limits of the computer science, and intellectual understanding of the central role of the algorithm in information systems. (3 credits)

IT Security

BMEVIHIAC01

This course gives an overview of the different areas of IT security with the aim of increasing the security awareness of computer science students and shaping their attitude towards designing and using computing systems. The course prepares BSc students for security challenges that they may encounter during their professional carrier, and at the same time, it provides a basis for those student who want to comtinue their studies at MSc level. We put special emphasis on software security and the practical aspects of developing secure programs. (3 credits)

Management of Information Systems

BMEVITMAC02

The course introduces the students to the tasks of the IT System Administrators. The objective of the course is to teach the maintenance and system administration tasks of computers and networked information systems. The course provides a system level overview about the information systems and about the tasks of system administrators in a broad sense. Among many others, the students will learn basis of the Network and Desktop Management Systems, the data management (data networks, back-up and restore), the virtualization and cloud computing, the service management, the Telecommunications Management Network (TMN), the IT management-related standards, and the security issues. (4 credits)

Integration & Verification Techniques

BMEVIMIAC04

The subject aims to provide an overview of a variety of information integration systems, and introduces the development and verification techniques of such systems. We discuss the most common integration approaches of distributed data, documents and other type of resources available on the Web. The subject deals with the semantic heterogeneity and structural problems, and unveils the necessary technologies. We analyze in this framework the approaches and technologies of the Semantic Web concept. The subject continues with the discussion of the verification processes and the checking possibilities in the typical development phases. Among the several verification tasks, we focus on the static analysis of the specifications and plans for dealing with static controls, the dynamic verification of the components, and with the tests of integration. The subject ends with the overview of the system testing methods. (4 credits)

Industrial Control

BMEVIIIAC03

Industrial control systems are present in fields including packaging, water management, petrochemical processes, manufacturing lines or food and beverage processing. Although seem different, all of these applications share the requirements of accurate measurements and executing appropriate actions based on the state of the process. The first part of the course focuses on sensor technology: methods for temperature, force, pressure, flow, displacement, proximity and level sensing are presented along with transmitters and interfacing signals with control systems. Second part of the course gives a deep overview on PLCs, devices most commonly used in industrial automation systems. Beside the software architecture and programming languages, industrial field bus systems are also presented in details. (4 credits)

Description of MSc Courses

Engineering Management

BMEVITMMB03

Engineering management (EM) in the knowledge-based society. Definition, role and areas of the EM. The evolution of the EM discipline. Peculiarities, generic trends and EM of the information, communication and electronic media technologies (ICT). Managerial elements of the engineering activity. Components and principles of the managerial activity. Managerial situations, methods and tools. Strategic management. Strategy types and parts. Business strategic planning methods. Classes of competitive strategies. Implementation of strategy: success factors, progress tracing. Methods of the strategic direction and control. Complex engineering decision problems, customer-oriented and systemic approaches, solutions, procedures. Planning and allocation of resources, multi-project management. Management of organizations. Organization types in the ICT sector. Lifecycle, decision culture of organizations, change management. Managing cooperation of organizations, complex working groups. Knowledge management. Knowledge process: accumulation, internalization, adaptation, externalization. Competence. Knowledge sharing and transfer. Knowledge-based systems. Types of the intellectual property, principles of intellectual property rights. Open access software. Exploitation of the intellectual properties. Intellectual public utilities. ICT specific EM. Technology management. Technological planning, forecast, transfer, launching, change. Making technology vision, analyzing driving forces, scenarios. Technology-driven business strategies. Corporate ICT functions. Application of the ICT in shaping new business strategies, global work-flows, efficient organization structures. Innovation management. Goals of research, development and innovation. Innovation models and metrics. Management of the innovation process, quality and risks. Innovation chain: university-industry partnership, role of the government. Innovation financing. National and EU sources, grants, funds, tenders. Development projects. Technological incubators, innovation centers, start-up companies, technological consortia in the ICT sector. Product management. Goals and process of the product development. Markets of the ICT products and services. Market players, competitive environment. Market segmentation. Life-cycle of the product, and its management. Product pricing, price-sensitivity of the customers. Market-research, sale and sale-support methods. Business process management. Analyzing, planning, regulating, improving and transforming corporate business process. Criteria of the process-based management systems. Methods for developing processes. IT in the corporate value creation. Customer relationship management (CRM), operation support systems, supply chain management, business continuity management. Special business functions (e.g. billing), industry-specific systems, IT system architecture of telecommunication service providers. Regulatory environment. Sector regulation. Goals and principles of the regulation in general and in the networked and public service sectors. Competition regulation, consumer protection. Regulatory institutions and procedures, ex-ante and ex-post regulation, self-regulation, public hearing, standards. Regulation of the ICT markets. Technology and marker regulatory models in the ICT sector. Regulatory tasks for deploying the convergence of the telecommunications, information and media technology sectors. Community and national regulation of the electronic communications network and services. Framework and specific directives. Rules for the cooperation of the network operators and service providers. Regulation for managing scarce resources, frequency and identifier management. Concept for regulating information security, data protection and content. (4 credits)

Engineering Information Technology

System Optimization

BMEVISZMA02

The subject introduces some areas of operations research and combinatorial optimization. Besides covering the most relevant algorithms and methods and their limits, it also aims at giving a glimpse into some of their engineering applications. Thus the subject also covers some general algorithmic approaches like linear and integer programming and matroid theory. Furthermore, the course aims at extending and deepening the knowledge formerly provided by the Introduction to the Theory of Computing 1 and 2 and the Theory of Algorithms subjects of the BSc degree program in Software Engineering. (4 credits)

Formal Methods

BMEVIMIMA07

As the complexity of information systems and the costs of potential failures are increasing, it becomes more and more important to prove that the design of the critical system components is correct. One of the typical solutions for the challenge of provably correct design is the application of formal methods. Mathematically precise formal models allow the precise and unambiguous specification of requirements and construction of designs; formal verification allows the checking of design decisions and proof of design properties; while the verified models allow automated software synthesis. The subject provides an overview of the formal background needed for the elaboration and analysis of the formal models of IT components and systems: the modelling paradigms, the widely used formal modelling languages, and the related verification and validation techniques. The subject demonstrates the application of formal methods in the field of requirement specification, system and software design, model based verification and source code synthesis. (4 credits)

Information Theory

BMEVISZMA03

This course offers an introduction to the quantitative theory of information and its applications to reliable, efficient communication systems. Topics include mathematical definition and properties of information, source coding theorem, theoretical bounds for lossless data compression, optimal data compression methods for both known and unknown distribution of the source, the fundamentals of lossy source coding principles, channel encoding and the main types of multiple access channels. The course lays the foundation for doctoral research in the subject of mobile telecommunications. (4 credits)

Languages and Automata

BMEVISZMA04

During the course of the semester we review the basic types of automata and examine their capabilities. Examination of automata is closely related to the examination of formal languages. The objective is the description of the relations between the classic automata and formal languages. Students will learn the theoretical principles to that can be used for the preparation of a compiler. In connection with Turing machines we examine the algorithmic decidability of some theoretical and practical problems and languages. (4 credits)

Computer Engineering Applied Informatics

Software Development Methods and Paradigms

BMEVIAUMA00

The goal of this course is to teach the software development methodologies, their application possibilities and conditions, practices and tools required and preferred for the design and development of methods. Students become practiced in treating issues of common software architectures and software systems, furthermore, they will have a good knowledge related to software development methods.
The course discusses the software development methodologies, the methods and techniques supporting methodologies and development processes, furthermore, practices, architectural requirements and solutions related to software systems. (4 credits)

Distributed Systems and Domain-Specific Modeling

BMEVIAUMA01

The goal of this course is to teach component-based technologies, the usage of middleware services, distributed systems, asynchronous communication, reliability, security, scalability, distributed state handling and monitoring. Furthermore, the goal is to teach domain-specific languages and modeling techniques, model processing and using these techniques in creating software. (4 credits)

Service Oriented System Integration

BMEVIIIMA04

Service-Oriented Architecture (SOA) defines the principles of connecting distributed heterogeneous software components. Web services provide the technology for implementing these principles. Web services are built on open standards. They are based on XML, therefore, they are suitable for connecting different platforms with each other (e.g. .NET and Java). Most platforms provide simple APIs for creating web services. For example, .NET has the library called Windows Communication Foundation (WCF), while Java offers the Java API for XML-based Web Services (JAX-WS) specification. Using these APIs it is very easy to communicate between applications created in different platforms. Enterprise Service Bus (ESB) is a framework for hosting web services, and publishing legacy applications also as web services providing a unified platform for interaction between applications. Business entities can also benefit from SOA, since business processes can also be described as web services through the Business Process Execution Language (BPEL). Business processes can also be defined at a higher level using the Business Process Modeling Notation (BPMN). The goal of this subject is to explain the principles behind SOA and to give a deep understanding in the corresponding standards, APIs and technologies. (4 credits)

Business Intelligence

BMEVIAUMA02

The goal of the subject is to give a current knowledge to the students about modern data warehouse building, business intelligence system design, data transformation, reporting, charts, dashboards, data visualization, location based data processing, KPI discovery and churn and fraud detection. (4 credits)

Software and Systems Verification

BMEVIMIMA01

The objective of the course is to present the different verification techniques that can be used throughout the full software and systems development lifecycle. Nowadays such techniques are used not only in critical systems (where their usage are usually mandated by standards), but quality is a requirement for every system. After completing the course, students will have a general understanding of the whole verification process and will know which techniques are recommended for the different phases. They will be able to identify the various static verification techniques, and will be able to review specifications and designs, and to apply static analysis tools on source code. They will be able to list the different levels and methods of software testing, and to use specification and structure based test design techniques. They will know the techniques for verifying extra-functional properties (e.g. modeling and analyzing dependability) and will be able to describe the techniques for runtime verification. (4 credits)

Distributed Systems Laboratory

BMEVIAUMA03

The goal of this course is to give a practical knowledge to the materials learned during Distributed Systems and Domain-Specific Modeling and Software Development Methods and Paradigms. (4 credits)

Computer Engineering Internet Architecture and Services

Agile Network Service Development

BMEVITMMA01

The course introduces the students to the Agile development method, which is widely used in software development since it can easily react to the frequent changes. The students will be introduced to Extreme Programming (XP), different Agile methods (Scrum, Kanban). They will learn the Continuous Integration (CI) and the typical environments supporting it. The course also gives an overview about testing methodologies, Test Driven Development (TDD), Behaviour Driven Development (BDD) and Model Based Testing (MBT). During the practical classes, the students form Agile teams that develop a software product in the field of Telecommunications. (4 credits)

Cloud Networking

BMEVITMMA02

A cloud platform is a complex system, its architecture consists of many different technological building blocks, where the cloud networking has an important and emerging role. The lectures present the types of cloud computing platforms, the different service models, the applied technologies and management methods focusing mainly on the networking aspects. The networking background of cloud architectures, including network virtualization, tunneling techniques, data center network topologies and the application of Software Defined Networking in clouds are presented. The special requirements of clouds that can provide telecommunication services in the form of Network Function Virtualization are also discussed. (4 credits)

Modeling Seminar for Engineers

BMEVITMMA03

In this course the students face the main engineering challenges and design goals of infocommunication networks from local computer networks to the global Internet. We show through practical examples that how easy to use the algorithmic knowledge they already have for communication network modeling. In specific the course includes examples from the routing and control mechanisms of the Internet, topology design, traffic and bandwidth characterization of networks, some problems from software defined and virtual networks, and shows how the theoretical tools the students already have can be applied for these practical engineering problems. (4 credits)

Internet Services and Applications

BMEVITMMA04

The course will give a thorough overview of application-specific, content-centric and collaborative services, the challenges of the Internet as a service and application development platform, and its service models. The technology foundations necessary for service implementation are also covered, including service quality issues as well. Use cases from different application areas are discussed to show the process of service planning and implementations well as the method to build successful business models. An Internet architect will be able to develop efficient network services satisfying the required service quality. During the course project homework the students will gain experience in practice as well. (4 credits)

Sensor Networks and Applications

BMEVITMMA09

The "intelligence" of the so-called smart environments (smart city, smart office, smart home) is largely depends on the sensors integrated into physical objects (walls, surface of roads, etc.) or carried by the users (e.g., intelligent user devices, wearable devices). Sensors monitor the surrounding physical environment continuously, gather raw measurement data that is communicated towards the application. To do this, an efficient sensor networking environment has to be set up. The course will give a thorough overview of wireless sensor networking, from the physical devices up to the networking and application layers. Application areas that are connected to smart cities and intelligent transport systems are emphasized. (4 credits)

Intelligent Traffic Systems

BMEVITMMA10

The aim of the course is to present the technologies used and current trends in the field of intelligent transport systems. The students will learn the principles of vehicular systems, the technologies deployed in vehicles and the supporting infrastructure. They will understand how these technologies support the Smart Cities. During practical courses the students will have to understand a selected technology and the application built on it, and implement their own services using the publicly available interfaces. (4 credits)

Human-machine Interface

BMEVITMMA11

The aim of the subject is to introduce visual and speech interface technologies to students in Human Computer Interaction. The course will introduce in detail the elements of the user interface, the basic principles of software ergonomics, the evaluation methods of software from an ergonomic point of view. Parallel to introduction to the principles of theory, practical classes are also held. Students will demonstrate the comprehension of the material by solving practical problems. By the end of the course students will learn the basic principles necessary for the design, testing and evaluation of user interfaces. They could employ that knowledge during their future work career. (4 credits)

Cloud Computing

BMEVIIIMA05

The basic objective of the course is introducing the basics of the modern computing cloud systems and cloud based applications. The students learn about the virtualization techniques and software solutions, protocols, standards and interfaces, which advanced the development of cloud-based services can be used in practice. They learn about the cloud-based IT systems design, development, operation, and quality control methods and tools. The students receive comprehensive information on the most commonly used approaches, models, standards related to software quality. Students learn about the characteristics of the software product and the product manufacturing process and should be interpreted taking into account the characteristics of the cloud-based systems can. They understand the similarities and differences between ISO 9001, CMMI, SPICE and auditing structure, will be able to more software quality model is applied in an integrated manner. (4 credits)

High Performance Parallel Computing

BMEVIIIMA06

The basic objective of the course is introducing the very intensive and high-performance computing solutions which are needed of engineering and research tasks. The students will learn about the supercomputing architecture classes, the supercomputer software components and programming languages. The students get acquainted with the subject of networking solutions that use the most powerful machines (TOP500) as well. They learn about the various co-processors and storage systems. The purpose of the object is important to give a comprehensive picture of the use, programming, control and operation of these systems as well. (4 credits)

GPGPU Applications

BMEVIIIMB01

The course presents the possibility of general purpose use of the computational power of graphics boards thanks to a generalized model of their GPUs. The hardware architecture of graphical processors is presented together with the general purpose OpenCL software development environment. Algorithms suitable to massively parallel implementation are presented using practical examples. Topics studied in deatils include: operations on big amount of data, parallel primitives in the OpenCL environment, solution of a set of linear equations, physical simulation on GPU, hash based parallel algorithms, Monte Carlo methods in GPU, optimization issues of GPGPU algorithms, effective cooperation with graphical APIs, special questions of multi GPU and distributed systems. (4 credits)

Electrical Engineering

Smart City Laboratory

BMEVITMMB04

Smart City Laboratory is a part of the Smart City specialization of the Electrical Engineering MSc. course. The goal of this laboratory subject is to present some interresting and noteworthy elements from the huge set of software and hardware building blocks which support the concept of smart city. Students can learn the programming sensors and sensor networks as well as the usage of microcontrollers to control these sensors and to process data collected by them. Moreover the subject has two exercises about the construction of applications in an Augmented Reality environment and the usage of a gesture control device, respectively. (2 credits)

Physics 3

BMETE11MX33

The course covers introduction to two disciplines: Quantum Mechanics and Solid State Physics. After the semester students should be able to understand the basic principles behind these two disciplines and solve some simple problems. This will contribute to the understanding of the workings of modern electronics and nanotechnology. (4 credits)

Measurement Theory

BMEVIMIMA17

The subject discusses the theoretical background as well as the qualitative and quantitative characterization of the engineering methods used for studying the physical world around. It gives an overview of the basic methods of signal and system theory, estimation and decision theory, as well as of the most important data- and signal processing algorithms. The main goal of the subject is to show how different tasks such as complex measurement problems, modelling and information processing problems, etc. can be solved using this theoretical background. The knowledge discussed in the subject gives a general basis for solving research and development problems too. (4 credits)

Linear Algebra (Advanced Mathematics for Electrical Engineers)

BMETE90MX54

Vectors in 2- and 3-dimensions, Rn, linear combination, linear independence. Vector spaces. Solving system of linear equations by elimination. Matrices, column space, nullspace, rank, basis and dimension, the four fundamental subspaces. Matrix operations, inverse of matrices, LU-decomposition. Linear transformations, matrices of linear transformations, change of basis. Determinant as a multilinear function, as a sum of products, by cofactor expansion. Inner product, orthogonalization, QR-decomposition, least squares and data fitting. Eigenvalues, diagonalization, orthogonal diagonalization, spectral decomposition. Complex and real matrices, symmetric matrices, positive definite matrices, quadratic forms. Singular Value Decomposition and other matrix decompositions. Jordan canonical form. Applications in mathematics (derivative as a linear transformation, solving differential equations...) Applications in engineering (graphs and networks, Markov matrices, Fast Fourier Transform, data mining...) (3 credits)

Combinatorial Optimization (Advanced Mathematics for Electrical Engineers)

BMEVISZMA06

The subject introduces some areas of operations research and combinatorial optimization. Besides covering the most relevant algorithms and methods and their limits, it also aims at giving a glimpse into some of their engineering applications. Thus the subject also covers some general algorithmic approaches like linear and integer programming and matroid theory. Furthermore, the course aims at extending and deepening the knowledge formerly provided be the Foundations of Computer Science subject of the BSc degree program in Electrical Engineering. (3 credits)

Communication Theory

BMEVIHVMA07

Widespread concepts of and tasks to be solved by telecommunications can be described by a more or less unified theory, that are the objectives of the Communication Theory. Aim of this subject is to present basics of and applied approaches in this theory. Main topics dealt with are information theory, decision- and estimation theory as well as theory of digital communications including source coding, channel coding, modulations, and performance of noisy channels. In this framework students get acquainted with important concepts, methods and procedures. Application of these concepts is presented via a detailed discussion of practical examples taken from the techniques of wireless and optical communication. Lectures, exercises as well as tests are put together so to prepare students for being able to understand and apply these concepts. Thus understanding of new or novel systems is relatively easy for them; also they get the basis for following more specialized subjects in later semesters as well as in solving novel tasks during their career. (4 credits)

Electrical Engineering Embedded Systems

Artifical Intelligence Based Control

BMEVIIIMA09

The goal of the course is to introduce the state-of-the-art soft computing and artificial intelligence methods used in system modeling and control theory. The methods are introduced in the frame of nonlinear identification and control problems.

Students successfully satisfying the course requirements are prepared in system modeling and to design and implement control algorithms for complex systems. In general, they are able to contribute to the solution system optimization and decision making problems. They obtain skills to apply fuzzy systems, neural networks, genetic algorithms and swarm intelligence on technological and nontechnological areas (e.g. biology, economics). Also, they are able to take part in the development and research of information system with high demand on artificial intelligence techniques. (4 credits)

SW Technology for Embedded Systems

BMEVIMIMA09

The subject introduces the students to the modern technologies used in developing embedded software for better software quality. The introduction is both theoretical and practical. The subject shows why modern embedded software systems are complex, it lists the consequences of complexity and details how we handle complexity in this context, and how we define and increase software quality. The subject then iterate through the modern solutions available to keep control over the software development process, and how we can increase software quality. These modern solutions are introduced, and its properties are investigated using both a theoretical and a practical approach by programming examples. (4 credits)

Computer Vision Systems

BMEVIIIMA07

Aim of this course is to transfer knowledge about most important techniques of computer vision. This includes simple methods for daily use and more complex ones as well. Theory and Practice are kept in balance. The areas and methods covered by this course are not complete. Our aim is to help the students to be able to understand the alternatives of the discussed methods to the extent necessary for choosing among them in the perspective of theory and praxis. The topics of the course have been separated into three parts as follows: two- and three-dimensional vision and real time image processing covering the right choice of paradigms and image processing hardware components. (4 credits)

Development of SW Applications

BMEVIAUMA09

The goal of the course is to introduce those software development tools and practices which are essential for larger scale development projects. This includes the higher level class libraries, automatic testing and continuous integration tools, version control and documentation tools. Special configuration options of the compiler and deployment processes, and cloud services for server side applications. Beside these, the course emphasizes the use of these techniques in embedded system development and its special requirements. (4 credits)

Design & Integration of Embedded Systems

BMEVIMIMA11

The aim of the subject is the presentation of the basic methods that are needed for the systematic development of embedded systems. First, the following topics are discussed: development life cycle models (e.g., V-model, iterative models), quality assurance, project planning, requirements traceability, version control and configuration control methods. Among system development methods, the subject presents the hardware-software co-design and component integration techniques, based on the previously studied technologies and building blocks, emphasizing also the model-based design approaches. The subject also covers the specific design methods for safety-critical embedded systems in which the malfunctions may lead to hazards, or in case of given environmental conditions even to accidents or damages. Such safety-critical systems are used for example in transportation, vehicles, medical equipment or process control systems. The students will be familiar with the architectural concepts (that are often referred in related standards), the techniques of safety and dependability analysis (that are needed to assess the design decisions), as well as the techniques of systematic verification. The exercises present concrete tools and techniques to support the typical tasks in requirement management, configuration control, source code analysis, unit testing, integration testing, system testing, hazard analysis and model based design. (4 credits)

Embedded Systems Laboratory 1

BMEVIMIMA12

The laboratory exercises present the modern, up to date technologies which are used for the design of embedded systems. The student thus get acquainted with FPGA based system design, efficient software development on dedicated digital signal processors and with high level, model-based virtual instrumentation using LabVIEW. The laboratory exercises also consist of setting up and solving real tasks by utilizing the before mentioned techniques. (4 credits)

Electrical Engineering Multimedia Systems and Services

Mobile and Wireless Networks

BMEVIHIMA07

The objective of this course is to introduce today's modern wireless and mobile systems to our students. This contain basic knowledge needed to operate and maintain such networks. Further goal of this subject is to show the possibilities and operations of advanced radio and wireless solutions, through practical examples. (4 credits)

Broadband Wireless Telecommunication and Broadcasting Systems

BMEVIHVMA01

The objective of the subject is to develop design, modeling and analysis skills related to the physical layer of wideband fixed, mobile communications and broadcasting systems of the future. Four major topics are discussed. The first one covers some special aspects of digital communication: spectrally efficient coding methods (high order QAM modulations, CPM, OFDM and FBMC), coded modulation systems and spread spectrum systems, as well as multiple access methods (CDMA, FDMA, TDMA, SDMA). The second part of the subject explains the properties of terrestrial and satellite microwave bands, fixed and broadcasting radio channels (WSSUS model), including also (multi)point-to-(multi)point transmissions (e.g. MIMO). The third part of the subject introduces specific terrestrial, cable and satellite broadcasting systems (mainly DAB, DVB and DRM variants), along with BFWA networks. Convergence between cellular and broadcasting networks is also considered (including SDR, LTE, 5G, DVB IP, DVB RCT/RCC/RCS). The fourth part gives in-depth knowledge about the test and measurement techniques of state-of-the-art digital broadcasting and communication systems, covering frequency domain and time domain measurements, modulation analysis and bit error / packet error related tests. The baseband representation of these systems is also discussed along with modeling and simulation methods, extending also to the generation of real and complex signals featuring specific stochastic characteristics. (4 credits)

Foundations of Multimedia Technologies

BMEVIHIMA08

The course gives an overview of modern media communication system architectures, coding and modulation techniques, media service customer behavior and user devices. This course allows students to get acquainted with the capabilities of different media capture, storage, delivery and display solutions. (4 credits)

Laboratory on Multimedia Systems and Services 1

BMEVIHIMA10

The aim of this laboratory course is to extend the knowledge learnt in Foundations of multimedia technologies lecture and improve practical skills. Technical methods and solutions for mobile and media communication systems are studied in this course. (4 credits)

Electrical Engineering
Electric Power Systems

Power System Operation and Control

BMEVIVEMA01

The course is intented to provide theoretical knowledge and practical skills in the following fields: system approach of power system design, operation and control, understanding of related physical phenomena and processes and devices capable of influencing these processes, application of the theoretical knowledge in computer aided design, control and safe operation. (4 credits)

Electrical Systems of Sustainable Energetic

BMEVIVEMA02

The purpose of the subjet is to give information for the students about the problems of ageing in the power system. Basics of asset management, monitoring and diagnostic methods, live line management (including the economic questions) is also presented. Electric and magnetic field acting on the workers and the protection against their harmful effects are also in the focus. Further topics ar also involved in the subject, like special energy converters of renewable energy systems, like duble-fed asynchronous generator, motor.Special energy converters of large scale energy storing are also the part of the subject as well as the integration of renewables into the renewable energy system. (4 credits)

Power System Transients

BMEVIVEMA03

The aim of the course is to provide theoretical knowledge and practical skills for computer based modelling of power system transients including understanding physics of electromagnetic wave propagation on multiphase power lines, being familiar with the origin of transients and their consequences, understanding transients appearing at abnormal system conditions, like switching on or off, during short-circuit or fault clearing. Students will be familiar with design practices and protection principles against overvoltages in order to be skilled about advanced solution methods to reduce the risk of failures. They will have an opportunity to learn how to operate modern power system transient simulation software tools and how to create digital models and evaluate the results obtained by computer simulation. (4 credits)

Protection Systems and Measurement Technology

BMEVIVEMA04

The aim of the course is to provide theoretical knowledge and practical skills for understanding principles and settings of protections used for parry of failure in power systems, power plants, industrial and communal systems, being familiar with measurement technology, digital signal processing, as well as intelligent protections and introducing functions and constructions of operational and malfunction automatics which provide reliable operation of the power system. (4 credits)

Electric Energy Market

BMEVIVEMA05

Aim of the course is to lecture the students the basic principles, stakeholders and their connections, market designs, the technical, legal and commerce rules of the electricity markets that have already been deeply integrated with the operation and control of the electricity power systems, along with the economic principles, price trends of the commodities and services and the investment promoting techniques of the power markets. After successfully completing the course the learnt basics of the methods and approaches applied in the Hungarian and the European energy markets gives the students the possibility to have the required competences to join the workforce of an energy trading, a market oriented services, distribution or system operator corporation. (4 credits)

Fundamentals of Smart Systems

BMEVIEEMA04

The course aims to develop a detailed knowledge and critical understanding of Smart Systems technologies and the physics of MEMS devices. A significant range of principal and specialist skills will be developed in the fields of Smart Systems manufacturing technology, and its applications in MEMS and bio-MEMS devices. During the laboratory work the students are getting familiar with the numerical modeling and analysis by the use of a cutting edge simulation tools. (4 credits)

System Level Design

BMEVIEEMA05

The subject presents the design, implementation and verification of digital hardware. Various concepts and tools are presented, inlcuding alternatives of digital system relatization, automatization, silicon compilers, simulation methods, system level modelling. The languages hardware modellign languages SystemC, CatapultC, VHDL, Verilog, and Verilog-AMs are introduced. The actual trends are also discussed, e.g, hardware-software co-design, IC and MES co-design, MEMS integration. The subject also includes computer-based design demonstrations and practices. (4 credits)

Circuit Environment

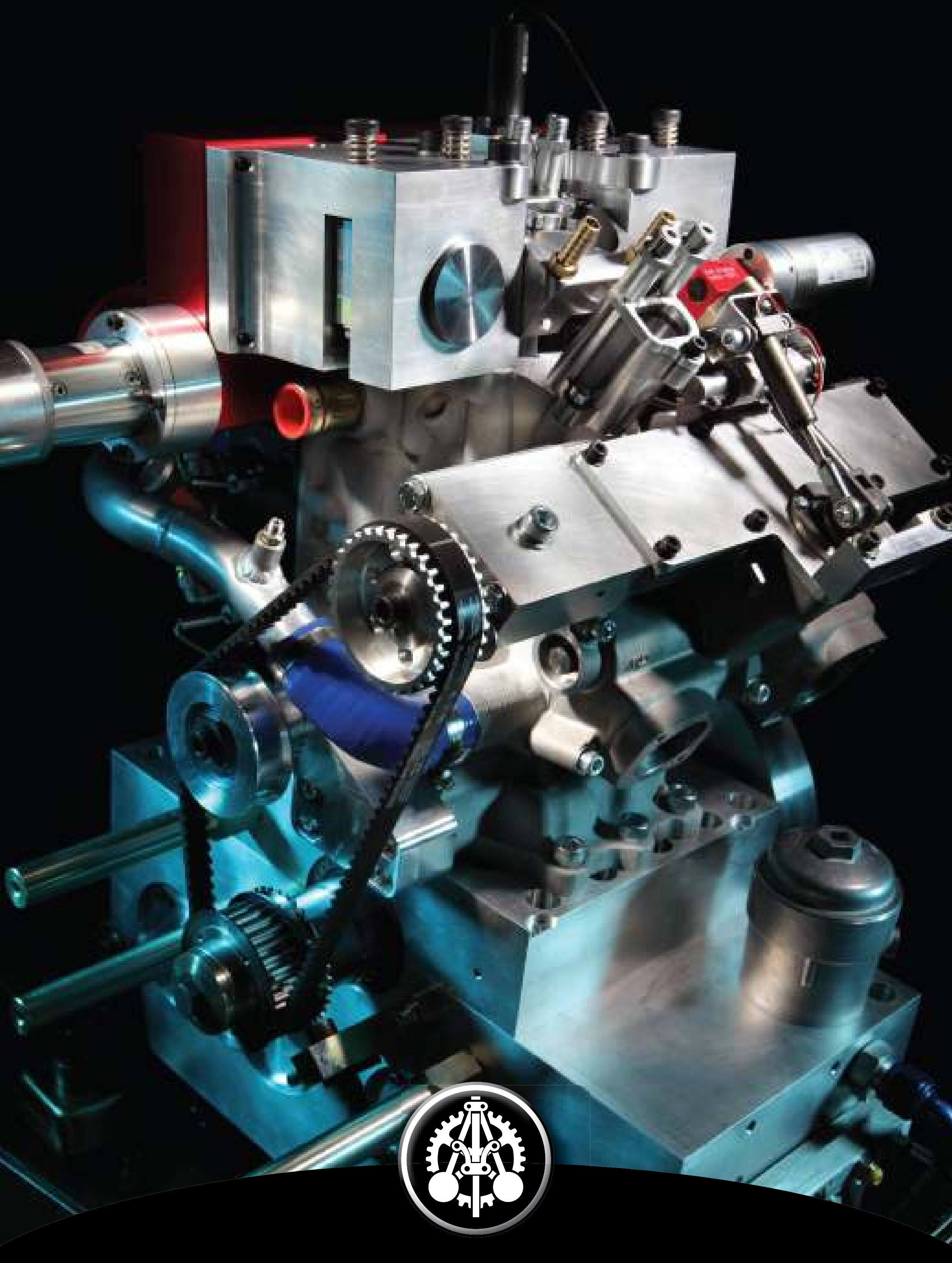
BMEVIEEMA06

The scope of the subject is to get the students acquainted with the development of the packaged intelligent devices operating environment, the design software, the modern simulation tools. Deals with the design, testing, simulation steps and gives practical knowledge on their industrial applications. The whole process development flow is described, including basics steps of the developments, test methods, reliability investigations, and the effects of the ambient to the operation of the circuit. The subject also introduces to signal integrity, e.g., plane capacitance, losses, delays, skin effect and proximity effect, wave impedance and passive devices in real parasitic elements. (4 credits)

Smart Systems Design Laboratory

BMEVIEEMB00

The laboratory practice covers the complete design flow of IC and MEMS co-design. A workgroup of students are designing a Smart System solution including MEMS sensors and actuators and the relevant CMOS circuitry. The laboratory practice is built on the lecture course of System Level Design. Up to date industry standard software CAD tools are utilized thanks to the EU and international support. (2 credits)



Faculty of Mechanical Engineering

Introduction

The Mechanical Engineering Program at the Budapest University of Technology and Economics began in 1863, and the Faculty of Mechanical Engineering was established soon afterward, beginning official operations in the 1871/72 academic year. The Faculty is justly proud of its continuous, progressive and more than 140-year history and now offers undergraduate and graduate programs in both Hungarian and English.

The Faculty of Mechanical Engineering offers a seven-semester undergraduate BSc degree program in English. Two specializations, 1) Engineering Design and Technology, and 2) Process Engineering give the students alternatives from the 5th semester. A two-year graduate program in English - Mechanical Engineering Modeling - leading to an MSc degree started in February 2009, and students can start their study either in the fall or in the spring semester. Individual postgraduate academic and research programs, which are usually completed in three to four years, are available for those who already have an MSc degree and wish to pursue a PhD degree.

The undergraduate BSc program of the Faculty of Mechanical Engineering is designed to continue a tradition of excellence by:

- providing well-grounded and broad knowledge that graduates of this Faculty can apply immediately in their work and also use as the basis for further studies; and
- graduating competent engineers who are not only masters of their profession, but also possess an ethical philosophy of engineering based on accuracy, punctuality and reliability as well as a respect for the human element.

The goals of our MSc and PhD programs are as follows:

- to train creative, inventive mechanical engineers who can apply the engineering skills and the knowledge they have gained from the natural sciences on a state-of-the-art level; and
- to foster the development of leaders in engineering research and development.

The courses in the Mechanical Engineering Modeling MSc-program deal with those time-dependent problems of mechanical engineering, which typically require the efficient modeling of tasks in order to access the continuously developing methods of computational engineering. As the joke says: 'One designed by a civil engineer starts moving that is bad, one designed by a mechanical engineer does NOT move that is bad, too.' Modern computational methods are very popular since they show their easy-to-use interface for engineers. This often causes misunderstanding and disappointment during the naive applications of engineering software. Computational methods are reliable if they are properly tested and the principles of their applied algorithms and procedures are understood. This is analogous to the modern cartoon industry: the 25 pictures of one second of a cartoon can be drawn by computers if the first and the last picture of that second are designed for them by the artist but the computers will totally fail if they have to draw the cartoon without any reference picture, or based on the first (or last) picture only.

The tasks of mechanical engineers that typically require the modeling of machines in motion and that of time-varying processes are based on solid and fluid mechanics, thermodynamics and electronics. Modeling means the understanding and active application of the related theories, which are supported by differential equations and numerical methods in mathematics. Modeling needs also experimental work during the research-development-innovation process, in case engineers do not have enough information about the motions and processes they want to capture by a model. Finally, modeling is also affected by the engineers knowledge in design, technology, and informatics, since the model should not be so complex that the available software is unable to solve them within reasonable time and for reasonable cost.

The above principles affected the formation of this master course. After the brief summary of the required fundamental courses (mathematics, mechanics, thermodynamics, electronics, control and informatics), the students have to choose a major and a minor specialization from the following list of modules:

1. Solid Mechanics 2. Fluid Mechanics 3. Thermal Engineering 4. Design and Technology

The possible combinations provide flexibility among more research-oriented knowledge (combinations of the first 3 modules), and the development-oriented one (major from modules 1-3 and module 4 as minor or vice versa).

This course is running in English only. It is based on the foundations provided by the long-standing positive traditions of some former successful courses of the Faculty of Mechanical Engineering at BME.

This course is also compatible to many master courses in mechanical engineering in the European Union (see, for example, U Bristol, U Bath, ENS Cachan, TU Karlsruhe, U Hannover, TU Munich).

Our Faculty offers its engineering education excellence rooted in, and being fully aware of its unique position of training decision makers, and technological leaders of tomorrow. Our aim in the course of the training is to qualify our graduates to perform as competent problem solvers, good communicators, excellent team workers, successful project leaders, and - above all - ethical participants of the world around them – both locally and globally.

Departments:

Department of Materials Science and Engineering
Department of Fluid Mechanics
Department of Energy Engineering
Department of Building Service Engineering and Process Engineering
Department of Machine and Industrial Product Design
Department of Manufacturing Science and Engineering
Department of Hydrodynamics Systems
Department of Mechatronics, Optics and Mechanical Engineering Informatics
Department of Applied Mechanics
Department of Polymer Engineering

Budapest University of Technology and Economics
Faculty of Mechanical Engineering
Faculty Office:
Building R, ground floor, room 001.
Mailing Address: Műegyetem rkp. 7-9.
H-1111 Budapest

Dean: Prof. Dr. Tibor Czigány
Vice-Dean (scientific and international affairs):
Dr. Ádám Kovács
Course Director:
Mr. Axel Groniewsky, BSc Course Director

Curriculum of BSc Subjects
Process Engineering Specialization

Subject			lectures/practical lectures/laboratory								
Name	**Code**	**Credits**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Requisities**
1st semester, Fall											
Compulsory English I.	BMEGT63A301	2	0/4/0								p
Descriptive Geometry	BMETE90AX06	3	1/2/0								e
Introduction to Mechanical Engineering	BMEGEVGAG01	4	2/1/1								e
Information Systems	BMEGERIA31I	4	2/0/2								p
Macro- and Microeconomics	BMEGT30A001	4	4/0/0								e
Mathematics A1a - Calculus	BMETE90AX00	6	4/2/0								e
Technical Chemistry	BMEVEKTAGE1	3	2/0/1								p
Statics	BMEGEMMAGM1	3	1/1/0								p
	Total credits:	*29*									
2nd Semester, Spring											
Compulsory English II.	BMEGT63A302	2		0/4/0							p
Materials Science and Testing	BMEGEMTAGK1	6		4/0/1							e
Fundamentals of CAD	BMEGEGEA3CD	4		1/0/2							p
Physics A2	BMETE15AX02	2		2/0/0							e
Fundamentals of Machine Design	BMEGEGEAGM1	4		2/2/0							p
Mathematics A2a - Vector Functions	BMETE90AX02	6		4/2/0							e
Software Engineering	BMEGERIA32P	2		0/2/0							p
Strength of Materials	BMEGEMMAGM2	5		2/2/0							e
	Total credits:	*31*									
3rd Semester, Fall											
Dynamics	BMEGEMMAGM3	5			2/2/0						e
Materials Engineering	BMEGEMTAGK2	4			3/0/1						e
Physics A3	BMETE15AX03	2			2/0/0						e
Machine Elements 1.	BMEGEGEAGG1	5			2/1/1						e
Environmental Management Systems	BMEGT42A003	3			3/0/0						p
Mathematics A3 for Mechanical Engineers	BMETE90AX10	4			2/2/0						p
Mathematics Global Exam	BMETE90AX23										ge
Analysis of Technical and Economical Data	BMEGEVGAG14	3			2/1/0						p
Measurement Technology	BMEGEMIAMG1	3			2/0/1						p
	Total credits:	*29*									
4th Semester, Spring											
Basics of Electrical Engineering	BMEVIAUA007	3				2/0/1					p
Machine Elements 2.	BMEGEGEAGG2	6				3/1/1					e
Manufacturing	BMEGEGTAG01	5				2/0/3					e
Control Engineering	BMEGEMIAGE1	4				2/2/0					e
Engineering Thermodynamics	BMEGEENAETD	3				2/1/0					p
Polymer Materials Science and Engineering	BMEGEPTAG0P	6				3/0/2					e
Vibrations	BMEGEMMAGM4	3				2/1/0					p
Mechanics Global Exam	BMEGEMMAGM0										ge
	Total credits:	*30*									
5th Semester, Fall											
Electromechanics	BMEVIAUA008	4					2/1/1				e
Fluid Mechanics	BMEGEÁTAG11	5					2/2/1				p
Heat Transfer	BMEGEENAEHK	4					2/2/0				e
Diffusion Processes	BMEGEVÉAG02	2					1/1/0				e

e - exam, p - practical mark, ge - global exam

Subject			lectures/practical lectures/laboratory								
Name	**Code**	**Credits**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Requisities**
Measurement at Energy and Environment Protection	BMEGEENAG51	3					0/1/2				p
Measurement Technique of Processes	BMEGEVGAG03	2					1/0/1				p
Fundamentals of FEM	BMEGEMMAGM5	3					1/1/1				p
Management and Business Economics	BMEGT20A001	4					4/0/0				p
Business Law	BMEGT55A001	2					2/0/0				p
Optional subject:		2									
Marketing (2 credits) OR	BMEGT20A002						2/0/0				p
Communication Skills - English (2 credits)	BMEGT63A061						0/2/0				p
	Total credits:	*31*									
6th Semester, Spring											
Technical Acoustics and Noise Control	BMEGEÁTAG15	3						2/0/1			e
Fluid Machinery	BMEGEVGAG02	4						2/1/1			e
Heat Engines	BMEGEENAEGK	4						2/1/1			e
Numerical Simulation of Fluid Flows	BMEGEÁTAG06	2						1/0/1			p
Processes and Equipments of Chemical Industry	BMEGEVÉAG03	5						3/2/0			e
Air Pollution, Wastewater and Solid Waste Man.	BMEGEÁTAG04	3						3/0/0			p
Independent Study 1	BMEGEVGAG06	4						0/0/4			p
Optional subject:		4									
Heating (4 credits) OR	BMEGEÉPAG61							3/1/0			e
Manager Communication (2 credits) AND	BMEGT63A081							0/2/0			p
Crosscultural Communication (2 credits)	BMEGT63A091							0/2/0			p
	Total credits:	*29*									
7th Semester, Fall											
Fluid Flow Systems	BMEGEVGAG07	3							2/1/0		p
Energy Processes and Equipm.	BMEGEENAG71	5							3/0/2		p
Volumetric Pumps and Compressors	BMEGEVGAG04	2							1/1/0		p
Measurement for Chemical and Environment Proc.	BMEGEVÉAG04	3							0/1/2		p
Final Project	BMEGEXXA4SD	15							0/10/0		p
Optional subject:		4									
Air-Conditioning (4 credits)	BMEGEÉPAG62								2/2/0		e
	Total credits:	*32*									
Criterion											
Industrial Practice	BMEGEXXBYSZ										

XX in the Final Project code varies from department to department e - exam, p - practical mark, ge - global exam

Curriculum of BSc Subjects
Engineering Design and Technology Specialization

Subject			lectures/practical lectures/laboratory								
Name	Code	Credits	1	2	3	4	5	6	7	8	Requisities
1st semester, Fall											
Compulsory English I.	BMEGT63A301	2	0/4/0								p
Descriptive Geometry	BMETE90AX06	3	1/2/0								e
Introduction to Mechanical Engineering	BMEGEVGAG01	4	2/1/1								e
Information Systems	BMEGERIA31I	4	2/0/2								p
Macro- and Microeconomics	BMEGT30A001	4	4/0/0								e
Mathematics A1a - Calculus	BMETE90AX00	6	4/2/0								e
Technical Chemistry	BMEVEKTAGE1	3	2/0/1								p
Statics	BMEGEMMAGM1	3	1/1/0								p
	Total credits:	*29*									
2nd Semester, Spring											
Compulsory English II.	BMEGT63A302	2		0/4/0							p
Materials Science and Testing	BMEGEMTAGK1	6		4/0/1							e
Fundamentals of CAD	BMEGEGEA3CD	4		1/0/2							p
Physics A2	BMETE15AX02	2		2/0/0							e
Fundamentals of Machine Design	BMEGEGEAGM1	4		2/2/0							p
Mathematics A2a - Vector Functions	BMETE90AX02	6		4/2/0							e
Software Engineering	BMEGERIA32P	2		0/2/0							p
Strength of Materials	BMEGEMMAGM2	5		2/2/0							e
	Total credits:	*31*									
3rd Semester, Fall											
Dynamics	BMEGEMMAGM3	5			2/2/0						e
Materials Engineering	BMEGEMTAGK2	4			3/0/1						e
Physics A3	BMETE15AX03	2			2/0/0						e
Machine Elements 1.	BMEGEGEAGG1	5			2/1/1						e
Environmental Management Systems	BMEGT42A003	3			3/0/0						p
Mathematics A3 for Mechanical Engineers	BMETE90AX10	4			2/2/0						p
Mathematics Global Exam	BMETE90AX23										ge
Analysis of Technical and Economical Data	BMEGEVGAG14	3			2/1/0						p
Measurement Technology	BMEGEMIAMG1	3			2/0/1						p
	Total credits:	*29*									
4th Semester, Spring											
Basics of Electrical Engineering	BMEVIAUA007	3				2/0/1					p
Machine Elements 2.	BMEGEGEAGG2	6				3/1/1					e
Manufacturing	BMEGEGTAG01	5				2/0/3					e
Control Engineering	BMEGEMIAGE1	4				2/2/0					e
Engineering Thermodynamics	BMEGEENAETD	3				2/1/0					p
Polymer Materials Science and Engineering	BMEGEPTAG0P	6				3/0/2					e
Vibrations	BMEGEMMAGM4	3				2/1/0					p
Mechanics Global Exam	BMEGEMMAGM0										ge
	Total credits:	*30*									
5th Semester, Fall											
Electromechanics	BMEVIAUA008	4					2/1/1				e
Fluid Mechanics	BMEGEÁTAG11	5					2/2/1				p
Heat Transfer	BMEGEENAEHK	4					2/2/0				e
Injection Molding	BMEGEPTAGE2	3					1/0/1				p

Subject			lectures/practical lectures/laboratory								
Name	**Code**	**Credits**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Requisities**
Fundamentals of FEM	BMEGEMMAGM5	3					1/1/1				p
Manufacturing Processes	BMEGEGTAG91	4					2/0/1				e
Metal Forming	BMEGEMTAGE1	4					2/0/1				
Business Law	BMEGT55A001	2					2/0/0				p
Optional subject:		2									
Marketing (2 credits) OR	BMEGT20A002	2					2/0/0				p
Communication Skills - English (2 credits)	BMEGT63A061						0/2/0				p
	Total credits:	*31*									
6th Semester, Spring											
Novel Engineering Materials	BMEGEMTAGE3	3						2/0/0			p
Fluid Machinery	BMEGEVGAG02	4						2/1/1			e
Heat Engines	BMEGEENAEGK	4						2/1/1			e
Machine Design	BMEGEGEAGMD	4						2/1/0			e
Machine Tools and Manufacturing Systems	BMEGEGTAG92	3						2/0/0			p
Composites Technology	BMEGEPTAGE1	4						2/0/1			e
Project Work	BMEGEGEAGPW	3						0/1/2			p
Optional subject:		4									
Heating (4 credits) OR	BMEGEÉPAG61							3/1/0			e
Manager Communication (2 credits) AND	BMEGT63A081							0/2/0			p
Crosscultural Communication (2 credits)	BMEGT63A091							0/2/0			p
	Total credits:	*29*									
7th Semester, Fall											
CAD Systems	BMEGEGEAGCS	3							1/0/2		p
Non-Destructive Testing of Materials	BMEGEMTAGE2	3							2/0/0		e
CAD/CAM Applications	BMEGEGTAG93	3							1/0/2		p
Polymer Processing	BMEGEPTAGE3	3							1/0/1		p
Final Project	BMEGEXXA4SD	15							0/10/0		p
Optional subject:		4									
Air-Conditioning (4 credits)	BMEGEÉPAG62								2/2/0		e
	Total credits:	*31*									
Criterion											
Industrial Practice	BMEGEXXBYSZ										

XX in the Final Project code varies from department to department e - exam, p - practical mark, ge - global exam

Curriculum of MSc Subjects
Mechanical Engineering Modelling

Subject		lect / sem / lab / cr / p/e/s							
		Beginning: spring				Beginning: fall			
Name	**Code**	**1 Spring**	**2 Fall**	**3 Spring**	**4 Fall**	**1 Fall**	**2 Spring**	**3 Fall**	**4 Spring**
Basic Subjects									
Differential Equations and Numerical Methods	BMETE90MX46	4/2/0/8/e					4/2/0/8/e		
Laser Physics	BMETE12MX00		3/1/0/4/e			3/1/0/4/e			
Analytical Mechanics	BMEGEMMMW01	3/0/0/4/e					3/0/0/4/e		
Advanced Fluid Mechanics	BMEGEÁTMW01	3/0/0/4/e					3/0/0/4/e		
Advanced Thermodynamics	BMEGEENMWAT	2/1/0/4/e					2/1/0/4/e		
Electronics	BMEVIAUM001		2/0/1/4/e			2/0/1/4/e			
Advanced Control and Informatics	BMEGEMIMW01		2/1/0/4/e			2/1/0/4/e			
Special Compulsory Subjects									
Machine Design and Production Technology	BMEGEGEMW01		2/1/0/4/e			2/1/0/4/e			
Major Compulsory Subject I			3/0/1/5/p			3/0/1/5/p			
Major Compulsory Subject II		2/1/0/5/p					2/1/0/5/p		
Teamwork project			0/0/3/3/p			0/0/3/3/p			
Final Project A				0/13/0/15/p				0/13/15/p	
Special Subjects									
Major Elective Subject I				1/0/2/3/e					1/0/2/3/e
Major Elective Subject II					1/0/1/3/e			1/0/1/3/e	
Major Elective Subject III					1/1/0/3/p			1/1/0/3/p	
Minor Compulsory Subject I		3/0/1/5/p					3/0/1/5/p		
Minor Compulsory Subject II			2/1/0/5/p			2/1/0/5/p			
Minor Elective Subject I				1/0/1/3/e					1/0/1/3/e
Minor Elective Subject II				2/0/0/3/p					2/0/0/3/p
Final Project B					0/13/0/15/p				0/13/0/15/p
Subjects in Economics									
Management	BMEGT20MW02				3/0/0/5/p			3/0/0/5/p	
Marketing	BMEGT20MW01			3/0/0/5/p					3/0/0/5/p
Elective Subjects									
Further Elective Subject					1/0/1/3/p			1/0/1/3/p	
Further Elective Subject				1/1/0/3/p					1/1/0/3/p
Criterion									
Industrial Practice	BMEGEMMMWSZ								
Total									
Total credit points		30	29	32	29	29	30	29	32
Total contact hours		17/4/1/22	14/4/5/23	8/14/3/25	6/14/2/22	14/4/5/23	17/4/1/22	6/14/2/22	8/14/3/25
Number of Exams		4	4	2	1	4	4	1	2

Modules available in the Mechanical Engineering Modelling MSc program

Two specialization modules (major and minor) need to be picked from the five which are available in the BME Mechanical Engineering Modelling MSc program. Though there are four modules available, it is not guaranteed that all of them will be started every year. It is not possible to start a module with less than 6 applicants. Therefore, it is important that all students decide which modules they would like to study at the beginning of the program. Therefore, the students decide which modules will be started. Those students who choose modules which end up not having enough applicants can choose to either change over to a different module which is being started, or to wait until the desired module is started in a future semester. The students should make a decision about the major module before the application. However, the major and minor modules can be reversed before the students choose the major/final project topics. The module in which the students perform the major and final projects becomes the “major” one, the other remains the “minor” one.

Curriculum of MSc Subjects
Mechanical Engineering Modelling - Fluid Mechanics Module

Subject		lect / sem / lab / cr / p/e/s							
		Beginning: spring				Beginning: fall			
Name	Code	1 Spring	2 Fall	3 Spring	4 Fall	1 Fall	2 Spring	3 Fall	4 Spring
Basic Subjects									
Advanced Fluid Mechanics	BMEGEÁTMW01	3/0/0/4/e					3/0/0/4/e		
Special subjects / Major or Minor Compulsory Subjects									
Computational Fluid Dynamics	BMEGEÁTMW02		2/2/0/5/p			2/2/0/5/p			
Flow Measurements	BMEGEÁTMW03	2/1/1/5/p					2/1/1/5/p		
Teamwork Project	BMEGEÁTMWTP		0/0/3/3/p			0/0/3/3/p			
Final Project A	BMEGEÁTMWDA			0/13/0/15/p				0/13/0/15/p	
Special subjects / Major or Minor Elective Subjects									
Large-Eddy Simulation in Mechanical Engineering	BMEGEÁTMW05			2/0/0/3/ p					2/0/0/3/p
Open Source Computational Fluid Dynamics	BMEGEÁTMW11			1/1/0/3/p					1/1/0/3/p
Multiphase and Reactive Flow Modelling	BMEGEÁTMW17			1/1/0/3/p					1/1/0/3/p
Unsteady Flows in Pipe Networks	BMEGEVGMW02			2/0/0/3/p					2/0/0/3/p
Building Aerodynamics	BMEGEÁTMW08				2/0/1/3/p			2/0/1/3/p	
Aerodynamics and its Application for Vehicles	BMEGEÁTMW09				2/0/0/3/p			2/0/0/3/p	
Advanced Technical Acoustics and Measurement Techniques	BMEGEÁTMW10				2/0/0/3/p			2/0/0/3/p	
Hemodynamics	BMEGEVGMW06				2/0/0/3/p			2/0/0/3/p	
Flow Stability	BMEGEVGMW07				2/0/0/3/p			2/0/0/3/p	
Theoretical Acoustics	BMEGEVGMW08				2/0/0/3/p			2/0/0/3/p	
Final project B	BMEGEÁTMWDB				0/13/0/15/p				0/13/0/15/p

List of abbreviations appearing in the curriculum:

lect – lecture; sem - seminar (classroom practice); lab - laboratory practice; cr – credits; p/e/s - practical mark/exam/signature

Curriculum of MSc Subjects
Mechanical Engineering Modelling - Solid Mechanics Module

Subject		lect / sem / lab / cr / p/e/s							
		Beginning: spring				Beginning: fall			
Name	**Code**	**1 Spring**	**2 Fall**	**3 Spring**	**4 Fall**	**1 Fall**	**2 Spring**	**3 Fall**	**4 Spring**
Basic Subjects									
Analytical Mechanics	BMEGEMMMW01	3/0/0/4/e					3/0/0/4/e		
Special subjects / Major or Minor Compulsory Subjects									
Finite Element Analysis	BMEGEMMMW02	2/0/2/5/p					2/0/2/5/p		
Continuum Mechanics	BMEGEMMMW03		2/1/0/5/p			2/1/0/5/p			
Teamwork Project	BMEGEMMMWPA		0/0/3/3/p			0/0/3/3/p			
Final Project A	BMEGEMMMWDA			0/13/0/15/p				0/13/0/15/p	
Special subjects / Major or Minor Elective Subjects									
Elasticity and Plasticity	BMEGEMMMW05			1/1/0/3/p					1/1/0/3/p
Nonlinear Vibrations	BMEGEMMMW06			1/1/0/3/e					1/1/0/3/e
Coupled Problems in Mechanics	BMEGEMMMW07			1/0/1/3/p					1/0/1/3/p
Mechanisms	BMEGEMMMW08				1/1/0/3/p			1/1/0/3/p	
Beam Structures	BMEGEMMMW09				1/1/0/3/e			1/1/0/3/e	
Experimental Methods in Solid Mechanics	BMEGEMMMW10				1/0/1/3/p			1/0/1/3/p	
Final project B	BMEGEMMMWDB				0/13/0/15/p				0/13/0/15/p

List of abbreviations appearing in the curriculum:

lect – lecture; sem - seminar (classroom practice); lab - laboratory practice; cr – credits; p/e/s - practical mark/exam/signature

Curriculum of MSc Subjects
Mechanical Engineering Modelling - Thermal Engineering Module

Subject		lect / sem / lab / cr / p/e/s							
		Beginning: spring				Beginning: fall			
Name	**Code**	**1 Spring**	**2 Fall**	**3 Spring**	**4 Fall**	**1 Fall**	**2 Spring**	**3 Fall**	**4 Spring**
Basic Subjects									
Advanced Thermodynamics	BMEGEENMWAT	2/1/0/4/e					2/1/0/4/e		
Special subjects / Major or Minor Compulsory Subjects									
Combustion Technology	BMEGEENMWCT		2/1/1/5/p			2/1/1/5/p			
Energy Conversion Units and their Equipment	BMEGEENMWEP	2/1/0/5/p					2/1/0/5/p		
Teamwork Project	BMEGEENMWPR		0/0/3/3/p			0/0/3/3/p			
Final Project A	BMEGEENMWDA			0/13/0/15/p				0/13/0/15/p	
Special subjects / Major or Minor Elective Subjects									
Measurements in Thermal Engineering	BMEGEENMWM2			1/0/3/4/p					1/0/3/4/p
Simulation of Energy Engineering Systems	BMEGEENMWSE			1/0/2/3/p					1/0/2/3/p
Thermal Physics	BMEGEENMWTP			2/0/1/3/p					2/0/1/3/p
Thermo-Mechanics	BMEGEMMMWTM				2/0/1/3/p			2/0/1/3/p	
Steam and Gas Turbines	BMEGEENMWTU				2/1/0/3/p			2/1/0/3/p	
Final project B	BMEGEENMWDB				0/13/0/15/p				0/13/0/15/p

List of abbreviations appearing in the curriculum:

lect – lecture; sem - seminar (classroom practice); lab - laboratory practice; cr – credits; p/e/s - practical mark/exam/signature

e - exam, p - practical mark, ge - global exam

Curriculum of MSc Subjects
Mechanical Engineering Modelling - Design and Technology Module

Subject		lect / sem / lab / cr / p/e/s							
		Beginning: spring				Beginning: fall			
Name	Code	1 Spring	2 Fall	3 Spring	4 Fall	1 Fall	2 Spring	3 Fall	4 Spring
Special subjects / Major or Minor Compulsory Subjects									
Machine Design and Production Technology	BMEGEGEMW01		2/1/0/4/e			2/1/0/4/e			
Product Modelling	BMEGEGEMW02		2/0/1/5/p			2/0/1/5/p			
Advanced Manufacturing	BMEGEGTMW01	1/0/3/5/p					1/0/3/5/p		
Teamwork Project	BMEGEGEMWP1		0/0/3/3/p			0/0/3/3/p			
Final Project A	BMEGEGEMWDA			0/13/0/15/p				0/13/0/15/p	
Special subjects / Major or Minor Elective Subjects									
CAD Technology	BMEGEGEMW04			1/0/2/4/e					1/0/2/4/e
Materials Science	BMEGEMTMW01			2/0/0/3/e					2/0/0/3/e
Structural Analysis	BMEGEGEMW05			1/0/2/4/p					1/0/2/4/p
Process Planning	BMEGEGTMW02				1/1/0/3/p			1/1/0/3/p	
NC Machine Tools	BMEGEGTMW03				1/1/0/3/p			1/1/0/3/p	
Fatigue and Fracture	BMEGEMTMW02				2/0/0/3/e			2/0/0/3/e	
Final project B	BMEGEGEMWDB				0/13/0/15/p				0/13/0/15/p

List of abbreviations appearing in the curriculum:

lect – lecture; sem - seminar (classroom practice); lab - laboratory practice; cr – credits; p/e/s - practical mark/exam/signature

Subjects of the final exam

The subjects for the final exam need to be chosen from the major module subjects (totaling 16 cr):
- Major Compulsory Subject I, 5 cr
- Major Compulsory Subject II, 5 cr
- Major Elective Subject, 3 cr
- Major Elective Subject, 3 cr

Description of BSc Subjects

Compulsory English I and II.

BMEGT63A301, BMEGT63A302

The courses are designed to enable students to communicate fluently and effectively in study environment. Receptive, productive and interactive activities and strategies are included in the curricula. By the end of the 2nd semester the overall language ability of the students is on level B2 (by the Common European Framework of Reference). 4 hours/2 credits.

Descriptive Geometry

BMETE90AX06

Mutual positions of spatial elements. Orthogonal projections in Monge's representation, auxiliary projections. Intersection of polygons and polyhedra. True measurements of segments and angles. Perpandicular lines and planes. Projection of the circle. Representation of rotational surfaces and their intersections with a plane. Axonometric view. Construction of the helix. 3 hours/3 credits.

Introduction to Mechanical Engineering

BMEGEVGAG01

Some definitions for machines. Basic and derived quantities. Transmission of mechanical work. Losses and efficiency. Uniformly accelerated motion of machines. Motion graphs. Absolute and gauge pressure. Bernoulli's equation. Venturi meter. Linear and rotational analogues. Thermal energy. The specific heat capacity and latent heat. Introduction into error estimation. Balance machines. Orifice and volume meter tank. Measuring pressure and moment of inertia. 4 hours/4 credits.

Information Systems

BMEGERIA31I

Introduction to informatics. Computer structures. Operating systems. Computer networks - Internet. Theoretical and practical data structures. Algorithms. Computer programs, program design, programming methods, program structures. Programming languages: basics, data types, variables, programming structures. Programming languages: subroutines and modules. Data bases: Relational data bases, normalized database design. Data bases: the SQL language. Basics and algorithms of computer graphics. 4 hours/4 credits.

Macro- and Microeconomics

BMEGT30A001

Introduction to macroeconomics. Output and aggregata demand. Fiscal policy and foreign trade. Money and banking. Interest rates and monetary transmission. Monetary and fiscal policy. Aggregate supply, prices and adjustment to shocks. Inflation, expectations, and credibility. Unemployment. Exchange rates and the balance of payments. Economic growth. Economics and the economy. Tools of economic analysis. Demand, supply and the market. Elasticities of demand and supply. Consumer choice and demand decisions. Introducing supply decisions. Costs and supply. Perfect competition and pure monopoly. Market structure and imperfect competition. The labor market. Factor markets and income distribution. 4 hours/4 credits.

Mathematics A1a - Calculus

BMETE90AX00

Algebra of vectors in plane and in space. Arithmetic of complex numbers. Infinite sequences. Limit of a function, some important limits. Continuity. Differentiation: rules, derivatives of elementary functions. Mean value theorems, l'Hospital's rule, Taylor theorem. Curve sketchig for a function, local and absolute extrema. Integration: properties of the Riemann integral, Newton-Leibniz theorem, antiderivatives, integration by parts, integration by substitution. Integration in special classes of functions. Improper integrals. Applications of the integral. 6 hours/6 credits.

Technical Chemistry

BMEVEKTAGE1

Thermodynamics of chemical reactions. Reaction kinetics and catalysis. Chemical equlibriums. Electrochemistry, galvanic cells, eletrochemical corrosion. Principles of combustion. Coal types and coal combustion. Petroleum and petroleum refining. Petroleum products. Automotive fuels. Lubrication and lubricants. Water for industrial use. Environmental protection in chemical engineering. Laboratory practices. 3 hours/3 credits.

Statics

BMEGEMMAGM1

Force, moment, force-couple. Fixed vector systems. Reduction of a force system. Equilibrium equations. Rigid body. Centroid. Plane constraints. Trusses. Method of joints and method of section. Combined plane structures. Principle of superposition. Stress resultants. Stress resultant diagrams and functions. Coulomb-friction. Belt friction. Rolling resistance. 2 hours/3 credits.

Materials Science and Testing

BMEGEMTAGK1

Atomic structure and inter-atomic bonding. The structure of crystalline solids. Crystallography. Imperfections in solids. Mechanical properties of metals. Diffusion. Phase diagrams. Phase transformation in metals. Recrystallization, precipitation hardening, strain hardening, solid solution hardening. Failure mechanism, fatigue, creep fracture. Basics of fracture mechanics. Failure case studies. 5 hours/6 credits.

Fundamentals of CAD

BMEGEGEA3CD

Definitons of CAD, CAM and CAE. Sequential engineering. Concurrent Engineering. Integration of CAD, CAM and CAE through database. The concurrent engineering process. The product model formed from aspect models. Product data management (PDM) systems. Component of CAD/CAM/CAE systems. Hardware configurations for CAD/CAM/CAE systems. Computer graphics. Typical graphics operations. Geometric modeling. Feature based modeling. Parametric modeling. CAD/CAM databases. 3 hours/4 credits.

Physics A2

BMETE15AX02

Properties of electric charges. Insulators and conductors. Coulomb's law. The electric field. Superposition. Electric field lines of forces. The electric flux. Gauss's law. Examples: the electric field of some specific charge distributions. The electric field inside and outside of conducting materials. Work and the electric potential. Capacitance and dielectrics. The electric current in various media. Microscopic interpretation of current density and resistivity. Classical and differential Ohm's law. Resistance and energy dissipation. Resistance and temperature. Low temperature behavior of conductors. Footprints of quantum mechanics: residual resistivity, superconductors, semiconductors. Batteries, electromotive force, internal resistance. Magnetic fields. The Lorentz law. Sources of magnetic fields. The non-existence of magnetic monopoles. The Biot-Savart law. Ampere's law. Examples: the magnetic field of some specific current distributions. Forces acting on current carrying conductors. Torque, magnetic moment, spin. Electric motor. The microscopic structure of ferro magnets. Faraday's law of induction. Generators, transformers. Inductance, self-inductance. Energy stored in magnetic fields. Displacement current, generalized Ampere's law. Maxwell's equations of the electromagnetic field. Electromagnetic waves. Properties of radio, infrared, visible, ultraviolet, X-ray and gamma radiation. 2 hours/2 credits.

Fundamentals of Machine Design

BMEGEGEAGM1

Projections. The orthographic drawing and sketching. Arrangement of views. Auxiliary and sectional views. Dimensions, notes, limits and accuracy. Representations of threaded parts and threaded fasteners, gears, splines, and keys. Drawing for engineering design and construction (detail, assembly and other drawings). Detail drawings of simple machine elements (stuffing box cover; clevis pin). Assembly drawing and partial assembly of the elements mounted on shafts (belt pulley assembly; shaft with bearings; stuffing box assembly). Set of working drawings of a valve (making sketches by freehand; pencilling of detail and assembly drawings). 4 hours/4 credits.

Mathematics A2a -Vector Functions

BMETE90AX02

Solving systems of linear equations: elementary row operations, Gauss- Jordan- and Gaussian elimination. Homogeneous systems of linear equations. Arithmetic and rank of matrices. Determinant: geometric interpretation, expansion of determinants. Cramer's rule, interpolation, Vandermonde determinant. Linear space, subspace, generating system, basis, orthogonal and orthonormal basis. Linear maps, linear transformations and their matrices. Kernel, image, dimension theorem. Linear transformations and systems of linear equations. Eigenvalues, eigenvectors, similarity, diagonalizability. Infinite series: convergence, divergence, absolute convergence. Sequences and series of functions, convergence criteria, power series, Taylor series. Fourier series: expansion, odd and even functions. Functions in several variables: continuity, differential and integral calculus, partial derivatives, Young's theorem. Local and global maxima/minima. Vector-vector functions, their derivatives, Jacobi matrix. Integrals: area and volume integral. 6 hours/6 credits.

Software Engineering

BMEGERIA32P

Modern programming methods. Object-oriented programming. Usage of components. Working with rapid application development environments. Structure of Windows applications. Components of Windows programs, elements of supporting program languages, data types, conversions, structures, parameter passing. Event-based multitasking strategies. Computer graphics. File management. Databases. 2 hours/2 credits.

Strength of Materials

BMEGEMMAGM2

Stress state and strain state in linear elastic bodies. Simple tension and compression. Simple Hooke's law. Area moments of inertia. Bending. Torsion. Combine loads: tension and bending, shear and bending. Bending of curved plane beams. Principal stresses and strains. Mohr's circles. Eigenvalues and eigenvectors of the stress tensor. Dimensioning for combined loads. Mohr- and von Mises-type equivalent stresses. Calculation of deflection and slope of beams. Work theorems of elasticity (Betti, Castigliano). Euler's theory of slender beams. Statically indeterminate structures and frames. Thin pressure vessels, - theory of membranes. 4 hours/5 credits.

Dynamics

BMEGEMMAGM3

Kinematics and kinetics of a particle. Constrained motion. Dynamics of a set of particles. Plane kinematics of rigid bodies. Motion of a wheel of a vehicle. Relative kinematics. Plane kinetics of rigid bodies. Mass moments of inertia. Work and power theorems. Kinetic energy. General plane motion. Rotation about a fixed axis. Static and dynamic balancing. Gyroscopic motion. 4 hours/5 credits.

Materials Engineering

BMEGEMTAGK2

Production technologies of materials. Connection between the structure and properties of materials. Iron and steel making technologies. Basics of plastic deformation and technologies. Hot working, semi-hot working. Effects of alloying elements on steels. Classification of steels. Welding processes. Casting and moulding processes for ferrous alloys. Ceramics and metal matrix composites. Materials selection. 4 hours/4 credits.

Physics A3

BMETE15AX03

Statistical thermodynamics. The kinetic theory of gases. Pressure, temperature, etc. Statistical physics. Probabilities. Statistical description of many-body systems. Specification of the states of a system. Ideal gases. Maxwell velocity distribution. Boltzmann distribution. Statistical temperature. Entropy. The stretched string in classical mechanics. Boundary conditions: traveling and standing waves. Atomic physics. Blackbody radiation. Photoelectric effect. Compton scattering. Spectral lines of atoms. Franck-Hertz experiment. Bohr's model of hydrogen. Schrödinger equation. Pauli's exclusion principle. Exact solutions for the harmonic oscillator and the hydrogen atom. Few applications to molecular and solid-state physics. 2 hours/2 credits.

Machine Elements 1

BMEGEGEAGG1

Design principles, loading cases, critical conditions, safety factor. Joints. Classification. Bolted joints. Threaded fasteners. Applications. Thread profiles. Bolt selections. Torque calculation. Bolt tightening. Power screws. Riveted joint. Elastic cushion (spring) model. Welded joint. Types, loading. Stress calculation. Shaft and hub joints. Torque transmission joints (key, flat key, spline). Interference fit. Transmittable torque. Cylindrical and taper joints. Elements of pipe networks. Pipe fittings. Pressure vessels. Standard and optimal design. Gaskets and Seals. High pressure, temperature and speed applications. Springs. Steel and rubber springs. Functional and stress design. Shafts and rotors. Stress analysis of shafts and rotors for static combined loads. Fatigue and life of members. Dimensioning on strength at harmonically varying loads. 4 hours/5 credits.

Environmental Management Systems

BMEGT42A003

The course covers the topics relevant to the protection of environmental compartments, environmental pressures and pollution in a global context. Introduces the concepts, indicators and tools of environmental protection (air, water, noise and soil protection and waste management. Environmental management systems (EMS) at enterprises and other organizations. EMS topics include the assessment of environmental aspects and impacts, environmental audit, reporting, environmental performance evaluation, life cycle assessment and related international standards. 3 hours/3 credits.

Mathematics A3 for Mechanical Engineers

BMETE90AX10

Classification of differential equations. Separable ordinary differential equations, linear equations with constant and variable coefficients, systems of linear differential equations with constant coefficients. Some applications of ODEs. Scalar and vector fields. Line and surface integrals. Divergence and curl, theorems of Gauss and Stokes, Green formulae. Conservative vector fields, potentials. Some applications of vector analysis. Software applications for solving some elementary problems. 4 hours/4 credits.

Analysis of Technical and Economical Data

BMEGEVGAG14

Introduction. Data acquisition by sampling. Quality and reliability. Obtaining data from experiments, basic concepts of measurement methods. Measurement errors. Point estimation and statistical intervals. Statistical measurement theory. Correlation and regression analysis, regression models. Testing statistical hypotheses. Introduction to the techniques of variance analysis. Applications and examples. 3 hours/3 credits.

Measurement Technology

BMEGEMIAMG1

The measurement of geometric quantities of mechanical engineering. Statistical analysis and data acquisition of the measured values. Systematization of errors, according to their origin, character and form. Measurement methods. Electronic measurement of typical time-depending non-electric quantities of mechanical engineering and of mechatronics. Structure of the measurement chain, sensor and transducer types, the role of intermediate quantities. Dynamical errors, frequency transfer characteristics. Classification and Fourier analysis of signals. Digital measurement systems for length and angle. Basics of digital measurement of signals, digitization methods and sampling theorem. 3 hours/3 credits.

Basics of Electrical Engineering

BMEVIAUA007

Basics of stationary and time-varying electric and magnetic fields and their engineering applications. DC and single-phase AC circuit with lumped parameters. Complex quantities, and phasor diagram. Active, reactive and apparent powers. Modeling electromechanical systems. Basic electrical instruments and measurements. 3 hours/3 credits.

Machine Elements 2

BMEGEGEAGG2

Fundamentals of tribology. Friction, wear and lubrication. Bearings. Sliding (plain) bearings. Designing hydrodynamic and hydrostatic bearings. Rolling bearings, dimensioning for life and static loading. Couplings and clutches. Indirect drives. Friction and belt drives. Chain drives. Gear drives, geometry and strength. Drives for big gearing ratio: worm gear-, planetary gear-, harmonic gear- and cycloid gear drives. 5 hours/6 credits.

Manufacturing

BMEGEGTAG01

The basic model of the machining system (WFMTC system), introduction to the part modeling, to the fixturing the parts, to the machine tools and robotics, to the cutting tools and to the controlling of the machine tools. Mechanics of cutting, geometry of the cutting edge, chip breaking, stability of cutting. Tool wear and tool life. Tool materials and cutting fluids. Fundamentals of the measuring techniques and quality control. The main measuring devices. Fundamentals of metal cutting machine tools kinematics. Manually operated, cam controlled and computer controlled machine tools. Basic types of machine tools. Flexible manufacturing cells and systems. Manufacturing process planning. Computer-Aided Manufacturing. 5 hours/5 credits.

Fluid Mechanics

BMEGEÁTAG11

Theory and practical applications in the following topics: Newton's law of viscosity. Gas, steam, liquid. Cavitation, cavitation erosion. Comparison of gases and liquids. Lagrangian and Eulerian description of fluid motion. Pathline, streakline, streamline, stream surface, stream tube. Steady, unsteady, quasi-steady flow. Continuity. Free vortex. Dynamics. Euler equation. Bernoulli equation. Static, dynamic, total pressure and their measurement. Pitot probe, Prandtl probe. Volume flow rate measurements using contraction elements and deduced from velocity measurement. Comparison. Unsteady Bernoulli equation. Radial fan, Euler equation for turbomachines. Linear momentum equation, applications. Viscous fluids. Non-Newtonian fluids, rheology. Navier-Stokes equation. Similarity of flows. Hydraulics. Bernoulli equation extended to hydraulic losses. Pipe friction loss. BC, outlet, diffuser, bend, elbow, valve, inlet. Description of turbulent flows. Boundary layers and their effects. Fluid mechanical forces acting on bodies. Gas dynamics. Energy equation. Bernoulli equation for compressible fluids. Sound speed for gases and solids. Discharge of an air reservoir through a simple circular orifice, at various pressure ratios. Flow in a Laval nozzle. 5 hours/5 credits.

Engineering Thermodynamics

BMEGEENAETD

Basic concepts. Work, heat, entropy, specific heats. Zeroth Law of Thermodynamics. Temperature scales. Properties of pure substances. First Law of Thermodynamics, internal energy and enthalpy, closed and open systems. Simple processes with ideal gas. Gas power cycles: heat engines, refrigerators, heat pumps. Second Law of Thermodynamics, exergy, losses due to irreversibility. Liquids and vapors. Equations of state. Two-phase systems. Basic cycles of power generation. Mixtures of gases, atmospheric (moisten) air. 3 hours/3 credits.

Polymer Materials Science and Engineering

BMEGEPTAG0P

The main goal of the Materials Science and Engineering is to introduce the students to the polymers as structural materials with emphasis on their differences from traditional engineering materials. The role of polymers in the engineering materials. Classification of polymers, thermoplastics and thermosets, Crystal structure and morphology. Mechanical, dynamic mechanical and thermo-mechanical behaviour of polymers. Melt-rheology of thermoplastics. Polymer melts as non-Newtonian viscous liquids. Flow of polymer melts in tubes and rectangular ducts. Extrusion of thermoplastics. Manufacturing of polymer sheets on calanders. Polymer processing technologies of complex 3D parts and products. Main parts and function of reciprocating screw-injection moulding machines. Thermoforming. Processing technologies of thermosets. Rubber technology. Processing technologies of high strength, reinforced polymer composites. 5 hours/6 credits.

Vibrations

BMEGEMMAGM4

Impact. Single degree-of-freedom vibrating systems. Free, undamped vibrations. Pendula. Damped vibrations (dry friction, viscous damping). Forced vibrations, isolation of vibrations. Several degrees-of-freedom systems. Langrange-equation of the second kind. Natural frequencies and vibration modes. Energy and numerical methods (Rayleigh-Stodola, Dunkerley). 3 hours/3 credits.

Electromechanics

BMEVIAUA008

Multiphase circuits. Single and three-phase transformers. Rotating magnetic field. Induction machines and drives. Synchronous machines, drives and electric energy production. DC machines and drives. Transients in DC and AC circuits. Electric utility network. Electric safety. 4 hours/4 credits.

Control Engineering

BMEGEMIAGEI

Methods of system analysis. Modeling and analysis of linear systems. Non-linear systems, linearization methods, soft computing approaches. Stability analysis. Synthesis of systems. Simulation as the tool for operating mathematical models. Simulation methods and software for engineering applications. Control and its classification (open-loop and feedback control). Linear feedback control systems. Compensation methods: serial compensation, compensation with feedback, multi-loop control systems. Optimal control. 4 hours/4 credits.

Heat Transfer

BMEGEENAEHK

Basic forms of heat transfer. Fundamental equations. General differential equation of heat conduction. Steady state and transient conduction. Thermal resistance. Extended surfaces, fin performance. Continuously operating heat sources. Numerical methods. Convection; concepts and basic relations, boundary layers, similarity concept. Free convection, forced convection, boiling and condensation. Empirical formulas. Dimensioning of heat exchangers, efficiency. Radiation heat transfer. 4 hours/4 credits.

Diffusion Processes

BMEGEVÉAG02

Introduction to mass transfer. Phenomenological theory of molecular diffusion. Turbulent diffusion, mass transfer in turbulent flow. Analogies between mass, heat and momentum transfer. Two-film (Lewis-Whitman) theory. Principles of mass transfer in packed and tray columns. Industrial applications of diffusion. Methods, calculation and equipment of distillation. 2 hours/2 credits.

Measurement at Energy and Environmental Protection

BMEGEENAG51

The role of measurements in maintaining and controlling the energy conversion processes. Hardware and software tools of the control and measurement systems. Laboratory tests of different engines and equipments. Simultaneous determination of system variables (flow rates, pressures, temperatures, etc.). Methods of determination of performance, efficiency, exhaust gas composition. 3 hours/3 credits.

Measurement Technique of Processes

BMEGEVGAG03

Physical quantities of processes and their measurements, indirect measurements and errors. Noise as stochastic process variable. Density and distribution function, cross-correlation and autocorrelation. Fourier-transformation in data processing, spectrum, detection periodic signals and noise. Measurement of time-dependent quantities, digital sampling. Data acquisition and data processing. Measurements of characteristics of machines. Statistical hypothesis tests. 2 hours/2 credits.

Fundamentals of FEM

BMEGEMMAGM5

The minimum principle of the total potential energy for linear elastic continua. Ritz method for slender beams subjected to tension/compression and bending, matrix formulation. Basic algebraic operations in Maple/Mathematica. Function approximation, C0 and C1 continuity of line elements. Description of the TRUSS1D/2D and BEAM1D/2D elements. Local-global coordinate transformations. Lagrangian and Hermitian interpolation functions. Derivation of element and structural stiffness matrices, load vectors. Modeling examples: beams and frames, symmetric structures. Solution of the finite element equations. Postprocessing of the results: calculation of strain, stress and displacement. Develoment of simple codes in Maple/Mathematica. Comparison of the numerical and analytical solutions of beam problems. Convergence of displacement components and stress resultants with mesh resolution. The assembly process to create structural matrices, index mapping and freedom numbers. Longitudinal, torsional and bending vibration of linear elastic continua. Animation of wave propagation in elastic slender beams. Finite element analysis of free vibration problems, equation of motion, frequency and mode shape analysis. Lumped and consistent mass matrices. Eigenvalue problems in Maple/Mathematica. Convergence studies. Vibration of beams with disks. Basic equations of plane elasticity. FE solution of axisymmetric problems: rotating disks. Quadrilateral and linear triangle elements, stiffness matrix, load vector, modeling examples. Stress concentration effect. Vibration simulation of beams with plane elements. Solution of FE problems in Maple/Mathematica. Laboratory practices using Maple/Mathematica and ANSYS.

Management and Business Economics

BMEGT20A001

This course introduces the essentials of management as they apply within the contemporary work environment and gives a conceptual understanding of the role of management in the decision making process. Particular attention is paid to management theories, corporate finance, leadership, teamwork, quality management, management of technology, economics calculation and operations management. For problem formulation both the managerial interpretation and the mathematical techniques are applied. 4 hours/4 credits.

Business Law

BMEGT55A001

The problems of the area will be treated in two major parts. Part One introduces students to the general topics, for example the concept of law, the functions of the law in the socioeconomic life. Some basic legal problems, like the conception, characteristics and functions of the modern state and, in a comparative view, the characteristics of the Anglo-Saxon and continental systems of business law and the development of the Hungarian business law will be also discussed. The emphasis of Part Two is on the questions of company law and competition law presented in a European context. The lectures of this part outline not only the regulations of the Hungarian Company Act and Company Registry Act but they cover EU directives and regulations on companies and competition as well. 2 hours/2 credits.

Marketing

BMEGT201A002

Basic Marketing Expressions. Strategic Marketing Planning. Marketing Information System and Marketing Research. Market Segmentation, Targeting and Positioning. Consumer Behavior. Business-to-business Marketing. Product Strategy. Pricing Strategy. Distribution Strategy. Marketing Communication. 2 hours/2 credits.

Communication Skills - English

BMEGT63A061

It is designed to meet the language needs of students in academic and professional fields. Special emphasis is on the language of meetings and discussions, oral presentation and summary writing. 2 hours/2 credits.

Technical Acoustics and Noise Control

BMEGEÁTAG15

Concept of acoustics, classification of the subject. The concept of sound, two-fold nature of sound. Linear acoustic model, and speed of sound. Homogeneous wave equation, general solution, solutions in bounded space. Harmonic waves, trigonometric and complex representation. Model testing and similitude, Helmholtz-number. Standing wave and beat. Helmholtz-resonator. Harmonic analysis, sound spectra, octave band. Energetical relations of acoustic waves. Kinetic and potential energy density, sound intensity, sound power, RMS value and levels. Calculation with levels. Transmission loss, insertion loss, noise reduction. Impedances. Spherical waves, sound sources, monopole, dipole and quadrupole radiators. Far field approximation of point and line sources in free field, sound propagation in the atmosphere. Attenuation of sound waves. Normal transmission from one medium to another, and transmission of obliquely incident sound waves. Transmission loss of one-layer wall. Sound propagation in duct and higher order modes. The energetical model of closed sound space. Direct and reverberant sound fields. Room constant. The subject of noise control. Physiological effects of noise. Subjective measurement units, phon, dB(A), equivalent sound pressure level. The general methodology of noise control. Sound waves generated by mechanical, fluid mechanical and thermal processes and their reduction. Noise control in free and in bounded space. Personal noise protection. Acoustic measurements, microphones, analysers, calibrators, anechoic and reverberating chambers. 3 hours/3 credits.

Fluid Machinery

BMEGEVGAG02

Euler equation, specific work, head, performance characteristics of axial and centrifugal machines. Losses, efficiencies. Non-dimensional parameters, scaling laws, specific speed. Cavitation, NPSH. Operation (parallel, serial) and control of turbomachines. Thrust loads (axial, radial). Axial fan, axial compressor stage. 4 hours/4 credits.

Heat Engines

BMEGEENAEGK

Fuels, fuel technology. Different type of boiler constructions. Circulation in boilers. Steam and gasturbine cycles. Theoretical and real cycles. Impulse and reaction stages. Radial and axial turbines. IC engines. Otto/Diesel engines, crank mechanism, valve arrangement and constructions. Fuel systems of IC engines. Refrigerators and heat pumps. Mechanical construction, dimensioning. Control and operation. Environmental aspects. 4 hours/4 credits.

Numerical Simulation of Fluid Flows

BMEGEÁTAG06

Overview of numerical methods used in fluid mechanics. Conservation form of transport equations. Fundamental concept of finite volume method. Numerical approximation of fluxes, upwinding methods. Solution of pressure-velocity coupling in the case of incompressible flows. Solution methods for Poisson equation. Turbulent models: Reynolds averaged approximation, zero-, one- and two-equation models. Boundary layers, boundary conditions of turbulent models. Direct solution of Navie-Stokes equation and Large Eddy Simulation. Compressible flow models. One-dimensional, time dependent flow pipe systems. Errors and uncertainties in numerical models. 2 hours/2 credits.

Processes and Equipment of Chemical Industry

BMEGEVÉAG03

Theory of liquid mixing. Mixers for low- or medium-viscosity liquids. Separation of gas-solid and liquid-solid systems. Settling in gravity and centrifugal field. Theory of filtration, filters. Theory and practice of heat transfer. Heat exchangers and evaporators. Heat and mass transfer in drying processes. Drying rate and time. Belt, kiln and spray driers. Theory of absorption, method of transfer unit. Packed and tray columns. 5 hours/5 credits.

Air Pollution, Wastewater and Solid Wastes Management

BMEGEÁTAG04

Gaseous and particulate air pollutants. Source control of emissions. Waste gas treatment techniques for volatile organic compounds and inorganic compounds, for gaseous pollutants in combustion exhaust gases and for particulate matter. Wastewater characteristics, pre-treatment. Primary separation or clarification wastewater treatment techniques. Physical, chemical, and water treatment techniques. Biological treatment techniques for biodegradable waste water. Wastewater sludge treatment techniques, sludge disposal. Types, sources, properties, quantities, and qualities of solid wastes. On-site handling, storage and processing of solid wastes. Collection, transfer and transport of solid wastes. Solid wastes processing techniques. Biological, chemical and energetic resource recovery processes. Ultimate disposal. 3 hours/3 credits.

Independent Study 1

BMEGEVGAG06

One-semester long individual project work. 4 hours/4 credits.

Heating

BMEGEÉPAG61

Practical heat transfer calculations for buildings. Heat load calculations. Energy performance of buildings. Calculation of energy consumption. Human thermal comfort, energy balance. Elements and structure of typical heating systems. Basic system design. Hydraulic sizing and balancing of pipe systems. Low temperature heating systems. Condensing boilers. Application of renewable energy. 4 hours/4 credits.

Manager Communication

BMEGT63A081

It is designed to establish and update basic language skills, and competences required by acting in management fields. 2 hours/2credits

Crosscultural Communication

BMEGT63A091

It is designed to make students aware of cultural differences, develop their intercultural competencies. Special emphasis is on verbal and non-verbal communication, language diversity, and socio-cultural factors. 2 hours/2 credits.

Fluid Flow Systems

BMEGEVGAG07

Operation of pumps and fans in systems. Selection of the proper turbomachine considering safety, cavitation free operation and efficiency of controlling the turbomachine. Stability of operation of fans and compressors in systems containing large air volumes - an investigation based on a simple linear theory of stability. Computation of the flow rate and pressure distribution in looped pipe networks. Flow in open channels. Optimisation of the operation of water distribution systems containing pumps and reservoirs for minimum electricity cost. Basics of hydraulic transients. 3 hours/3 credits.

Energy Processes and Equipments

BMEGEENAG71

Energy demands and sources. Basic processes of energy conversion: fossil, renewable, and nuclear sources. Steamand gasturbine, IC engines, fuel-cells, solar collectors, heat exchangers, storage tanks. power stations: gas, steam and nuclear. Combined heat and power generation. Decentralized power generation. Complex energy utilization systems. Energy saving consumer equipment. 5 hours/5 credits.

Volumetric Pumps and Compressors

BMEGEVGAG04

Positive displacement pumps. Pump characteristic and performance. Reciprocating and rotary types. Gear pumps. Performance of a gear pump. Characheristics. Pressure balancing. Bearing forces. Screw pumps. Screw pumps for delivery of higher viscosities fluid. Roots blower. Delivery, isentropic and adiabatic power. Reciprocating compressors. Compression efficiency. Valves. Regulation. Pressure-volume diagrams for different methods of regulating and governing compressors. Sliding vanes pump. Characteristic performance. Capacity and efficiency. Effect of viscosity. 2 hours/2 credits.

Measurement for Chemical and Environmental Processes

BMEGEVÉAG04

Introduction to instrumentation and measurement systems. Process instrumentation, measurement methods, instruments and techniques of various physical quantities. Online measurement with modular multi-parameter measuring system. Laboratory exercises for monitoring of waste water and air pollutants. Receive practical hands on experience in the laboratory using dryer, filter and heater equipment. 3 hours/3 credits.

Final Project

BMEGEXXA4SD

One-semester long individual project work. 10 hours/15 credits. * XX in the code varies from department to department.

Air-Conditioning

BMEGEÉPAG62

Basis for ventilation, thermal comfort and indoor air quality. Heating and cooling load calculations. Calculation of supply airflow rate for ventilated rooms, pollution and energy balance. Layout of air conditioning systems. Air movement in rooms, air distribution systems. Elements and processes of air handling systems. Filtration of air, filters. Treatments of air, equipment of heating, cooling, heat recovery and humidification. Hydraulic sizing of airduct system. Psychrometric charts. Process and flow diagrams of several air-conditioning systems. 4 hours/4 credits
Additional and optional courses on BSc level Pre-requisites: BSc final exam (diploma)

Optional Subjects (upgrade to ECTS 240)

Modeling of Processes and Equipment

BMEGEÉEAG01

Generalized two- and three-phase stage model. Types of equations describing the operation of equipment. Number of degrees of freedom. Design and modeling algorithms.Vaporliquid and liquid-liquid equilibrium calculations. Simulation of countercurrent separation processes (distillation, absorption, stripping, extraction, extractive distillation) with a professional flow sheet simulator. 2 hours/3 credits.

Laboratory

BMEGEÉEAG00

Heat and material balance in spray drier. Overall heat transfer coefficient in tubular heat exchangers. Adsorption of gases (Breakthrough curve). Absorption in packed columns (Mass transfer coefficient, number of transfer units). Air volume flow rate measurement in an air technology system. The measurement of pressure relations of a ventilator on a Bernoulli bench. Thermal comfort related laboratory measurements. Measurement of combustion parameters and efficiency of gas boilers. 4 hours/5 credits.

Independent Study 2

BMEGEVGAIP2

One-semester long individual project work. 8 hours/8 credits

Heating

BMEGEÉPAG61

Practical heat transfer calculations for buildings. Heat load calculations. Energy performance of buildings. Calculation of energy consumption. Human thermal comfort, energy balance. Elements and structure of typical heating systems. Basic system design. Hydraulic sizing and balancing of pipe systems. Low temperature heating systems. Condensing boilers. Application of renewable energy. 4 hours/4 credits.

Manager Communication

BMEGT63A081

It is designed to establish and update basic language skills, and competences required by acting in management fields. 2 hours/2credits

Crosscultural Communication

BMEGT63A091

It is designed to make students aware of cultural differences, develop their intercultural competencies. Special emphasis is on verbal and non-verbal communication, language diversity, and socio-cultural factors. 2 hours/2 credits.

English for Engineers

BMEGT63A051

It is designed to meet the language needs of students in academic and professional fields. Special emphasis is on understanding complex technical texts, as well as producing clear paragraphs and essays on certain technical topics. 2 hours/2 credits.

Analytical Mechanics

BMEGEMMMW01

Classification of mechanical systems of assemble of particles and rigid bodies. Classifications of constraints, geometric and kinematic constraints. Virtual velocity, virtual power and general force. Lagrangian equations of the second kind. Examples. Approximations of the natural frequencies of continua. Longitudinal, torsional and bending vibrations of beams, standing wave and travelling wave solutions. Strings. Vibrations of rotors, critical speed of shafts, Campbell diagram. 3 hours/4 credits.

Advanced Fluid Mechanics

BMEGEÁTMW01

Main objective of the subject is to understand the physical phenomena occurring in various flow categories of technical relevance and to gain practical knowledge in analyzing flow phenomena. Detailed thematic description of the subject: Overview of the fundaments of fluid mechanics. Vorticity transport equation. Potential flows, solution methods based on analytical solutions. Percolation, Darcy flow. Wells. Boundary layers. Similarity solutions for laminar and turbulent boundary layers. Overview of computational fluid dynamics (CFD). Turbulence models. Fundaments of gas dynamics. Wave phenomena. Izentropic flow, Prandtl-Meyer expansion, moving expansion waves. Normal shock waves, oblique shock waves, wave reflection. Jets. Open surface flows, channel flows. Pipe networks. Transient flow in pipelines. Atmospheric flows. 3 hours/4 credits.

Advanced Thermodynamics

BMEGEENMWAT

General model structure of thermodynamics. Equation of state (gases, liquids and solids). Laws of thermodynamics. System of body and environment, heat, work, reservoirs, extended systems. Irreversible processes, availability, exergy analysis, entropy generation minimization. Multicomponentphase equilibrium. Reaction equilibrium. Basics of non- equilibrium thermodynamics. Second law. Linear laws. Onsager reciprocity. Local equilibrium. Heat conduction, diffusion, cross effects. Rheology. Poynting-Thomson body. 3 hours/4 credits.

Motion Control

BMEVIAUA016

Classification of electrical machines according to their operating principles, advantages, disadvantages of each type, typical areas of application. Requirement of electric servo drives. Modeling of electric machines, basics of unified electric machine theory. The basic equations of the two-phase universal motor. Cylindrical and salience pole machines. Torque production, cylindrical and reluctance torque. Transformations. Phase and commutator transformation. The concept of three-phase space vector. Positive, negative and zero sequence components. Derivation of the commutator DC motor equations. Control block diagrams. Per-unit model. Dynamic behaviour of the DC machine. Issues of basic speed and position control. P, PI, PD, PID controllers. The effects of the saturation blocks. The usage of anti-wind-up structures. Design of the cascade controller. The current control loop. The disturbing effect of the induced voltage and its compensation. Setting of the speed controller, symmetrical optimum method. Position control loop. Discrete time controller design in DC servo drives. Power supplies of electric drives. Switched-mode converters. Circuits of one, two and four-quadrant drives. Circuits of braking and regeneration. Converters for three-phase machines. Pulsed-Width-Modulation (PWM) techniques. Bipolar, unipolar modulation. Space vector modulation of three-phase converters. Space vector model of AC machines, the induction machine, permanent magnet synchronous machines. Field-oriented control of AC machines. Hysteresis controllers. Current controllers. Direct Torque Control. 3 hours/3 credits.

Power Electronics

BMEVIAUA017

Semiconductor devices, the basic power electronics (PE) circuits and their application to such an extent that makes the students capable of understanding the principle of operation of PE equipment, carry out their laboratory tests, diagnosing faults and solving the task of selection as well as operation. Topics: 1. Introduction, Definition of PE; 2. Applications of Power Electronics; 3. DC/DC Converters; 4. Characteristics of Semiconductor Switching Devices; 5. Diodes, Thyristors, Application of Thyristors, 6. Controllable Semiconductor Switches: BJT, MOSFET, IGBT, GTO, Emerging Devices; 7. Converters: Classification, Configurations, Properties; 8. Output Voltage Regulation Methods, Overview of PWM; 9. AC Voltage Controllers: On-Off Control, Phase Control, Applications; 10. DC motor types, DC motor drives, Fields of Application; 11. Characteristics of the DC motors, Power Supplies for the DC Motor Drives, Transfer functions, Dynamic analysis; 12. Introduction to Space Vector Theory; 13. AC Motor Types, Characteristics, AC Motor Drives, Fields of Application; 14. Inverters for AC Motor Drives, Voltage Source Inverters, Current Source Inverters; 15. Control of AC Motor Drives, Control methods: Field Oriented Control, DTC, V/f. 4 hours/4 credits.

Engineering Design and Technology Specialization

The below courses make exclusive part of the Engineering Design and Technology Specialization.

Metal Forming

BMEGEMTAGE1

To present different processes in the field of cold, hot and sheet metal forming using the base-knowledge about material structure, mechanics and tribology taking into account the deformability of the material and other process parameters. Process design is based on the modeling of plastic deformation. Tools and equipments for the forming also are presented.
Lecture: Metal-forming process as a system. Dislocation theory of plastic flow. Mechanism of plastic deformation. Cold and hot deformation, recrystallization. Fundamentals of technical plasticity: Strain and stresses. Plastic flow conditions. Hardening materials. Constitutive equations of deformed body. Elements of Tribology. Deformability of metals at different state parameters (temperature, strain rate, stress state). Plastic instability and ductile fracture. Measurements of process parameters.
Base technologies and raw materials of cold forming processes: upsetting, heading, forward, backward and radial extrusion. Workability of materials. Die and process design of technology.
Open die forging. Forging operation: edging, piercing, punching, fullering, swaging. Design of technological processes for the formation of cavities. Closed die forging operations: billet, heating, preshaping, rough forging, finishing, trimming, final product, heat treatment. Forging with and without flash. Die materials, required properties. Effect of forging on microstructure. Fibrous microstructure Equipment for forging: Hammers, screw presses, presses controlled by stroke, hydraulic presses
Hot and cold extrusion. Die design and die materials. Cross sections to be extruded. Drawing process. Rode and tube drawing operations. Characteristic features of a typical die design for drawing. Die materials and lubrications.
Sheet metal forming processes and materials. Anisotropic properties of sheet metal. The basic shearing processes. Forming by bending. Spring back. Deep drawing. Design of technology.
Laboratory: Flow curve and friction factor determination, testing of cold forming processes, design of die and forming technology, modeling of plastic forming. (4 credits)

Non-Destructive Testing of Materials

BMEGEMTAGE2

The subject gives an experience-oriented overview to the up-to-date non-destructive testing and evaluation (NDT and NDE) methods and technologies applied in mechanical-, electrical- and electronic industries. The subject deals with the basic and special non-destructive material testing methods, equipment and techniques of material defect analysis.
Lectures: Classification of NDT and NDE methods. Visualization, liquid penetration investigation of cracks. Ultrasonic testing and monitoring methods. Properties of materials in X-ray radiation. X-ray methods (transmission and diffraction). Image forming systems, tomography. Magnetic properties of materials. Ordered magnetic structures, ordering of magnetic moments. Magnetic anisotrophy, magnetostriction, and their effects. Domain structure formation, effect on macroscopic magnetic properties. Basic types of magnetizing curves. Magnetic field detectors. Crack investigations by magnetic methods. Magnetooptical phenomenas and their applications. Special electromagnetic testing methods. Barkhausen-noise measurements, method of nonlinear harmonics. Eddy current methods. Special eddy-current methods (low frequency, remote field). Acoustic emission tests. Reliability of nondestructive testing methods. Statistical evaluation methods. Transmission electron microscope, electron diffraction. Electron-material interactions, scanning electron microscope. Electron beam microanalysis. Special microscopic techniques, environmental scanning electron microscope (ESEM), electron back scattering diffraction (EBSD), electron beam induced current (EBIC). Confocal laser scanning microscope. Possibilities of digital image processing.
Laboratories: liquid penetration crack investigation. Ultrasonic testing. Acoustic emission. Magnetic field detectors, magnetization curve measurement. Magnetooptical effects, domain structure investigation. Measurement of magnetic Barkhausen-noise, evaluation of spectra. measurement of nonlinear harmonics. Scanning electron microscopy, energy-dispersive spectroscopy. Electron back scattering diffraction. (3 credits)

Novel Engineering Materials

BMEGEMTAGE3

The structure, properties of novel structural and functional materials used in mechanical and electrical engineering applications and their testing methods are discussed. The technological processes and their practical aspects are discussed. Fundamental concepts of material structures and the principles of material properties and their relations. Special attention is paid to materials used in the electronics industries including their production and technological usability.
Basics of crystallography, crystal defects, dimensional effects, nano-, micro-, and macrostructures, multi-component systems. Thermal behavior, diffusion mechanisms. Phase transformations, heat treatments, recrystallization. Mechanical properties and their measurements.
Types and properties of novel structural and stainless steels. Fundamental new concepts in steel development. High entropy alloys.
Alloys used in biomedical engineering applications.
Materials deterioration processes such as corrosion, fracture, fatigue (mechanical, thermal, etc.), creep, migration. Microscopy, electron microscopy, X-ray diffraction.
Conduction properties, conductive, superconductive, resistive, and insulator materials. Semiconductor materials. Effects of material properties on semiconductor materials used in microelectronics and in integrated optoelectronics. Insulator, dielectric and ferro-electric materials. Production of semiconductor single crystals and the related measurement techniques (Hall, CV). Non-metallic materials in electrotechnics. Magnetic properties and the types of magnetic materials used in industrial applications. Intelligent materials. Shape memory and super elastic alloys. (3 credits)

Machine Design

BMEGEGEAGMD

Mechanical engineering design, development, behavior analysis (stress and stiffness analysis, reliability and service life estimates), knowledge of the behavior of mechanical structures, modeling opportunities, various aspects of the design. Learning the modeling of different characteristics, and of the finite element model creation process and the evaluation of the stress state practicing on simple structural elements. Introduction to CAE systems, and case studies. The structure analysis process. Finite element modeling. Basic element types. Modeling issues. Thermal tasks. Integrated CAD / FEM systems. Optimal design of machine structures. Optimization objectives and criteria. Economic issues. Dynamic simulation. The load-bearing structural features of the machine. Structure Types and Applications. The modeling process. Actual and approximate models, the accuracy of approximation. Design principles. Material Laws. Material types. Limit states and serviceability limit state characteristics. General design principles and methods. Models and standard features. Safety factors, stress categories for allowable stresses. Stress Concentration. Design of welded joints. Technologies. Structural design. Load Bearing seams. Examples welded structures and designs. Design of steel structures. Applications and structural design. Design methods and standards. Bar structure and node design. Tanks, piping, sheet metal and design of shell structures. Areas of application and operating conditions. . Type of structure. Design principles and methods. Application examples. Case studies. (4 credits)

CAD Systems

BMEGEGEAGCS

The course prepares the students to resolve complex task in the mechanical engineering with the tools of the computer aided design.
Lecture topics: Introduction, using of the intelliFiles. Theory of the TOP-DOWN design. Integrated CAD systems. Virtual product development. Parametric design. Design of the mechanisms. Topics of the labs: Introduction, overview on the 3D part modeling. TOP-DOWN design in static constructions. Issuing homework No.1. Overview on 3D assembly modeling. Design of the cast parts. 3D model based technical drafting. SW test (45 min). (3 credits)

Project Work

BMEGEGEAGPW

The course is to introduce the behavior analysis of machine construction and the optimal design using the tools of geometrical modeling and analysis. During the semester a machine design project should be worked out in small groups according to the following schedule. The task involves the conceptual and detailed designing of a machine structure, building a 3D-geometrical model in a CAD-System and, furthermore, the solving of several analysis problems.
The main steps and milestones of the project:
Fixing the aim of the project. Project scheduling. Collecting information. Requirements. Developing and evaluating of design concepts. Simplified modeling and analytical calculation of the construction. Building the structural model (simplified geometry, load cases, boundary conditions and material properties). Presentation 1 (in team, max. 10 points). Working out the 3D-solid model of the evaluated design concept. Numerical modeling of the problem (static, dynamic, thermal, kinematic analysis). Evaluating and critic of the first model. Presentation 2 (in team or individually, min. 10, max. 20 points). Finalizing the construction. Preparing the project documentation and the assembly drawing. Presentation 3 (in team and individually, 20 minutes, max. 20 points). Submitting the project documentation and drawings (individually max. 50 points). (3 credits)

Manufacturing Processes

BMEGEGTAG91

The aim of the subject is to present the generally applied machining processes of part manufacturing. The focus of the subject is introduction to the metal cutting theory and applications. The up to date advanced machining processes are also discussed. Students may study the practice of the metal cutting in the laboratory lessons.
Introduction. Collaboration of the product and production planning. Manufacturability of parts. Principles of cutting processes. Energetics of cutting processes, tool wear, tool life, surface roughness. Cutting tools. Tool materials. Geometries of single point tools. Cutting with single point tools. Turning, milling, drilling, reaming, sawing processes. Cutting with abrasive tools. Grinding tools, kinematics of grinding, grinding parameters, tool selection. Non-conventional technologies. Laser machining, waterjet machining, electrical discharge machining, electro chemical machining, electron beam machining, ion beam machining, coating technologies. Gear manufacturing. Manufacturing of cylindrical gears by cutting processes. Profiling, Maag, Fellows, Pfauter gear manufacturing technologies. Assembly. Dimension chains, Tolerance, design for assembly. Measurement technologies in industry. Principles, measuring methods, measurement systems, process measurement. Economics of manufacturing. Production time and costs. Manufacturing Process Planning. Levels of planning, planning methods. Computations in manufacturing. Calculations related to the cutting processes. Production time and cost calculation, production optimization. (4 credits)

Machine Tools and Manufacturing Systems

BMEGEGTAG92

The subject introduces structural elements, structural layout, and various types of the metal-cutting machine tools, their technological and operation characteristics, the basic concepts and layouts of manufacturing systems, and the most important material supply equipment needed to build up manufacturing systems.
The lectures include the following topics. Fundamentals of the kinematics of machine tools and the NC technology. Classification of metal-cutting machine tools. Selection criteria of machine tools. Structural building blocks: friction, rolling and hydrostatic guideways; ball screws; linear motors; rack and pinion mechanisms; hydrostatic screws; indexing and NC rotary tables; rotary actuators: gears, warm wheel, torque motor. Spindles: belt drive, gear drive, direct drive, integrated spindle; rolling, hydrostatic, aerostatic bearings; tool holders and tool clamping; lathe and milling spindles. Lathes and turning centres. Milling machines and machining centres. Automatic tool and workpiece changing peripheries. Multi-functional machine tools. Parallel and hybrid kinematics machine tools. Methods and tools for design and simulation of machine tools. Types and various layouts of manufacturing systems. Material supply principles. Material supply equipment: conveyors, forklifts, AGVs, robots. Flexible manufacturing systems. Methods and tools for planning, design and simulation of manufacturing systems. (3 credits)

CAD/CAM Applications

BMEGEGTAG93

The aim of the subject is to introduce students into computer aided design and manufacturing systems via industry proven tasks, application examples. Out through laboratory works they can learn the main principles of computer aided manufacturing programming techniques, the characteristics, advantages and limits of recent CAD and CAM systems and up to date developments. The focus of the subject is to teach manufacturing oriented computer modeling (preprocessing), applications and programming (post-processing).
Detailed thematic description of the subject: Product and production life cycle: Product, product workflow (lifecycle), production and manufacture, product design and production planning, modeling (models). Computer aided automation of process planning (engineering): manufacturing process planning and engineering models (CAD/CAM models); object and process oriented, integrated planning methods (CIM); manufacturing and manufacturability planning. CAD or/and CAM systems: principles of CAD and CAM system application, design for manufacture and assembly, feature based design and manufacturing process planning, manufacturing process oriented (generated) surface models and modeling, technology and quality controlled design and planning. CAM items and basic workflows: modeling of parts, assembly, environment (machine, device, tool, control, etc.) and technological process; CAD/CAM systems and elements (modules); CAM work- and data flows (interfaces, documents); manufacturing dimension; material, tool and technological databases; manufacturing strategies (roughing and finishing, path generation and combination, etc.); manufacturing levels and boundaries; 2.5-3D tasks, cycles, options. >3D manufacturing via CAM systems: manufacturing planning on lathes, mills and wire EDMs, spatial motion strategies, manufacturing sculptured and composed (combined) surfaces, applications of combined strategies, high speed machining (HSM) and special techniques. CAM-CNC interfaces, postprocessors: adaptation and transportation interface drivers (engine, processor), surfaces (HW/SW) and languages (formats), intermediate surfaces, languages, ISO CLDATA, ISO standard and advanced NC program languages, post processing (postprocessors and postprocessor generator), DME connections (DMIS) and NC auxiliary functions (in process measure, adaptive feed and/or path optimization, etc.) .Surveying knowledge: lecture's and supplementary labor's test.
Thematic of laboratories: Subject requirements and thematic, 2.5D multiple hollow part modeling, NASA CAD test laboratory, Test1 (CAD labor work), surface and solid modeling of complex surfaces and combined, assembled block, NASA CAM test milling, 2.5D milling of hollow part in EdgeCAM, 3D-s CAM modeling and manufacturing programming, Test2 (CAM labor work), Homework consulting, check and submission. (3 credits)

Composites Technology

BMEGEPTAGE1

Getting familiar with the matrices and reinforcing materials of polymer composites. Gaining knowledge about the manufacturing technologies of thermoplastic and thermoset matrix composites. Learning the basics of composite mechanics and composite specific design guidelines.
Lecture/seminar topics: Thermoset and thermoplastic composite matrix materials, properties and applications. Typical reinforcing materials of polymer composites. Reinforcing structures, properties and applications. Manufacturing technologies of thermoset matrix polymer composites: overview, typical products, tooling materials. Wet manufacturing technologies of thermoset matrix polymer composites: hand layup, spraying, RTM, pressing, pultrusion, filament winding, braiding, centrifugal casting. Dry manufacturing technologies of thermoset matrix polymer composites: autoclave curing of prepregs, out of autoclave prepreg curing, BMC pressing, SMC pressing, sandwich manufacturing. Manufacturing technologies of thermoplastic matrix polymer composites: extrusion, injection molding, pressing, vacuum forming, GMT. Damage and failure of polymer composites: testing and approving methodologies. Basics of composite mechanics: types of material behavior, rules of mixtures, laminate properties for different stacking sequences, composite plates under tension, composite plates under bending, failure criteria for composites. Example problem solving.
Laboratory practice topics: Tensile and flexural testing of the specimens. Test data evaluation. Calculating the expected mechanical properties of the specimen types, comparison with the test data, summarizing the results for the required technical report. (4 credits)

Injection Molding

BMEGEPTAGE2

Theoretical and practical understanding of the injection molding technology. Knowledge of production engineering and design aspects of modern plastic products. Understanding the most advanced design and simulation procedures.
Detailed description of the injection molding technology. Analysis of the process cycle diagram. Construction and operation of injection molding machines. Design for injection molding. Materials for injection molding, and fiber reinforced materials. Methods for the identification and elimination of molding defects. Injection mold design and injection molding simulation. (3 credits)

Polymer Processing

BMEGEPTAGE3

The aims of this subject is familiarizing the students with polymer processing technologies in details: preliminary techniques, extrusion, blow molding, thermoforming, rotational molding, polymeric foams and elastomers technology. Introduction. Classification of polymer processing technologies. Basic rheological aspects of polymers. Preliminary techniques of polymer processing (material conveying, drying, mixing, dosing etc.). Calendering. Extrusion. Extruder constructions, single and twin screw extruders. Compounding wit extruder. Extrusion dies (film blowing, flat film-, pipe, sheet, profile extrusion; extrusion blow molding; extrusion coating). Thermoforming: vacuum and pressure forming. Rotational molding. Foams technology: thermoplastic and thermoset foams. Elastomer technologies. Finishing and decoration. Joining technologies: welding and adhesive bonding. (3 credits)

Industrial Practice

BMEGEXXBYSZ

One of the requirements to obtain the BSc diploma is to carry out an internship in a company or institution that performs some activities in the field of mechanical engineering. The required duration of the industrial practice is 6 weeks. It is possible to request the place of the industrial practice from the department's responsible. To obtain the signature in Neptun it is required to apply the Industrial Practice subject before the acquisition of the BSc diploma. Industrial Practice can be accomplished after any semester during the specialization period. Upon request an internship made before studies in BME may be also accepted. (criterion)

Description of MSc Subjects

Basic Subjects

Mathematics Mi - Differential Equations and Numerical Methods

BMETE90MX46

Dr. Péter Moson, Dr. György Paál

First order ordinary differential equations, difference between linear and nonlinear equations. Elementary methods of solution (undetermined coefficients, variation of parameters, etc.) The existence and uniqueness theorem. Modelling with first order equations. First order difference equations. Introduction into numerical methods: explicit, implicit schemes, stability problems, multi-step methods. Second order linear ordinary differential equations, homogeneous and nonhomogeneous equations. Series solutions of second order equations, ordinary points, regular singular points, Bessel equations. Systems of first order ordinary differential equations. Classification of equilibrium points; Introduction into Lyapunov stability; almost linear systems. 2-dimensional autonomous systems. Linearization. Phase space analysis near equilibrium points (linearization, Poincaré theory), periodic orbits. Classification of abstract vector spaces, inner product spaces, generalized Fourier series. Orthogonal function systems, trigonometric Fourier series, Gibbs phenomenon. Sturm-Liouville problems, vibrating string, heat transfer problem in Cartesian and in cylindrical coordinates, Bessel functions, vibrating drumhead.

Laser Physics

BMETE12MX00

Dr. Emőke Lőrincz

Theory of laser oscillation, characteristics of laser light, laser applications. Interaction of photons with atoms, line-broadening mechanisms, coherent amplification, optical resonator, conditions of continous wave and transient laser oscillation. Properties of laser beams: monochromacity, coherence, directionality, brightness. Laser types: solid-state, semiconductor, gas, fluid (dye) and miscellaneous. Laser applications: industrial, medical, communication, measurement technique.

Analytical Mechanics

BMEGEMMMW01

Dr. Gábor Stépán

Review of Dynamics, Strength of Materials and Vibrations. D'Alambert's Priciple. Dynamic effects in Strength of Materials. Maximum equivalent stress calculation in structures of large acceleration (ventilator and turbine blades, engine parts). Natural frequencies and vibration modes of multi DoF systems. Rayleigh's ratio, Stodola iteration and Dunckerley's formula. Calculation of natural frequencies in beam structures by means of analytical estimation and finite element code. Natural frequencies and vibration modes of continuum beams (bending, longitudinal). Vibrations of strings. Calculation of natural frequencies in beam structures subjected to bending vibrations by solving partial differential equations. Bending vibrations of rotating shafts. Variation of natural frequencies due to gyroscopic effects. Campbell diagrams.

Advanced Fluid Mechanics

BMEGEÁTMW01

Dr. Gergely Kristóf

Overview of the fundaments of fluid mechanics. Vorticity transport equation. Potential flows, solution methods based on analytical solutions. Percolation, Darcy flow. Wells. Boundary layers. Similarity solutions for laminar and turbulent boundary layers. Transition. Turbulent boundary layers. BL control. Overview of computational fluid dynamics (CFD). Turbulence models. Fundaments of gas dynamics. Wave phenomena. Isentropic flow. Normal shock waves. Oblique shock waves, wave reflection. Prandtl-Meyer expansion. Supersonic jets. Atmospheric flows. Aerosols. Aeroacoustics. Pipe networks. Case studies.

Advanced Thermodynamics

BMEGEENMWAT

Dr. Balázs Czél

General model structure of thermodynamics. Equation of state (gases, liquids and solids). Laws of thermodynamics. System of body and environment, heat, work, reservoirs, extended systems. Irreversible processes, availability, exergy analysis, entropy generation minimization. Multi component phase equilibrium. Reaction equilibrium. Basics of non equilibrium thermodynamics. Second law. Linear laws. Onsager reciprocity. Local equilibrium. Heat conduction, diffusion, cross effects. Rheology. Poynting-Thomson body.

Electronics

BMEVIAUM001

Dr. Balázs Rakos

Electronic components: Diode, Zener diode, Transistors (bipolar and field effect transistors), Common-emmiter characteristics.

Discrete circuits: Emitter-follower circuit, Amplification, Impedance matching, Series connection of amplifier stages, Feedback.

Integrated circuits: Operational amplifier, Mathematical operations, Wave shape generation, Function generation, Filters, Power supply.

Advanced Control and Informatics

BMEGEMIMW01

Dr. Péter Korondi, professor

Short overview of the classical design methods of PID controllers. Sensors and actuators of an internet based motion control system. Implementation of discrete time PID controller for an internet based motion control system. Linear Time Invariant systems. Controllability and Observability. Canonical forms, the Kalman decomposition, realization theory, minimal realizations. Sate feedback control: pole placement, Linear Quadratic Regulator (LQR), Linear Quadratic Gaussian (LQG) control designs. Discrete Time Systems. Robust Control, H infinity control, Sliding Mode Control, Implementation of sliding control desing for an internet based motion control system.

Machine Design and Production Technology

BMEGEGEMW01

Dr. Gábor Körtélyesi
(Special Compulsory Subject)
The goal of the course is to give a theoretical overview on the fields of machine design and production technology, according to the detailed topics below. Some elements of the methodology are covered on the seminars throughout a semester project.
Machine design: Design principles and methods. Requirements. Modern design techniques. Structural behavior and modeling. Design of frame structures. Polymer and composite components. Load transfer between engineering components. Structural optimization (object function, design variables, constrains, shape and size optimization).
Production: Machine-tools and equipment, devices and fixtures, kinematics, machining principles, production procedures and processes, production volume, batches and series. Manufacturability and tooling criteria, preliminary conditions and production analysis, methods of sequencing operations, production planning and scheduling. Production management (TQC and JIT), automated production; cellular manufacturing, machining centres and robots. Product data and technical document management (PDM, TDM), engineering changes and production workflow management (CE, ECM).

Subjects of the Fluid Mechanics module

Special Subjects / Major or Minor Compulsory Subjects

Computational Fluid Dynamics

BMEGEÁTMW02

Dr. Gergely Kristóf
Main objective of the subject is providing sufficient theoretical background and practical knowledge for professional CFD engineers. Detailed thematic description of the subject: Numerical approximations of derivatives and integrals. Discretisation of divergence, gradient and Laplace operator by means of finite volume method. Numerical modelling of incompressible flows, resolution of pressure-velocity coupling in terms of psi-omega method and pressure correction method. Characteristics of turbulence and turbulence modelling. Application of finite volume discretisation method in a one-dimensional case. Stability of the central differencing scheme, upwinding, and numerical diffusion. Solution of algebraic systems which are obtained by the discretisation of the governing equations of fluid flows. Iterative methods, multigrid methods. Compressible flow modelling. Method of characteristics, application of finite volume method. Introduction to multiphase flow modelling. Application of User Defined Functions (UDFs) in ANYSYS-Fluent simulation system. Seminars in CFD Laboratory: Generation of block-structured meshes with ICEM CFD software. Individual assignment. Convergence checking, mesh independency checking, comparison of results of various models with measured data. Handing in the report of the individual assignment. Group assignment (in groups of 3 students). Convergence checking, mesh independency checking, comparison of results of various models with measured data. Tutorial examples in multiphase flow modelling. Handing in the report of group assignment. UDF examples. Presentation of the results of group assignments.

Flow Measurements

BMEGEÁTMW03

Dr. János Vad
Main objective of the subject is getting acquainted with the measurement principles, application areas, advantages and limitations of various flow measuring techniques applied in industrial practice as well as in research & development related laboratory activities. Detailed thematic description of the subject: Practical / industrial aspects of flow measurements. Measurement of temporal mean pressures: static, total, dynamic. Probes and methods. Manometers. Pressure-based measurement of velocity magnitude and direction. Anemometers, thermal probes. Measurement of unsteady pressures. Temperature measurements. Hot wire anemometry. Laser optical flow diagnostics: Laser Doppler Anemometry (LDA), Phase Doppler Anemometry (PDA), Particle Image Velocimetry (PIV). Flow visualization. Flow rate measurements with use of contraction elements and deduced from velocity data. Comparison. Flowmeters: ultrasonic, MHD, capacitive cross-correlation technique, Coriolis, vortex, rotameter, turbine, volumetric. Industrial case studies. Collaboration of measurement technique and computational simulation. Laboratory exercise.

Teamwork Project

BMEGEÁTMWTP

Dr. Viktor Szente

Experimental and/or numerical (CFD) teamwork project proposals will be announced by the supervisors on the registration week or before for group of 2-3 students. The Teamwork Project proposals are defined as being complex problems for the 1st or 2nd semester, and also can be continued partly by a single student in course of the Final Project A or B (BMEGEÁTMWDA or BMEGEÁTMWDB) in the 3rd and 4th semester, hence resulting in a fully complex MSc Thesis of the student at the end of the curriculum. A so-called Evaluation Team (ET) is formed in that the group's supervisor + two advisors are participating, being the members of ET.

Final Project A

BMEGEÁTMWDA

Dr. György Paál

The aim of the course is to develop and enhance the capability for complex problem solving of the students under advisory management of the so-called Evaluation Team. The student's supervisor and two advisors form the Evaluation Team (ET). Detailed thematic description of the subject: various experimental and/or numerical (CFD) project proposals are announced by the supervisors well before the registration week. The project proposals are defined as being complex problems both for the 3rd and further on the 4th semester, since they are to be continued in course of the Final Project B (BMEGEÁTMWDB) in the 4th semester. The findings of the complex, two-semester long project will be summarised in the final Master (MSc) Thesis.

In course of the Final Project A and further on the Final Project B the student will work on one selected challenging problem of fluid mechanics.

1st ET meeting on the 4th week: 1st project presentation by the student

2nd ET meeting on the 8th week: 2nd project presentation by the student

3rd ET meeting on the 14th week: 3rd project presentation by the student

On the 15th week: submission of the major Project Report in printed and electronic format.

Evaluation Team members assess the students work, presentations & report.

Note, that for students taking the major in Fluid Mechanics of Mechanical Engineering Modelling MSc various Final Project A proposals are announced also by the Dept. Hydrodynamic Systems (under their own subject code BMEGEVGMWDA).

Special Subjects / Major or Minor Elective Subjects

Large-Eddy Simulation In Mechanical Engineering

BMEGEÁTMW05

Dr. Gergely Kristóf

The main objective of the subject is to get familiar with the concept of Large-Eddy Simulation and its widely used techniques. A secondary objective is to gain knowledge about post-processing techniques specially suited for instantaneous and steady 3D flow data. Applications from turbulent heat transfer and noise production will be shown.

Detailed thematic description of the subject: Motivations why to use Large-Eddy Simulation (LES). Filtering of the incompressible Navier-Stokes equations, basic filter properties. Numerical requirements of the simulation. Subgrid scale modelling approaches. Interacting error dynamics. Practical aspect of the simulation (domain time and mesh requirements). Special LES boundary conditions: inlet turbulence generation. Hybrid and zonal LES/RANS approaches. Postprocessing of LES results: flow topology description, vortex detection methods. Case studies: internal cooling channel, flow around an airfoil, near field of a jet.

Open Source Computational Fluid Dynamics

BMEGEÁTMW11

Dr. Gergely Kristóf

Introduction to OpenFOAM including Linux basis, and other required software such as gnuplot and paraview. Installation of OpenFOAM on several Linux distributions and virtual linux systems (Ubuntu, Opensuse, Fedora) from packages and on other systems from source. Solution of simple 2D fluid dynamics problems using OpenFOAM (driven cavity flow, 2D boundary layer, Poiseuille flow) including the comparison with theoretical results. Detailed introduction to OpenFOAM software components including meshing tools, solvers and post-processing tools. Single phase stationary and transient flows, turbulence, compressible flows. Introduction to models, boundary conditions and solvers required for the simulation of these problems. Examples on these problems. Multiphase and reactive flows, including the introduction to models, boundary conditions and solvers required for the simulation of these problems. Examples on these problems. Extension of OpenFOAM capabilities by program code development in C++. Compiling code components, the implementation of boundary conditions, applications and models. Personalized projects using OpenFOAM. Further open source CFD tools (Code Saturn, Palabos).

Multiphase And Reactive Flow Modelling

BMEGEÁTMW17

Dr. Jenő Miklós Suda

Physical phenomena, major concepts, definitions and modelling strategies. Mass transport in multi-component systems: diffusion and chemical reactions. Modelling chemical reactions: flames, combustion models, atmospheric reactions. Fluid dynamical and thermal phenomena in two-phase pipe flows: flow regimes in vertical, horizontal and inclined pipes. Advanced multi-phase flow instrumentation. Transport through deforming fluid interfaces: jump conditions at discontinuities. Single-fluid and interpenetrating media modelling approaches. Obtaining practical transport equations for multiphase pipe flows by cross sectional integration and cross sectional averaging. Closure relations. Mixture and multi-fluid models. Using experimental correlations. Relevant dimensionless numbers. Gravity and capillary waves. Dispersed particle transport. Sedimentation and fall-out, particle agglomeration and break-up. Bubble growth and collapse. Phase change and heat transfer in single-component systems: boiling, cavitation, condensation. Related heat transport problems and industrial applications. Computational Multi-Fluid Mechanics (CMFD): general methods and limitations, usage of general purpose computational fluid dynamics codes, design of specialized target software. Numerical modelling free surfaces and fluid-fluid interfaces. Review of applications in power generation, hydrocarbon and chemical industry.

Unsteady Flows In Pipe Networks

BMEGEVGMW02

Dr. Csaba Hős

Overview of the program, introduction. Overview of applied numerical methods (Newton-Raphson, Runge-Kutta). 1D instationary flow of quasy-constant density fluid, MOC. Method of characteristics (realisation). Dynamics of air wessel. Dynamical model of pumps. Water hammer, transient pipe network simulation, homework. Open channel flow, basic equations. Lax-Wendroff scheme. Application of MOC for open channel flow. Gasdynamics. 1D transient gas.

Building Aerodynamics

BMEGEÁTMW08

Dr. Jenő Miklós Suda

Basics of meteorology: characteristics of atmospheric boundary layer and its modelling. Arising of wind forces, bluff-body aerodynamics: boundary layer separation, characteristics of separated flows, vortices, their effects on the flow description of complex 3-dimensional flow fields. Wind comfort, dispersion of pollutants in urban environment / Numerical simulation of dispersion of pollutants in urban environment by using MISKAM code. Numerical simulation of dispersion of pollutants in urban environment using the MISKAM code. Usage of wind tunnels in determination of wind loading. Flow visualization around buildings in wind tunnel. Static wind load on buildings and structures, prediction of static wind load by using EUROCODE and ASCE standards. Fundamentals and philosophy. Wind and structure interaction, aero-elasticity. Aerodynamics of bridges, prediction of dynamic wind load on buildings, structures by using EUROCODE, basics of numerical simulation using solid-fluid interaction. Design of cooling towers. Design and wind load of water spheres. Wind load on telecommunication masts - aerodynamic and related design issues, developments. Aerodynamics of membrane structures. CFD and wind tunnel case studies (large buildings, stadium roofs).

Aerodynamics and its Application for Vehicles

BMEGEÁTMW09

Dr. Jenő Miklós Suda

Introduction, bluff body aerodynamics. Characteristics of atmospheric boundary layer. Basics of car design (in co-operation with MOME: Moholy-Nagy University of Arts and Design Budapest). Aerodynamics of automobiles. Aerodynamics of buses and trucks. Aerodynamics of racing cars. Wind tunnels and their use for vehicle aerodynamics. Definition of projects, forming groups of students. Measurement of car models evaluation of car bodies from aerodynamic and design point of view (in co-operation with MOME: Moholy-Nagy University of Arts and Design Budapest).

Individual project: passenger car modelling. 2-4 students form one group. Every group will receive two modelling wood of 3 various given dimensions. With the help of plasticine, a passenger car of M 1:20 scale can be created. The relative position of the pieces of woods can be freely chosen, as far as the model resembles a car. The ground clearance (underbody gap) is 11mm, the distance of the axes is 140mm. The diameter of the wheels is 30mm, their width is 8mm. Wheels can be formed of the plasticine provided. In the larger piece of wood – under the passenger compartment – four boreholes are created, in order to attach the model to the aerodynamic force measuring mechanism. The maximum length of the model is 250mm, its minimum height is 60mm, and its width is between 82 and 90mm. The perpendicular cross section of the model has to be determined (together with the wheels), in order to determine drag and lift coefficients. There is a possibility to place attachments on the car model, like spoilers, ski boxes, etc. Besides the force measurement, there will be a possibility for flow visualization around the car, during which the location and size of the separation bubbles, the size of the dead water region behind the car, effect of spoilers and other attachments, and soiling of the rear face of the car can be observed. The measurements groups have to prepare a project presentation on the last class. The groups have to send their presentation by e-mail 2 working days before the presentation at the latest.

Advanced Technical Acoustics and Measurement Techniques

BMEGEÁTMW10

Dr. János Vad

3D homogeneous wave equation and the general solution. The 3D solution of the wave equation in bounded space, room modes. The sound propagation in tubes, the sudden cross-sectional area change and tube termination. The simple expansion chamber silencer, and the sound propagation in horns. Sound propagation in duct and higher order modes. The ray theory, sound propagation in non-homogeneous media. Spherical waves, and the point monopole, dipole and quadrupole sound sources, model laws. The flow generated sound, Lighthill's acoustic analogy and the inhomogeneous wave equation. The attenuation of sound waves. Acoustic measurements, microphones, analysers, calibrators. Anechoic and reverberating chambers. Basic acoustic measurement problems. The sound intensity measurement, the microphone array.

Hemodynamics

BMEGEVGMW06

Dr. György Paál

Introduction to physiology. Circulation system, arterial and venous system. Blood flow measurement methods, invasive techniques. Non-invasive blood flow measurements, Transmission properties of cuff-systems, estimation of eigenfrequency. Introduction to the method of characteristics (MOC). MOC and Solution for rapid change, Alievi (Joukowsky)-wave. MOC and study of the transmission properties of invasive blood pressure measurement technique (arterial catheter). Models and methods for the description of blood flow in blood vessels, material properties, Streeter-Wiley Model 1 and Model 2. Characteristic physiological quantities and their influence in hemodynamics. Flow in aneurysms.

Flow Stability

BMEGEVGMW07

Dr. György Paál

Mechanisms of instability, basic concepts of stability theory, Kelvin-Helmholz instability. Basics of linear stability for continuous and discrete systems with examples; stability of discretization techniques (explicit and implicit Euler technique, Runge-Kutta schemes) and linear stability analysis of surge in turbomachines. The Hopf bifurcation theorem with application to turbomachinery. Galerkin projection and its applications. Lorenz equations, derivation (Rayleigh-Bénard convection), linear and nonlinear stability, interpretation of the bifurcation diagram. Loss of stability of parallel inviscid and viscous flows. Instability of shear layers, jets, boundary layers. Compound matrix method.

Theoretical Acoustics

BMEGEVGMW08

Dr. György Paál

Wave equation. Lighthill's theory, monopole, dipole, quadrupole sound sources. Green's functions on the example of the vibrating string. Free space Green's functions. Modification of Green's functions in the vicinity of solid bodies. Vortex sound equation.

Final Project B

BMEGEÁTMWDB

Dr. György Paál

The aim of the course is to develop and enhance the capability for complex problem solving of the students under advisory management of their project supervisor and two advisors. Each student's project is guided by the project supervisor and depending on the problem -if applicable- by two advisors. They form the so-called Evaluation Team (ET). ET meetings are organized 3 times per semester.

Detailed thematic description of the subject: Several experimental and/or numerical (CFD) final project proposals will be announced by the project leaders well before the registration week. The final project proposals are defined as being complex problems of mainly fluid mechanics, usually they must be the continuation of the major projects' proposals. The students will work on complex problems proposed in the 3rd semester in course of the Final Project A (BMEGEÁTMWDA). The Final Projects A and B together serves as a two-semester project that results in the Master (MSc) Thesis of the student. In course of the Final Project B one single student will work on the selected challenging problem of fluid mechanics.

1st ET meeting: on the 4th week: 1st project presentation by the student

2nd ET meeting: on the 8th week: 2nd project presentation by the student

3rd ET meeting: on the 14th week: 3rd final project presentation by the student

On the 15th week: submission of the final Project Report (ie. the Master Thesis) in printed and electronic format. Evaluation team members assess the students work, presentations & report.

Note, that for students taking the Final Project A that was announced by the Dept. Hydrodynamic Systems (under subject code BMEGEVGMWDA) must continue their project in course of the Final Project B announced also by the Dept. Hydrodynamic Systems (under code BMEGEVGMWDB).

Subjects of the Solid Mechanics module

Special Subjects / Major or Minor Compulsory Subjects

Finite Element Analysis

BMEGEMMMW02

Dr. András Szekrényes

The basic equations of linear elasticity, Green-Lagrange strain tensor. Stability of linear elastic systems, the Euler method. FE formulation of stability problems, geometric stiffness matrix. Buckling, lateral buckling and lateral-torsional buckling of slender beams with symmetric cross section. Torsion of straight prismatic beams. Second order dynamics, vibration of beams with initial load. Dynamic stability analysis including flutter and divergence. Elastic structures subjected to conservative and nonconservative loads. Beck's column, stability diagrams and phase plane portraits. FE solution of nonlinear dynamic problems. Direct time integration schemes, central difference method, Newmark's method, numerical examples. Modeling of parametrically excited linear elastic systems, harmonic balance method. Solution for system of Mathieu-Hill DE equations, application of infinite matrices and finite determinants. Elastic column subjected to periodic compressive force, stability diagrams, calculation of the displacement response. Simulations and animations of parametrically unstable systems. Classification and FE solution of nonlinear static structural problems, classical and modified Newton-Raphson methods. Tangent stiffness matrix and iteration schemes. The principle of virtual work. Degenerate beam element with von Kármán type nonlinearity. Nonlinear TRUSS structures. Nonlinear vibration of elastic structures, solution by direct iteration technique. Chaotic motion of elastic structures. Nonlinear bending of elastic beams including large displacements and large strains. Modeling examples in ANSYS including elasticity, plasticity, static and dynamic elastic stability, nonlinear structural static/dynamic and thermomechanical problems.

Continuum Mechanics

BMEGEMMMW03

Dr. Attila Kossa

Historical overview. Mathematical background (Cartesian tensors, properties and representations, invariants, tensor fields, derivatives of tensors, integral theorems). Kinematics. Bodies and configurations. Lagrangian and Eulerian description of a continuum. Deformation gradient. Deformation of arc, surface and volume elements. Deformation and strain tensors. Polar decomposition: stretch and rotation tensors. Displacement, infinitesimal strain and rotation. Material time derivative. Rates of deformation: stretching and spin tensors. Conservation of mass, continuity equation. Concept of force. Cauchy's theorem on the existence of stress. First and second Piola-Kirchhoff stress tensors. Linear momentum principle. Equation of motion. Angular momentum principle. Balance of energy: concepts on stress power, rate of work, internal energy. First and second law of thermodynamics. Clausius-Duhem inequality. Dissipation function. Constitutive theory. Principles of determinism and local action. Material frame indifference and objectivity. Constitutive equations of elasticity, viscoelasticity, plasticity and fluid mechanics.

Teamwork Project

BMEGEMMMWPA

Dr. Attila Kossa

Solution of complex problems by forming group of students including the following topics: cutting processes, vibration measurements, robot control, stability theory.

Final Project A

BMEGEMMMWDA

Dr. András Szekrényes

The Final Project A subject is dedicated to the preparation of the first half of the MSc thesis. Each student must choose a proposal and a supervisor or supervisors. The proposals are available at the websites of the department or they can be requested from the professors in the course of a personal communication. The aim of the subject is to develop and enhance the problem solving capability of the students under advisory management of their supervisor. The requirement is a practical mark at the end of the semester, which is determined entirely by the supervisor.

Special Subjects / Major or Minor Elective Subjects

Elasticity And Plasticity

BMEGEMMMW05

Dr. Attila Kossa

Introduction to the constitutive modelling in solid mechanics. Classification of the constitutive theories. Gradient, divergence and curl in cylindrical coordinate system. Small strain theory. Compatibility of strain. Governing equations of linear elasticity. Hooke's law. Plane stress and plane strain problems. Airy stress function. Torsion of prismatic bar. Analytical stress solution of rotating disc and of thick-walled tube with internal pressure. One-dimensional plasticity. Uniaxial extension and compression problems with hardening. Elastic-plastic deformation of thick-walled tube with internal pressure. Haigh-Westergaard stress space. Formulation of the yield criteria. Linear isotropic and kinematic hardening. Nonlinear hardenings. Formulation of the constitutive equation in 3D elastoplasticity. Radial return method.

Nonlinear Vibrations

BMEGEMMMW06

Dr. Gábor Stépán, professor

Nonlinearities in mechanical systems: springs, dampers, inertia. Phase plane analysis of 1 degree-of-freedom systems. Saddles, nodes and spirals, stable and unstable equilibria. Vibrations of conservative nonlinear systems. Catastrophe theory: typical bifurcations of equilibria. Construction of trajectories and their analysis in case of inverted pendulum supported by spring, pitchfork bifurcation. The dynamic effects of nonlinear damping. Forced vibration and resonances in systems of nonlinear springs. Analytical and numerical calculation of resonance curves in case of hardening and softening characteristics. Self-excited vibrations. Liénard and Bendixson criteria for limit cycles. Hopf bifurcation theory. Stick-slip oscillations, estimation of stable and unstable periodic motions.

Coupled Problems in Mechanics

BMEGEMMMW07

Dr. Ádám Kovács

Coupled field problems. Diffusion equations. Coupled piezo-thermo-mechanical equations. Steady-state thermal analysis. Thermo-mechanical analysis. Micro-electromechanical systems. Beam and plate type microstructures. Sensors and actuators. Piezoelectric-thermo-mechanical analysis of an actuator. Electro-mechanical analysis of a capactive pressure sensor. Fluid-structure interaction. Fluid-structure coupled acoustic analysis. Contact problems. Contact simulation of two microcantilevers. Shape memory alloys, smart structures.

MECHANISMS

BMEGEMMMW08

Dr. Ambrus Zelei, research associate

Overview of structural elements and kinematic fundamentals. Basics of synthesis of planar mechanisms. Fourbar mechanisms. Coupler curves. Single and double dwell mechanisms. Velocity and acceleration analysis. Apparent velocity, Aronhold-Kennedy theorem, coordinate partitioning method, and the method of appended driving constraints. Spatial representation of position and orientation. Parameterization of rotations, Euler angles, Tait-Briant angles, Roll-Pitch-Yaw angles, Axis-angle representation, Exponential mapping, Euler parameters. Joint- and operational space. Forward kinematics. The Denavit-Hartenberg convention. Equation of motion of robots, Euler-Lagrange method, Recursive Newton-Euler approach. The concept of natural coordinates. Dynamic equation of motion in terms of non-minimum set of generalized coordinates. Constrained systems. Service robot-, and haptic application examples. Impulsive dynamic analysis. Numerical simulation.

Beam Structures

BMEGEMMMW09

Dr. András Szekrényes

General theory of free torsion of prismatic bars. Saint-Venant warping function, the circulation theorem of shear stresses. Warping of thin-walled sections, the sector area function, definition of shear center. Transformation of the sector area function. Examples for open and closed sections. Constrained torsion of thin-walled open sections, bimoment, torsional warping constant, warping statical moment. Governing differential equation and boundary conditions under constrained torsion, examples: U-section and I-section beams. Demonstration of the importance of shear center through real models. Shearing of thin-walled section beams. Shear-warp function, shear center. Engineering solutions for open and closed sections, modified statical moments. Nonlinear bending theory of slender beams by E.P. Popov. Nonlinear DE of flexure. Solution by elliptic integrals of the first and second kind. Solution of classical beam problems including large deformations. FE formulation of Timoshenko beams. Isoparametric Timoshenko beam element, shear locking, interpolation with exact nodal solution, examples. The basic theory of sandwich beams with thin and thick facesheets. Definition of anti-plane core materials, application examples.

Experimental Methods in Solid Mechanics

BMEGEMMMW10

Dr. András Szekrényes

Strain measurement methods, theory and practice, strain gauges. Application to an aluminium block. Linear elastic fracture mechanics of composites, fracture model of Griffith, definition of critical energy release rate. Evaluation of fracture mechanical test results. Direct and indirect data reduction schemes. Standard and direct beam theories, J-integral, the virtual crack-closure technique, compliance calibration, area method. Classification of fracture tests, mode-I and mode-II configurations. Manufacturing of composite specimens. Force and displacement control in fracture mechanics. Necessary and sufficient conditions of stable crack propagation in brittle materials. Stability criterion in theory and practice. Demonstration examples for stable and unstable crack advance. Test methods for the mode-III interlaminar fracture, the modified split cantilver beam, edge-cracked torsion and 4-point plate bending specimens. Dynamic stability and vibration analysis of delaminated beams. Vibration testing using modal hammer and sweep excitation tests. Measurement of the frequency response function and mode shapes. Evaluation of vibration tests. Numerical simulation of parametric instability in delaminated beams by harmonic balance and finite element methods. Mode shape simulation and calculation of phase plane portraits. The mixed-mode bending problem. Mode partitioning in mixed-mode I/II tests by global and local methods using distributed dislocation theory. Application of improved beam theory schemes (Winkler, Timoshenko) to cracked beams. Fracture envelopes and fracture criteria of laminated materials.

Final Project B

BMEGEMMMWDB

Dr. András Szekrényes

The Final Project B subject is dedicated to prepare the second half of the MSc thesis. As the continuation of the Final Project Project A, the aim of the subject is to demonstrate the ability of the student to solve high level, practical engineering problems, based on acquired knowledge in the fields of mechanical engineering. In some special cases the students can choose a different topic than that of the Final Project A, however in this case the thesis should be prepared in the course of one semester. The projects have to be prepared by the students under the guidance of supervisors. The Final Projects include tasks in design, simulations, laboratory tests, manufacturing as well as controlling, interfacing and software tasks. The expected result is mostly a Final Report prepared according to written formal requirements. During the Final Exam, the results have to be explained in an oral presentation.

Subjects of the Thermal Engineering module

Special Subjects / Major or Minor Compulsory Subjects

Combustion Technology

BMEGEENMWCT

Dr. Ferenc Lezsovits

Course is started with introduction of fuel properties and fuel supply systems. It is followed by calculation of mass and energy balance of combustion, stoichiometry and CO_2 and pollutant emission, flue gas loss calculation, condensation of flue gas components. Heat transfer in combustion chamber has important role on energy balance and retention time formation. After that combustion process of different fuels, parameters of combustion will be presented as homogenous / heterogeneous reactions, flow type and concentration effects on chemical reactions. Nowadays application of catalysts in combustion process and flue gas cleaning has become important part of this technology. Anaerobe biogas generation, gas cleaning and features and gasification technology overview, features of generated gas, gas cleaning technologies, tar filtering and/or condensation, torrefaction and pirolysis will be discussed as well. Carbon capture and storage (CCS) technologies will be also presented. In the end comparison of different thermal conversion technologies (combustion, gasification, etc.) on mass and energy balance will be presented. Finally, solutions applied in firing technic will be demonstrated as firing system in general, control and regulation, firing system principals for liquid and gaseous fuels, andfor soild fuels, and waste material incineration.

Energy Conversion Units and their Equipment

BMEGEENMWEP

Dr. Ákos Bereczky

Basics. Cooling systems and main parameters. Absorption cooling systems and special cooling systems. Fuel cells. Combustion technology, parameters and emissions. Different hot water and steam generation systems. Different hot water and steam generation main parameters. Steam turbines, different steam turbine cycles. Steam turbines, different steam turbine constructions. Gas turbines, different gas turbine constructions and cycles. Main parameters and characteristic of internal combustion engines. Management of internal combustion engines. Gas engines. Cogeneration and tri-generation systems and parameters.

Teamwork Project

BMEGEENMWPR

Dr. Tamás Laza

The complex task covers a semester project in the diverse topics of energetics.

Final Project A

BMEGEENMWDA

Dr. Tamás Laza

In course of the Final Project A one student or group of 2 students will work on one selected challenging problem of mechanical engineering. Several experimental and/or numerical project proposals will be announced by the project leaders. The aim of the course is to develop and enhance the capability for complex problem solving of the students under advisory management of their project leader. At the end of each semester a written Project Report is to be submitted and the summary and findings of the investigations on the selected problem is to be presented as Project Presentation.

Special Subjects / Major or Minor Elective Subjects

Measurements In Thermal Engineering

BMEGEENMWM2

Dr. Ákos Bereczky

Measurement methods and techniques of thermal processes. System - model - measurement - evaluation. State of the art data acquisition methods, systems and signal transducers. Operational and service measurements, engine diagnostics, performance characteristic. Stability and vibrations tests. Evaluation methods in data processing. Questions of safety, availability and reliability. Application of LabView graphical programming environment.

Simulation of Energy Engineering Systems

BMEGEENMWSE

Dr. Pál Szentannai

Methods of determination the dynamic models. Type of equation groups. Linear – nonlinear, distributed – concentrated parameters. Application of Matlab/Simulink interactive programming language. Case studies: simple and complex energy conversion processes. Student projects: dynamic modelling and simulation experiment.

Thermal Physics

BMEGEENMWTP

Dr. Balázs Czél

Physical backgrounds, mechanism and models of heat conduction in solids; measurement of thermo-physical properties; steady state and transient methods; numerical modeling of 1D and 2D heat conduction problems, inverse heat conduction problem. Heat conduction review (heat diffusion equation, boundary conditions). What are thermophysical properties? Different heat conduction models. Finite difference and control volume method for the solution of heat conduction problems. Measurement of the thermal conductivity. Measurement of the thermal diffusivity. Measurement of the specific heat capacity; direct determination of the temperature dependency of the properties. Inverse heat conduction problems. 2D steady-state heat conduction with contact boundary condition. Transient heat conduction with different boundary conditions (modeling the laser flash method). Transient heat conduction with contact boundary condition. Transient heat conduction with temperature dependent thermophysical properties (modeling the BICOND method).

Thermo-Mechanics

BMEGEMMMWTM

Dr. Ádám Kovács

Temperature dependence of material properties. Governing equations of coupled thermal and mechanical fields. Thermal boundary conditions. Thermal stresses in beams, plane problems, plates, thick-walled tubes and rotating disks. Instationary heat conduction, transient thermal stresses. Numerical thermal stress analysis. Heat conductance and capacitance matrices. Computer simulation of thermal stresses.

Steam And Gas Turbines

BMEGEENMWTU

Dr. Krisztián Sztankó

Preliminary, property of Parsons and Laval steam turbines, property of modern steam turbines. Properties of impulse stage. Curtis stage, negative reaction number evoluation, sonic speed, velocity bended, efficiency curve, properties of reaction stage, long blade bended criteria, equistress design, determination of steam turbine's main geometry, wet steam turbines, calculate pressure variation with Stodola constans. Reheated condensation steam turbine. Design of Package gas turbine. Uncool gas turbine cycle calculation. Real gas turbine cycle and optimum parameters. Properties of single shaft and dual shaft gasturbine, wing shape theory and compressor stage.

Final Project B

BMEGEENMWDB

Dr. Tamás Laza

The aim of the subject of is to demonstrate the ability of the student to solve high level, practical engineering problems, based on acquired knowledge in the fields of mechanical engineering. The projects have to be prepared by the students under the guidance of supervisors. The Final Projects include tasks in design, simulations, laboratory tests, manufacturing as well as controlling, interfacing and software tasks. The expected result is mostly a Final Report prepared according to written formal requirements. During the Final Exam, the results have to be explained in an oral presentation.

Subjects of the Design and Technology Module

Special Subjects / Major or Minor Compulsory Subjects

Product Modelling

BMEGEGEMW02

Dr. Károly Váradi, professor

The process of product modeling. Traditional and concurrent design. Product lifecycle management. Integrated product development. Conceptual design. Geometric models. Assembly models. Presentation techniques. Simulation models (Finite element analysis. Kinematic simulation. Behavior simulation). Optimization (object function, shape and size optimization). Application models. Virtual prototyping. Rapid prototyping. Product costing models.

Advanced Manufacturing

BMEGEGTMW01

Dr. Márton Takács

Introduction to Advanced Manufacturing. Visiting the manufacturing laboratory of the Department. Conventional machining operations. Fundamentals of machining operations. Mechanics of metal cutting. Machinability. Chip control. Fundamentals of advanced manufacturing (non-conventional machining). Reverse engineering. Rapid Prototyping. Mold design and manufacturing. Production Planning - Material Requirements Planning. Production Planning - Advanced models and algorithms. Consultation on semester essay. Electro Discharge Machining EDM), processes and application. Micro EDM machining. Laser Beam Machining. Laser marking. Rapid Prototyping. NC tool path planning by CAM system. Hard Cutting. Gear production.

Teamwork Project

BMEGEGEMWP1

Dr. Tibor Szalay

The complex task covers a semester project in the diverse topics of manufacturing.

Final Project A

BMEGEGEMWDA

Dr. Tibor Szalay

In course of the Final Project A one student or group of 2 students will work on one selected challenging problem of mechanical engineering. Several experimental and/or numerical project proposals will be announced by the project leaders. The aim of the course is to develop and enhance the capability for complex problem solving of the students under advisory management of their project leader. At the end of each semester a written Project Report is to be submitted and the summary and findings of the investigations on the selected problem is to be presented as Project Presentation.

Special Subjects / Major or Minor Elective Subjects

CAD Technology

BMEGEGEMW04

Dr. Attila Piros

Lecture topics: Introduction, using of the intelliFiles. Theory of the TOP-DOWN design. Integrated CAD systems. Virtual product development. Parametric design. Design of the mechanisms. Topics of the labs: Introduction, overview on the 3D part modelling. TOP-DOWN design in static constructions. Overview on 3D assembly modelling. Design of the cast parts. 3D model based technical drafting. Integration of the imported 3D data. Modelling of the parts with similar geometry. Design of the moving parts' kinematic. Modelling of the complex kinematic. Creating of kinematic analyses. TOP-DOWN design in moving constructions. Tolerancing in the CAD systems.

Materials Science

BMEGEMTMW01

Dr. István Mészáros

Structure of crystalline solids. Imperfections in crystals. Mechanical properties of alloys. Dislocations and strengthening mechanisms. Deterioration mechanisms of engineering materials. Phase diagrams. Phase transformations. Material characterization. Non-destructive evaluation techniques. Electrical properties of metals, alloys and semicinductiors. Superconductivity. Magnetic properties. Soft and hard magnetic materials.

Structural Analysis

BMEGEGEMW05

Dr. Tibor Goda

Structural analysis and machine design. Fundamentals of FEM. Basic element types of professional FE systems. Preparing FE models (symmetry conditions, mesh structure, boundary conditions, loading models and material properties). Material and geometric nonlinearity. Time-dependent behaviour. Steady state and transient heat transfer. Integrated CAD-FEM systems. Structure optimization.

Process Planning

BMEGEGTMW02

Dr. Gyula Mátyási

Introduction; demands and requirements of absolving mark in the subject; principles, concepts, terms, definitions concerning on manufacturing process planning and manufacturing processes, equipment, tooling and experience; The stages and steps of manufacturing process planning; deterministic and heuristic methods, issue of Type and Group Technology, methods of prevention and elimination; Production analysis; general sequencing problems; determination of all sequence variations; methods of matrix reduction and vector variants; abstract methods for process plans and production workflows; Scheduling; Process chains and diagrams; shop-floor programming and scheduling (GANTT diagrams), Network plans, leak control (Process graphs and trees), process chain representations, diagrams (Workflow techniques). Assembly (objects); definitions of assembly; units and items, object oriented assembly tree and documents Assembly and manufacturing (processes); assembly procedures, operations, methods and organisation structures; process oriented assembly tree and documents. Quality control (object and process oriented view of quality assurance); probability functions and distributions, dimensional chains and analysis; assembling methods and assurance; economic view of manufacturing; Quality assurance; Production strategies (TQC, JIT); statistical process control (SPC); measure and charts of process capability; charts attributes.

Nc Machine Tools

BMEGEGTMW03

Dr. István Németh

The lectures include the following topics: Fundamentals of the kinematics of machine tools and the NC technology. Classification of metal-cutting machine tools. Selection criteria of machine tools. Structural building blocks: friction, rolling and hydrostatic guideways; ball screws; linear motors; rack and pinion mechanisms; hydrostatic screws; indexing and NC rotary tables; rotary actuators: gears, warm wheel, torque motor. Spindles: belt drive, gear drive, direct drive, integrated spindle; rolling, hydrostatic, aerostatic bearings; tool holders and tool clamping; lathe and milling spindles. Lathes and turning centres. Milling machines and machining centres. Automatic tool and worcriece changing peripheries. Multi-functional machine tools. Parallel kinematics machine tools. The seminars support the design assignment and help the student in selecting the motion unit components (i.e. ball screw, rolling guideway, servo motor) and designing the main structural element i.e. frames, moving slides, tool changers) of machine tools.

Fatigue And Fracture

BMEGEMTMW02

Dr. Imre Norbert Orbulov

Cyclic loading. High cycle fatigue. S-N curve. Fatigue limit. Low cycle fatigue. Manson-Coffin relation. Neuber theory. Linear elastic fracture mechanics. Energy concept. Stress field near the crack tip. Stress intensity factor. Fracture toughness. Fracture mechanical design. Non linear fracture mechanics. Crack opening displacement. J-integral. Stable crack growth. Testing techniques. Design philosophy in nonlinear fracture mechanics. Environment assested cracking. Case studies.

Final Project B

BMEGEGEMWDB

Dr. Tibor Szalay

The aim of the subject of is to demonstrate the ability of the student to solve high level, practical engineering problems, based on acquired knowledge in the fields of mechanical engineering. The projects have to be prepared by the students under the guidance of supervisors. The Final Projects include tasks in design, simulations, laboratory tests, manufacturing as well as controlling, interfacing and software tasks. The expected result is mostly a Final Report prepared according to written formal requirements. During the Final Exam, the results have to be explained in an oral presentation.

Subjects In Economics

Management

BMEGT20MW02

Dr. Irén Gyökér

The objectives of the course are that the students know the duties of management and the attributes of the manager job with the current formed perception in different ages. Over the set targets the students will understand the characteristic of human behaviour, the behaviour of managers and their employee, the team properties in the labour-environment and the corporations how develop their functional rules. The applicable (for previous) management methods and their expected effects on the members of corporation and their capacities are presented in the course of the discussed themes.

Marketing

BMEGT20MW01

Dr. Zsuzsanna Szalkai

Marketing in the 21st century. Strategic marketing planning. The modern marketing information system. Consumer markets and buyer behavior. Business markets and business buyer behavior. Competitive strategies. Market segmentation, targeting, and positioning. Product strategy and new-product development. Managing services. Designing pricing strategies. Marketing channels. Integrated marketing communication.

Further Elective Subject

Biologically Inspired Systems

BMEGEMIMGBI

Dr. Péter Korondi, professor

The design of engineering structures increasingly involves mimicking and improvement of natural, living structures to perfection. In addition to a more accurate understanding and systematization of living systems, it is increasingly important that both engineering students and engineers get acquainted with this topic. The basic goal of the course is the analysis of different biological systems and of the engineering structures mimicking them throughengineering and systems theory considerations. Specific solutions of biological systems for different materials, structures, sensor systems, motion and control can be properly applied.

Criterion

Industrial Practice

BMEGEMMMWSZ

Dr. András Szekrényes

One of the requirements to obtain the MSc diploma is to carry out the internship in a company that performs some activities in the field of mechanical engineering. The industrial practice fulfilled in the BSc level is accepted automatically if the student accomplished the internship through the organization of the Department of Applied Mechanics. If the accomplishment took place through the organization of another department, then a certification needs to be provided to the department's responsible (Dr. András Szekrényes). If the student does not possess a valid industrial practice, then it has to be accomplished in the course of the MSc qualification. The required duration of the industrial practice is 4 weeks. It is possible to request the organization of the industrial practice from the department's responsible. To obtain the signature in Neptun it is required to apply the Industrial practice subject before the acqusition of the MSc diploma.

PhD Degree

The Faculty of Mechanical Engineering (GPK) at the Budapest University of Technology and Economics (BME) offers degree programs in both Hungarian and English. Most students from abroad choose to study in English.

The BME GPK is a strongly research-oriented university that has conferred doctoral degrees since the 19th century in various fields of engineering.

The academic staff of our Faculty are doing research in the most relevant fields of the mechanical enginereering discipline, and related applied sciences. PhD candidates are welcome to take part in this research work in order to prepare for the PhD procedure.

PhD at the BME GPK is a degree that can be earned by sufficiently proving the candidate's ability for selfstanding scientific work that must be demonstrated by writing a thesis summarising the candidate's research results. Furthermore, it is necessary to pass a set of qualifying examinations in some basic and applied sciences related to the field of the submitted thesis. Candidates are to publish their results prior to the submission of their theses.

Applicants for the PhD program must hold an MSc degree issued by an academic institution and must possess an overall understanding of, and a high competence in, their field of knowledge. They must also be capable of using research techniques. Admission requirements include excellent grades (mainly or exclusively A's), an excellent MSc (or equivalent) final project, and/or the achievement of good initial results in research. Besides their professional achievements, applicants should also demonstrate a sense of responsibility for the advancement of scientific knowledge.

PhD candidates carry out their studies and research on an individual basis under the guidance of a professor or a senior member of the academic staff at the faculty concerned. This research work must contribute to scientific knowledge in general, and it must be recognized as such by the international scientific community. In order to prove this, doctoral candidates must present their research results at national and international conferences and symposia, and they are expected to publish the significant and major achievements of their work in internationally referred professional periodicals.

Besides the research work, the PhD supervisor usually recommends the participation in various courses related to the research topic. In such a case, the appropriate examinations must be succesfully completed, the results of which will be documented in the transcripts of the candidate. Similarly, the advancement in individual study and research will be documented on a semester basis by the supervisor.

Working towards a PhD degree requires at least 4 years (8 semesters) of study. This time might be considerably longer, depending on the topic and the candidate's personal diligence. It is possible to set individual PhD study plans for candidates who spend certain parts of their preparation period at other insitution/s, e.g. their own original research-oriented affiliation or another university.

Upon completing all necessary work for the PhD thesis, this dissertation must be prepared according to the formal requirements in the Doctoral Code of the Budapest University of Technology and Economics.

According to the procedural code of our university, every PhD candidate individually must apply to the Doctoral Board of the faculty concerned. However, the recommendation of the supervising professor and department, including the attachment of the protocol of the departmental public presentation of the thesis (with the comments and recommendations of several departmental and/or internal referees, and other professional experts of the field) is a strong expectation.

The doctoral board will appoint an independent examination board for each candidate which consists of the President, two examiners and several jury members. Final decision lies on this board after hearing the public presentation and defense of the thesis work and the subject examination.

The conferred degree is declared and testified by a corresponding PhD diploma at the next solemn ceremony of the university by the Rector of the University concerned.

NOTE:

Individual research topics and their overall conditions are formulated in negotiations between candidates and supervisors at BME.

BME GPK guidelines for acceptance to the PhD programme

1. The primary condition of admission to post-graduate studies is that the applicant must hold an MSc-degree in Mechanical Engineering, or in some closely related fields. Minimum requirement is at least "good" (min. 3.51 out of 5.00 or equivalent) qualification of the diploma.

2. Applicants are expected to have a definite scope of research in the following fields:

- mechanical engineering (materials science and technology, solid or fluid mechanics, thermal engineering, combustion, process engineering, building services, manufacturing, engineering design, polymer science and technology),
- mechatronics (robotics, system and control technology, optics, measurement, instrumentation technologies, biomechatronics),
- energy engineering (heat and power generation, energy systems)

where they would like to advance their knowledge. They are requested to present a proposal, specifying a domain of interest with some research objectives, milestones and deliverables during the postgraduate studies. The suggested topic should have sufficient preliminaries in their university studies.

3. Applicants with experience and initial results are asked to submit a short summary of preliminary research activities together with relevant reports, published papers, which give help in the admission process.

4. Applicants should also submit two recommendations given by renowned academic personnel.

5. It is highly preferable when applicants have already agreed with the future supervisor prior to the application.

6. Each admission is valid only for the forthcoming academic year (starting right after the letter of acceptance).

7. Application procedure is as follows:

Application deadline: 1st July for Fall semester, 15th October for Spring semester.

Application fee, processing, postage: EUR 100 (non-refundable). The application will be considered and communication is assured when application fee has been tranferred to the bank account of BME, and submitted all the required documents.

Documents to submit:

- application form (online) completely filled (be careful that your personal data appear correctly as are in your passport because they will be the form to appear in your transcripts and degree certificate)
- copy of your passport
- one of the following documents of internationally recognized English language proficiency:
  - a) TOEFL iBT test score of 90, or PBT score 550,
  - b) Cambridge First Certificate "B",
  - c) IELTS score of 5.0
- official transcripts, degrees/diplomas of any higher education already completed. Notarized English translation
- 4 recent photographs
- curriculum vitae (autobiography/résumé)
- two letters of recommendation
- Study Plan (agreed with the supervisor)

NOTE: Notarization is necessary for every school leaving document even if the original is in English. Notification of your acceptance/rejection will be sent to you after your complete application has been reviewed. All necessary further information will be attached to the letter of acceptance.

Faculty of Natural Sciences

The Faculty of Natural Sciences, one of the newest faculties at the Budapest University of Technology and Economics, was established in 1998 and now employs 190 full and part time faculty members. The Faculty provides classes in Physics, Mathematics and Cognitive Science and is designed to meet the needs of its own and other faculties.

Courses are offered on BSc and MSc degree levels. The Faculty provides post-graduate scientific training as well. Currently more than 100 PhD students are pursuing personal programs in different areas of sciences. The Faculty also offers short courses on specific topics of current interest.

The Faculty of Natural Sciences administers its own BSc and MSc programs in Physics, Mathematics, Applied Mathematics and Cognitive Science. A continuing educational program is also offered in Reactor Physics and Reactor Technology. For many years the "Eugene Wigner International Training Course for Reactor Physics Experiments" has also been organized on a yearly basis.

The **BSc in Physics Program**, a traditional curriculum, leads to a BSc degree in 6 semesters. The facilities and scientific-tutorial background of the Institute of Physics and the Institute of Nuclear Techniques offer unique opportunities in areas like low temperature physics, acousto-optics, holography, nuclear techniques or medical physics. A further advantage of our Physics BSc Program is the engineering background provided by the Budapest University of Technology and Economics. From the forth semester students can choose specialized courses in the topic of Advanced mathematics, Advanced physics, Computer programming, Optics, Material science, Nuclear technology, and Medical physics.

In another 4 semesters an **MSc in Physics** degree can be earned. This program provides comprehensive knowledge, built upon strong theoretical and experimental bases in four areas of specialization. Students who choose the specialization "Physics" get acquainted with theoretical tools of modern physics and with state of the art experimental methods. In addition to the obligatory courses students can choose specialized professional courses in the topic of Quantum physics, Solid state physics, Statistical physics, Nanotechnology and material science, Optics and photonics, Nuclear technology, and Medical physics. A post-graduate PhD programme in Physics is available in all domains offered in the MSc programme.

The **BSc in Mathematics Program,** a traditional curriculum, leads to a BSc degree in 6 semesters. This program is recommended first of all to those who are interested in a deeper understanding of some branches of mathematics and in doing theoretical research and are probably going to continue their studies in a Mathematics or an Applied mathematics MSc program. Moreover, the BSc program is also recommended to students who are eager to apply their knowledge in industry or finance.

In another 4 semesters an **MSc in Mathematics** or **MSc in Applied Mathematics** degree can be earned.

A large variety of subjects are offered in the **MSc in Mathematics Program**, covering the topics algebra and number theory, analysis, geometry, probability theory and statistics, discrete mathematics, operations research. There is a large flexibility in choosing subjects according to the personal interests of the student. From the available subjects we also offer two specializations called "Analysis" and "Optimization". Currently our MSc in Mathematics program is available only in Hungarian.

Students of the **MSc in Applied Mathematics Program** choosing the "Applied Analysis" specialization will meet applications of mathematical analysis in natural sciences, finance and industry. Graduates from the "Operations Research" specialization are able to create models for problems in controlling systems or optimization. Students who specialized in "Financial Mathematics" can analyze financial processes or insurance problems and are able to interpret the results. Graduates from the "Stochastics" specialization can recognize and study random laws in various phenomena. The language of courses of the specializations "Applied Analysis" and "Operation Research" is Hungarian, but the specializations "Financial Mathematics" and "Stochastics" is English.

MSc in Computational and Cognitive Neuroscience (currently available only in Hungarian). The aim of the master program is to train researchers skilled in complex analysis of human cognition and knowledge relying on the methods of science. Students may complete courses in all major domains of cognitive science including cognitive psychology, neuroscience, linguistics and the philosophy of science. Students will be equipped with both theoretical knowledge and practical skills such as statistical analysis and research ethics. Graduates will be able to carry out research in various areas of cognitive science combining theoretical insights and methods of biological (neuroscience, experimental psychology, developmental studies), and formal (mathematics, logic, philosophy of science, linguistics) disciplines. Graduates' competences allow them to undertake doctoral studies, and to work in a variety of applied domains including medicine, biotechnology and education.

Continuing educational program in reactor physics and technology is a four semester program offered to professionals working in the nuclear industry. The subjects include reactor physics, thermohydraulics, radiation protection, radiochemistry, reactor technology, nuclear safety and laboratory experiments.

The Institute of Nuclear Techniques organises - or participates actively in the organisation of - several international courses as well. Worth mentioning are the HUVINETT (Hungarian Vietnamese Nuclear Engineering Train the Trainers) courses, where more than 150 Vietnamese educational professionals attended in 2013 and 2014. Also the participants of the training courses offered by the international EERRI consortium (Eastern European Research Reactor Initiative) perform experiments in the Training Reactor of the BME INT. In this consortium institutes of 5 Eastern European countries cooperate, with the organisatory and financial aid of the International Atomic Energy Agency (IAEA).

Postgraduate program in Operations Research in four semesters is recommended to professionals - with MSc - who often meet problems related to optimization (economists, engineers, etc.). The program includes theoretical classes (bases of discrete, continuous and stochastic optimization) and practice oriented classes as well (modelling, software packages, algorithm implementation, etc.). In the second and third semester students carry out individual projects which help them to obtain the required knowledge and practice for the future.

Institutes

Institute of Mathematics
- Department of Algebra
- Department of Analysis
- Department of Differential Equations
- Department of Geometry
- Department of Stochastics

Institute of Nuclear Techniques
- Department of Nuclear Techniques
- Department of Nuclear Energy

Institute of Physics
- Department of Atomic Physics
- Department of Physics
- Department of Theoretical Physics

Department of Cognitive Science

Budapest University of Technology and Economics
Faculty of Natural Sciences
Faculty Office:
Building K, 1st floor 18.
Mailing address:
H-1111 Budapest, Műegyetem rkp. 3.
Phone: (+36-1) 463-3561
Fax: (+36-1) 463-3560

Dean of the Faculty: Dr. Miklós Horváth
Vice-dean (finance): Dr. Imre Varga
Vice-dean (Scientific and International): Dr. György Károlyi
Vice-dean (education): Dr. István Prok

Curriculum of BSc in Physics

Subject			Lecture / Practice / Laboratory / Exam type / Credit					
Name	**Code**	**Type**	**1**	**2**	**3**	**4**	**5**	**6**
Mathematics	**All of them must be completed: 28 credits**							
Mathematical Methods in Physics 1	BMETE92AF35	K	4/2/0/v/6					
Mathematical Methods in Physics 2	BMETE92AF36	K		4/2/0/v/6				
Analysis for Physicists	BMETE93AF00	K	4/2/0/v/6					
Multivariate Analysis for Physicists	BMETE93AF01	K		4/2/0/v/6				
Probability Theory for Physicists	BMETE95AF00	K			2/2/0/v/4			
Fundamental Physics	**All of them must be completed: 24 credits**							
Experimental Physics 1	BMETE13AF02	K	4/0/0/v/4					
Practical Course in Experimental Physics 1	BMETE11AF26	K	0/4/0/f/4					
Experimental Physics 2	BMETE13AF03	K		4/0/0/v/4				
Practical Course in Experimental Physics 2	BMETE12AF20	K		0/4/0/f/4				
Experimental Physics 3	BMETE15AF21	K			3/0/0/v/3			
Practical Course in Experimental Physics 3	BMETE15AF22	K			0/2/0/f/2			
Experimental Nuclear Physics	BMETE80AF18	K				2/1/0/v/3		
Comprehensive Examination in Experimental Physics	BMETE13AF11	KR				0/0/0/s/0		
Advanced Physics	**All of them must be completed: 30 credits**							
Mechanics 1	BMETE15AF23	K			2/0/0/v/2			
Practical Course in Mechanics 1	BMETE15AF24	K			0/2/0/f/3			
Quantum Mechanics 1	BMETE15AF27	K				2/0/0/v/2		
Practical Course in Quantum Mechanics 1	BMETE15AF28	K				0/2/0/f/3		
Electrodynamics 1	BMETE15AF25	K					2/0/0/v/2	
Practical Course in Electrodynamics 1	BMETE15AF26	K					0/2/0/f/3	
Statistical Physics 1	BMETE15AF29	K						2/0/0/v/2
Practical Course in Statistical Physics 1	BMETE15AF30	K						0/2/0/f/3
Introduction to Solid State Physics	BMETE11AF05	K					2/0/0/v/2	
Practical Course in Solid State Physics	BMETE11AF06	K					0/2/0/f/2	
Applied Solid State Physics	BMETE11AF11	K						2/0/0/v/2
Optics	BMETE12AF35	K					2/2/0/v/4	
Laboratory, measurement techniques, electronics	**All of them must be completed: 32 credits**							
Introductory Laboratory Exercises	BMETE11AF27	K	0/0/2/f/2					
Laboratory Exercises in Physics 1	BMETE11AF28	K		0/0/3/f/4				
Laboratory Exercises in Physics 2	BMETE11AF29	K			0/0/4/f/5			
Electronics	BMETE12AF27	K			2/0/0/f/2			
Laboratory of Electronics	BMETE80AF03	K				0/0/2/f/2		
Measurement Techniques	BMETE11AF30	K			2/0/0/v/2			
Advanced Laboratory Exercises in Physics 1	BMETE11AF32	K				0/0/4/f/5		
Advanced Laboratory Exercises in Physics 2	BMETE11AF33	K					0/0/4/f/5	
Advanced Laboratory Exercises in Physics 3	BMETE12AF21	K						0/0/4/f/5
Computer programming, numerical methods	**All of them must be completed: 10 credits**							
Programming	BMEVIEEA024	KV	2/0/2/f/4					
Programming 2	BMEVIEEA026	KV		2/0/2/f/4				
Numerical Computations for Physicists	BMETE92AF01	KV		0/0/2/f/2				
Others	**All of them must be completed: 10 credits**							
Chemistry	BMEVEFKA144	KV	4/0/0/v/4					
Radiation Protection and its Regulatory Issues	BMETE80AF24	KV			2/0/0/f/2			
Management and Business Economics	BMEGT20A003	KV			2/0/0/f/2			
Specialized courses	**27 credits must be completed**							
Advanced Mathematics								
Modern Mathematical Methods in Physics	BMETE15AF31	KV				2/2/0/v/4		
Introduction to Experimental Data Handling	BMETE80AF25	KV				2/0/0/v/2		
Functional Analysis for Physicists	BMETE92AF02	KV				4/2/0/v/6		
Group Theory for Physicists	BMETE11AF35	KV					2/2/0/v/4	
Advanced Physics								
Mechanics 2	BMETE15AF32	KV				2/0/0/v/2		
Practical Course in Mechanics 2	BMETE15AF44	KV				0/2/0/f/3		
Quantum Mechanics 2	BMETE15AF36	KV					2/0/0/v/2	
Practical Course in Quantum Mechanics 2	BMETE15AF43	KV					0/2/0/f/3	
Electrodynamics 2	BMETE15AF34	KV						2/0/0/v/2

Curriculum of BSc in Physics (contd.)

Subject			Lecture / Practice / Laboratory / Exam type / Credit					
Name	**Code**	**Type**	**1**	**2**	**3**	**4**	**5**	**6**
Practical Course in Electrodynamics 2	BMETE15AF42	KV						0/2/0/f/3
Fluid Mechanics	BMEGEÁTAF11	KV				2/0/0/f/3		
Classical and Quantum Chaos	BMETE15AF39	KV					2/0/0/v/2	
Theory of Relativity	BMETE15AF38	KV						2/0/0/v/2
Computer programming								
Computer Controlled Measurements	BMETE11AF37	KV				0/0/2/f/2		
The Fundaments and Applications of Finite Element Modeling	BMETE12AF24	KV				0/0/2/f/2		
Computer Solution of Technical and Physical Problems	BMETE11AF36	KV					0/0/2/f/2	
Monte Carlo Methods	BMETE80AF26	KV					2/1/0/f/3	
Optics								
Spectroscopy	BMETE12AF28	KV					2/0/0/v/2	
Laser Technique	BMETE12AF07	KV					2/0/0/f/2	
Microscopy	BMETE12AF09	KV						2/0/0/f/2
Materials science								
Foundations of Biophysics	BMETE12AF10	KV				2/0/0/f/2		
Fundaments and Applications of Materials Science	BMETE12AF25	KV					2/0/0/v/2	
Microtechnology and Nanotechnology	BMETE12AF08	KV						2/0/0/f/2
Nuclear technology								
Nuclear Physics	BMETE80MD00	KV					3/1/0/v/5	
Nuclear Measurement Techniques	BMETE80MD01	KV					1/1/0/v/3	
Nuclear Safety	BMETE80MD05	KV						2/0/0/v/2
Radioactive Waste Management	BMETE80MD07	KV						2/0/0/v/2
Plasma Physics	BMETE80MD02	KV					3/1/0/v/4	
Medical physics								
Medical Imaging Systems	BMETE80AF17	KV						2/0/0/f/2
Supervised research	**10 credits**							
BSc Thesis Project	BMETE15AF11	K						0/0/10/f/10
Elective courses	**9 credits must be completed**							

Exam type: v = exam, f = midterm exam, a = signature, s = comprehensive exam

Subject type: K = obligatory, KV = elective , V = optional, KR = criterium

Curriculum of BSc in Mathematics

Subject			Lecture / Practice / Laboratory / Exam type / Credit					
Name	**Code**	**Type**	**1**	**2**	**3**	**4**	**5**	**6**
Obligatory courses	**All of them must be completed: 159 credits**							
Basics of Mathematics	BMETE91AM35	K	2/0/0/v/3					
Calculus 1	BMETE92AM36	K	6/2/0/v/9					
Introduction to Algebra 1	BMETE91AM36	K	6/2/0/v/9					
Introduction to Geometry	BMETE94AM17	K	2/0/0/v/3					
Informatics 1	BMETE91AM42	K	1/0/2/f/4					
Calculus 2	BMETE92AM37	K		6/2/0/v/8				
Introduction to Algebra 2	BMETE91AM37	K		6/2/0/v/8				
Combinatorics and Graph Theory 1	BMEVISZA025	K		2/2/0/v/6				
Geometry	BMETE94AM18	K		4/0/0/v/6				
Informatics 2	BMETE91AM43	K		1/0/2/f/4				
Physics 1 for Mathematicians	BMETE13AM16	K			2/0/0/f/2			
Accounting	BMEGT35A410	K			2/0/0/f/3			
Analysis 1	BMETE92AM38	K			4/1/0/v/7			
Algebra 1	BMETE91AM38	K			4/1/0/v/7			
Probability Theory 1	BMETE95AM29	K			2/2/0/v/6			
Programming Exercises for Probability Theory	BMETE91AM46	K			0/0/0/f/1			
Differential Equations 1	BMETE93AM15	K			2/2/0/v/6			
Informaitcs 3	BMETE91AM44	K				2/0/2/f/4		
Mathematical Statistics 1	BMETE95AM31	K				2/0/2/v/5		
Analysis 2	BMETE92AM39	K				2/2/0/v/5		
Differential Geometry 1	BMETE94AM19	K				2/1/0/f/4		
Operations Research	BMETE93AM19	K				2/2/0/v/5		
Theory of Algorithms	BMEVISZAB01	K				2/2/0/v/4		
Programming Exercises for Theory of Algorithms	BMETE91AM47	K				0/0/0/f/1		
Algebra 2	BMETE91AM39	K					4/0/0/v/4	
Optimization Models	BMETE93AM16	K					2/0/2/f/4	
Stochastic Processes	BMETE95AM41	K					5/0/0/v/6	
Creating Mathematical Models	BMETE95AM12	K					0/2/0/f/2	
Micro- and Macroeconomics	BMEGT30A410	K					3/0/0/f/4	
Applied Numerical Methods with Matlab	BMETE92AMxx	K						2/0/2/f/4
Differential Geometry 2	BMETE94AM20	K						3/1/0/v/4
Finance	BMEGT35A411	K						2/0/0/f/3
BSc Thesis Project	BMETE90AM47	K						0/0/10/f/10
Specialized courses	**12 credits must be completed**							
Tools of Modern Probability Theory	BMETE95AM33	KV					4/0/0/v/4	
Measure Theory	BMETE92AM42	KV					4/0/0/v/4	
Individual Research Project 1	BMETE90AM48	KV					0/0/0/f/2	
Partial Differential Equations	BMETE92AM45	KV						2/2/0/v/4
Convex Geometry	BMETE94AM22	KV						2/2/0/v/4
Combinatorics and Graph Theory 2	BMEVISZA026	KV						2/2/0/v/4
Individual Research Project 2	BMETE90AM49	KV						0/0/0/f/2
Elective courses	**9 credits must be completed**							

Exam type: v = exam, f = midterm exam, a = signature, s = comprehensive exam
Subject type: K = obligatory, KV = elective , V = optional, KR = criterium

Curriculum of MSc in Physics

Subject			Lecture / Practice / Laboratory / Exam type / Credit				
Name	**Code**	**Type**	**1**	**2**	**3**	**4**	**Requisities**
Basic Courses	**3 of 6 must be completed: 12 credits**						
Fundamentals of Photonics	BMETE12MF49	KV	2/1/0/v/4				
Nuclear Physics	BMETE80MF00	KV		3/0/0/v/4			
Nanotechnology and Materials Science	BMETE11MF36	KV	3/0/0/v/4				
Particle Physics	BMETE15MF43	KV	2/1/0/v/4				
Statistical Physics 2	BMETE15MF44	KV	2/1/0/v/4				
Computer Simulation in Physics	BMETE15MF45	KV	2/1/0/f/4				
Obligatory Courses	**All of them must be completed: 20 credits**						
Advanced Physics Laboratory	BMETExxMFxx	K	0/0/6/f/6				
Seminar 1	BMETExxMFxx	K	0/2/0/f/2				
Seminar 2	BMETExxMFxx	K		0/2/0/f/2			
Seminar 3	BMETExxMFxx	K			0/2/0/f/2		
Seminar 4	BMETExxMFxx	K				0/2/0/a/0	
Investments	BMEGT35M004	K		2/0/0/f/2			
Applied Numerical Methods with Matlab	BMETE92MFxx	K			4/0/2/f/6		
Summer Practice	BMETExxMFxx	KR		0/0/9/a/0			
Thesis Work	**All of them must be completed: 50 credits**						
Independent Laboratory 1	BMETExxMFxx	K		0/0/7/f/7			
Independent Laboratory 2	BMETExxMFxx	K			0/0/13/f/13		
Diploma Work	BMETExxMFxx	K				0/0/10/f/30	
Specialized Professional Courses	**29 credits must be completed**						
Advanced general courses							
Group Theory for Physicists	BMETE11AF40	KV	2/2/0v/5				
Electrodynamics 2	BMETE15AF34	KV	2/0/0v/2				
Practical Course in Electrodynamics 2	BMETE15AF42	KV	0/2/0f/3				
Quantum Mechanics 2	BMETE15AF36	KV		2/0/0v/2			
Practical Course in Quantum Mechanics 2	BMETE15AF43	KV		0/2/0f/3			
Mechanics 2	BMETE15AF32	KV		2/0/0v/2			
Practical Course in Mechanics 2	BMETE15AF44	KV		0/2/0f/3			
Computer Solution of Technical and Physical Problems	BMETE11AF41	KV	0/0/2f/3				
Theory of Relativity	BMETE15AF46	KV	2/0/0v/3				
Fundaments and Applications of Materials Science	BMETE12AF31	KV	2/0/0v/3				
Microtechnology and Nanotechnology	BMETE12AF33	KV		2/0/0f/3			
Computer Controlled Measurements	BMETE11AF38	KV		0/0/2f/3			
Quantum Physics							
Quantum Field Theory	BMETE15MF46	KV		3/2/0v/6			
Quantum Information Processing	BMETE11MF42	KV			2/0/0v/3		
Quantum Optics	BMETE15MF49	KV			2/1/0v/4		
Many-Body Physics 1	BMETE15MF50	KV		3/1/0v/5			
Many-Body Physics 2	BMETE15MF54	KV			2/0/0v/3		
Quantum Monte Carlo Methods	BMETE15MF40	KV			2/0/0f/3		
Statistical Field Theory	BMETE15MF39	KV			2/0/0v/3		
The Physics of One-Dimensional Systems	BMETE15MF05	KV		2/0/0v/3			
Solid State Physics							
Modern Solid State Physics	BMETE11MF41	KV	3/2/0v/6				
Group Theory in Solid State Research	BMETE11MF12	KV		2/0/0v/3			
Superconductivity	BMETE11MF45	KV	2/0/0v/3				
Theory of Magnetism	BMETE11MF44	KV		2/1/0v/4			
Theory of Magnetism 2	BMETE11MF14	KV			2/0/0v/3		
Magnetic Resonance	BMETE11MF43	KV		2/1/0v/4			
Theoretical Nanophysics	BMETE15MF47	KV	2/1/0v/4				
Electronic Structure of Solid Matter	BMETE15MF51	KV			2/1/0v/4		
Foundations of Density Functional Theory	BMETE15MF15	KV			2/0/0v/3		
Topological Insulators	BMETE11MF34	KV			2/0/0v/3		
Topological Insulators 2	BMETE11MF35	KV				2/0/0v/3	

Curriculum of MSc in Physics (contd.)

Subject			Lecture / Practice / Laboratory / Exam type / Credit				
Name	**Code**	**Type**	**1**	**2**	**3**	**4**	**Requisities**
Statistical Physics							
Evolutionary Game Theory	BMETE15MF11	KV	2/0/0v/3				
Phase Transitions and Criticality	BMETE15MF48	KV	2/1/0v/4				
Complex Networks	BMETE15MF38	KV	2/0/0v/3				
The Physics of Disordered Systems	BMETE15MF53	KV	2/1/0v/4				
Random Matrix Theory and Its Physical Applications	BMETE15MF10	KV	2/0/0v/3				
Classical and Quantum Chaos	BMETE15AF45	KV	2/0/0v/3				
Nanotechnology and Materials Science							
Fundamentals of Nanophysics	BMETE11MF37	KV		3/0/0v/4			
Material Science Laboratory	BMETE12MF50	KV		0/0/3f/4			
Selected Topics of the Modern Materials Science	BMETE12MF52	KV		2/0/0v/3			
Physics of Semiconductors 1	BMETE11MF26	KV	2/0/0v/3				
Chemistry in Nanotechnology	BMETE11MF38	KV			2/0/0v/3		
Nanotechnology Laboratory	BMETE12MF54	KV		0/0/3f/4			
Optical Spectroscopy in Materials Science	BMETE11MF39	KV		3/0/0v/4			
Optics and Photonics							
Physics of Semiconductors 1	BMETE11MF26	KV	2/0/0v/3				
Light Sources	BMETE12MF14	KV	2/0/0v/3				
Physical Optics	BMETE12MF37	KV	4/0/0v/5				
Spectroscopy and Structure of Matter	BMETE12MF25	KV		2/0/0v/3			
Laser Physics	BMETE12MF17	KV		2/0/0v/3			
Optical Metrology	BMETE11MF21	KV			2/0/0v/3		
Physical Foundations of Optical Communications	BMETE11MF20	KV			2/0/0v/3		
Nuclear Technology							
Reactor Physics	BMETE80MD08	KV		3/1/0v/4			
Thermal Hydraulics	BMETE80MD10	KV				2/0/0v/2	
Reactor Technology and Operation	BMETE80MD09	KV				2/0/0v/2	
Fusion Devices	BMETE80MD04	KV		1/1/0v/2			
Nuclear Safety	BMETE80MD05	KV				2/0/0v/2	
Nuclear Techniques Laboratory	BMETE80MD03	KV		0/0/4f/5			
Medical Physics							
Nuclear Medicine	BMETE80MF97	KV		2/0/1v/3			
Medical Imaging	BMETE80MF91	KV	3/1/0v/4				
Magnetic Resonance and Clinical Applications	BMETE80MF90	KV		2/0/0v/2			
Magnetic Resonance and Clinical Applications 2	BMETE80MF75	KV			2/0/0v/3		
Optional Courses	**9 credits must be completed**						

Exam type: v = exam, f = midterm exam, a = signature, s = comprehensive exam

Subject type: K = obligatory, KV = elective , V = optional, KR = criterium

Curriculum of MSc in Mathematics

Subject			Lecture / Practice / Laboratory / Exam type / Credit				
Name	**Code**	**Type**	**1**	**2**	**3**	**4**	**Requisities**
Theoretical Foundations from BSc Courses	20 credits						
Primary Professional Courses	30 credits						
Group Theory	BMETE91MM03	KV		3/1/0/v/5			
Commutative Algebra and Algebraic Geometry	BMETE91MM01	KV			3/1/0/f/5		
Fourier Analysis and Function Series	BMETE92MM00	KV	3/1/0/v/5				
Partial Differential Equations 2	BMETE93MM03	KV		3/1/0/f/5			
Dynamical Systems	BMETE93MM02	KV		3/1/0/v/5			
General and Algebraic Combinatorics	BMEVISZM020	KV	3/1/0/f/5				
Combinatorial Optimization	BMEVISZM029	KV		3/1/0/v/5		3/1/0/v/5	
Theoretical Computer Science	BMETE91MM00	KV		3/1/0/f/5			
Differential Geometry and Topology	BMETE94MM00	KV	3/1/0/v/5				
Representation Theory	BMETE91MM02	KV				3/1/0/f/5	
Linear Programming	BMETE93MM01	KV			3/1/0/v/5		
Global Optimization	BMETE93MM00	KV				3/1/0/f/5	
Mathematical Statistics and Information Theory	BMETE95MM05	KV		3/1/0/v/5			
Stochastic Analysis and its Applications	BMETE95MM04	KV			3/1/0/v/5		
Professional Courses	**40 credits**						
Algorithms and Complexity	BMEVISZM031	KV		3/1/0/f/5		3/1/0/f/5	
Graphs, Hypergraphs and Their Applications	BMEVISZM032	KV			3/1/0/f/5		
Advanced Linear Algebra	BMETE91MM05	KV	2/0/0/v/3				
Homological Algebra	BMETE91MM06	KV	2/0/0/f/2				
Representations of Groups and Algebras	BMETE91MM04	KV				3/1/0/f/5	
Operator Theory	BMETE92MM05	KV	3/1/0/v/5				
Inverse Scattering Problems	BMETE92MM08	KV			2/0/0/v/3		
Matrix Analysis	BMETE92MM03	KV			2/0/0/v/3		
Numerical Methods 2 – Partial Diff. Equations	BMETE92MM07	KV				2/0/2/v/5	
Distribution Theory and Green Functions	BMETE92MM22	KV				2/0/0/v/2	
Potential Theory	BMETE92MM04	KV				2/0/0/f/3	
Non-Euclidean Geometry	BMETE94MM03	KV	3/1/0/v/5				
Combinatorial and Discrete Geometry	BMETE94MM02	KV		3/1/0/v/5			
Projective Geometry	BMETE94MM01	KV			2/2/0/f/5		
Stochastic Programming	BMETE93MM05	KV		3/1/0/v/5			
Nonlinear Programming	BMETE93MM04	KV				3/1/0/v/5	LinProg
Algebraic and Arithmetical Algorithms	BMETE91MM08	KV			3/1/0/f/5		
Analytic Number Theory	BMETE95MM13	KV				2/0/0/f/2	
Algebraic Number Theory	BMETE91MM07	KV				2/0/0/v/3	
Statistical Program Packages 2	BMETE95MM09	KV	0/0/2/f/2				
"Limit- and Large Deviation Theorems of Probability Theory"	BMETE95MM10	KV		3/1/0/v/5			
Markov Processes and Martingales	BMETE95MM07	KV			3/1/0/v/5		
Advanced Theory of Dynamical Systems	BMETE95MM12	KV				2/0/0/f/2	
Stochastic Models	BMETE95MM11	KV				2/0/0/f/2	
Stochastic Differential Equations	BMETE95MM08	KV				3/1/0/v/5	StochAnal, MarkovProc
Other Courses	**30 credits**						
Mathematical Modelling Seminar 1	BMETE95MM01	K	2/0/0/f/1				
Individual Projects 1	BMETE92MM01	K		0/0/4/f/4			
Report	BMETE90MM90	KR		0/0/0/a/0			
Preparatory Course for Master's Thesis	BMETE90MM98	K			0/2/0/f/5		Report
Mathematical Modelling Seminar 2	BMETE95MM02	K			2/0/0/f/1		
Individual Projects 2	BMETE92MM02	K			0/0/4/f/4		
Master's Thesis	BMETE90MM99	K				0/8/0/a/15	PrepMThesis

Exam type: v = exam, f = midterm exam, a = signature

Subject type: K = obligatory, KV = elective , V = optional

Curriculum of MSc in Applied Mathematics
Specialization in Applied Analysis

Subject			Lecture / Practice / Laboratory / Exam type / Credit				
Name	**Code**	**Type**	**1**	**2**	**3**	**4**	**Requisities**
Theoretical Foundations from BSc Courses	**20 credits**						
Primary Professional Courses	**30 credits**						
Commutative Algebra and Algebraic Geometry	BMETE91MM01	KV			3/1/0/f/5		
Differential Geometry and Topology	BMETE94MM00	KV	3/1/0/v/5				
Dynamical Systems	BMETE93MM02	K		3/1/0/v/5			
Fourier Analysis and Function Series	BMETE92MM00	K	3/1/0/v/5				
General and Algebraic Combinatorics	BMEVISZM020	KV	3/1/0/f/5				
Global Optimization	BMETE93MM00	KV				3/1/0/f/5	
Linear Programming	BMETE93MM01	KV			3/1/0/v/5		
Mathematical Statistics and Information Theory	BMETE95MM05	KV		3/1/0/v/5			
Partial Differential Equations 2	BMETE93MM03	K		3/1/0/f/5			
Representation Theory	BMETE91MM02	KV				3/1/0/f/5	
Stochastic Analysis and its Applications	BMETE95MM04	KV			3/1/0/v/5		
Theoretical Computer Science	BMETE91MM00	KV		3/1/0/f/5			
Courses of Specialization	**30 credits**						
Distribution Theory and Green Functions	BMETE92MM22	K				2/0/0/v/2	
Geometry of Classical Field Theories	BMETE94MM11	K	2/0/0/f/2				
Inverse Scattering Problems	BMETE92MM08	K			2/0/0/v/3		
Mathematical Chemistry	BMETE92MM09	KV				2/0/2/v/5	
Numerical Methods 2 - Partial Differential Equations	BMETE92MM07	KV				2/0/2/v/5	
Mathematical Methods of Classical Mechanics	BMETE93MM12	K		2/0/0/f/2			
Mathematical Methods of Statistical Physics	BMETE95MM27	K		2/0/0/v/3			
Mathematical Percolation Theory	BMETE95MM24	KV				2/0/0/f/3	
Potential Theory	BMETE92MM04	KV				2/0/0/f/3	
Matrix Analysis	BMETE92MM03	K			2/0/0/v/3		
Operator Theory	BMETE92MM05	K	3/1/0/v/5				
Vector Spaces in Physics	BMETE92MM21	K	2/0/0/f/2				
Other Courses	**40 credits**						
Mathematical Modelling Seminar 1	BMETE95MM01	K	2/0/0/f/1				
Individual Projects 1	BMETE92MM01	K		0/0/4/f/4			
Report	BMETE90MM90	KR		0/0/0/a/0			
Optional Courses	10 credits	V					
Preparatory Course for Master's Thesis	BMETE90MM98	K			0/2/0/f/5		Report
Mathematical Modelling Seminar 2	BMETE95MM02	K			2/0/0/f/1		
Individual Projects 2	BMETE92MM02	K			0/0/4/f/4		
Master's Thesis	BMETE90MM99	K				0/8/0/a/15	PrepMThesis

Exam type: v = exam, f = midterm exam, a = signature
Subject type: K = obligatory, KV = elective , V = optional

Curriculum of MSc in Applied Mathematics
Specialization in Operation Research

Subject			Lecture / Practice / Laboratory / Exam type / Credit				
Name	**Code**	**Type**	**1**	**2**	**3**	**4**	**Requisities**
Theoretical Foundations from BSc Courses	**20 credits**						
Primary Professional Courses	**30 credits**						
Commutative Algebra and Algebraic Geometry	BMETE91MM01	KV			3/1/0/f/5		
Differential Geometry and Topology	BMETE94MM00	KV	3/1/0/v/5				
Dynamical Systems	BMETE93MM02	KV		3/1/0/v/5			
Fourier Analysis and Function Series	BMETE92MM00	KV	3/1/0/v/5				
General and Algebraic Combinatorics	BMEVISZM020	KV	3/1/0/f/5				
Global Optimization	BMETE93MM00	K				3/1/0/f/5	
Linear Programming	BMETE93MM01	K			3/1/0/v/5		
Mathematical Statistics and Information Theory	BMETE95MM05	K		3/1/0/v/5			
Partial Differential Equations 2	BMETE93MM03	KV		3/1/0/f/5			
Representation Theory	BMETE91MM02	KV				3/1/0/f/5	
Stochastic Analysis and its Applications	BMETE95MM04	KV			3/1/0/v/5		
Theoretical Computer Science	BMETE91MM00	KV		3/1/0/f/5			
Courses of Specialization	**30 credits**						
Combinatorial Optimization	BMEVISZM029	KV		3/1/0/v/5			
Control Systems	BMETE93MM07	K			2/0/0/v/3		
Econometrics	BMETE93MM10	K	0/0/2/f/2				
Game Theory	BMETE93MM09	K	2/0/0/f/3				
Introduction to Economic Dynamics	BMETE93MM08	K	3/1/0/v/5				
Nonlinear Programming	BMETE93MM04	K				3/1/0/v/5	LinProg
Operations Research Software	BMETE93MM06	K			0/0/2/f/2		
Stochastic Programming	BMETE93MM05	K		3/1/0/v/5			
Other Courses	**40 credits**						
Mathematical Modelling Seminar 1	BMETE95MM01	K	2/0/0/f/1				
Individual Projects 1	BMETE92MM01	K		0/0/4/f/4			
Report	BMETE90MM90	KR		0/0/0/a/0			
Optional Courses	10 credits	V					
Preparatory Course for Master's Thesis	BMETE90MM98	K			0/2/0/f/5		Report
Mathematical Modelling Seminar 2	BMETE95MM02	K			2/0/0/f/1		
Individual Projects 2	BMETE92MM02	K			0/0/4/f/4		
Master's Thesis	BMETE90MM99	K				0/8/0/a/15	PrepMThesis

Exam type: v = exam, f = midterm exam, a = signature
Subject type: K = obligatory, KV = elective , V = optional

Curriculum of MSc in Applied Mathematics Specialization in Financial Mathematics

Subject			Lecture / Practice / Laboratory / Exam type / Credit				
Name	**Code**	**Type**	**1**	**2**	**3**	**4**	**Requisities**
Theoretical foundations (20 ECTS credits). Earlier not completed, prescribed subjects from BSc in Math in order below.							
Stochastic Processes	BMETE95AM41	KV	5/0/0/v/6				
Probability Theory 2	BMETE95AM30	KV		3/1/0/v/4			
Tools of Modern Probability Theory	BMETE95AM33	KV	4/0/0/v/4				
Applied Stochastics	BMETE95AM42	KV	2/0/2/v/4				
Measure Theory	BMETE92AM42	KV	4/0/0/v/4				
Functional Analysis 1	BMETE92AM40	KV	4/0/0/v/4				
Partial Differential Equations	BMETE92AM45	KV		2/2/0/v/4			
Professional subjects (30 ECTS credits must be completed).							
Global Optimization	BMETE93MM00	KV				3/1/0/f/5	
Linear Programming	BMETE93MM01	K			3/1/0/v/5		
Theoretical Computer Science	BMETE91MM00	KV		3/1/0/f/5			
General and Algebraic Combinatorics	BMEVISZM020	KV	3/1/0/f/5				
Dynamical Systems	BMETE93MM02	KV		3/1/0/v/5			
Fourier Analysis and Function Series	BMETE92MM00	KV	3/1/0/v/5				
Partial Differential Equations 2	BMETE93MM03	KV		3/1/0/f/5			
Stochastic Analysis and its Applications	BMETE95MM04	K			3/1/0/v/5		
Mathematical Statistics and Information Theory	BMETE95MM05	K		3/1/0/v/5			
Commutative Algebra and Algebraic Geometry	BMETE91MM01	KV			3/1/0/f/5		
Representation Theory	BMETE91MM02	KV				3/1/0/f/5	
Differential Geometry and Topology	BMETE94MM00	KV	3/1/0/v/5				
Obligatory courses of specialization (36 ECTS credits)							
Nonparametric Statistics	BMETE95MM20	K	2/0/0/v/3				
Statistical Program Packages 2	BMETE95MM09	K	0/0/2/f/2				
Multivariate Statistics	BMETE95MM15	K	3/1/0/v/5				
Markov Processes and Martingales	BMETE95MM07	K			3/1/0/v/5		
Stochastic Differential Equations	BMETE95MM08	K				3/1/0/v/5	StochAnal, Markov Proc
Financial Processes	BMETE95MM14	K				2/0/0/f/3	
Extreme Value Theory	BMETE95MM16	K		2/0/0/v/3			
Insurance Mathematics 2	BMETE95MM17	K				2/0/0/f/2	
Macroeconomics and Finance for Mathmeaticians	BMETE95MM30	K	2/0/0/v/3				
Analysis of Economic Time Series	BMEGT30M400	K			2/0/0/f/2		
Time Series Analysis with Applications in Finance	BMETE95MM26	K	2/0/0/f/3				
Obligatory common subjects (30 ECTS credits)							
Individual Projects 1	BMETE92MM01	K		0/0/4/f/4			
Individual Projects 2	BMETE92MM02	K			0/0/4/f/4		
Mathematical Modelling Seminar 1	BMETE95MM01	K	2/0/0/f/1				
Mathematical Modelling Seminar 2	BMETE95MM02	K			2/0/0/f/1		
Report	BMETE90MM90	KR	0/0/0/a/0				
Preparatory Course for Master's Thesis	BMETE90MM98	K			0/2/0/f/5		Report
Master's Thesis	BMETE90MM99	K				0/8/0/f/15	PrepMThe-sis
Elective professional courses (4 ECTS credits must be completed)							

Exam type: v = exam, f = midterm exam, a = signature
Subject type: K = obligatory, KV = elective , V = optional, KR = criterium

Curriculum of MSc in Applied Mathematics
Specialization in Stochastics

Subject			Lecture / Practice / Laboratory / Exam type / Credit				
Name	**Code**	**Type**	**1**	**2**	**3**	**4**	**Requisities**
Theoretical foundations (20 ECTS credits). Earlier not completed, prescribed subjects from BSc in Math in order below.							
Stochastic Processes	BMETE95AM41	KV	5/0/0/v/6				
Probability Theory 2	BMETE95AM30	KV		3/1/0/v/4			
Tools of Modern Probability Theory	BMETE95AM33	KV	4/0/0/v/4				
Applied Stochastics	BMETE95AM42	KV	2/0/2/v/4				
Measure Theory	BMETE92AM42	KV	4/0/0/v/4				
Functional Analysis 1	BMETE92AM40	KV	4/0/0/v/4				
Partial Differential Equations	BMETE92AM45	KV		2/2/0/v/4			
Professional subjects (30 ECTS credits must be completed).							
Global Optimization	BMETE93MM00	KV				3/1/0/f/5	
Linear Programming	BMETE93MM01	KV			3/1/0/v/5		
Theoretical Computer Science	BMETE91MM00	KV		3/1/0/f/5			
General and Algebraic Combinatorics	BMEVISZM020	KV	3/1/0/f/5				
Dynamical Systems	BMETE93MM02	KV		3/1/0/v/5			
Fourier Analysis and Function Series	BMETE92MM00	KV	3/1/0/v/5				
Partial Differential Equations 2	BMETE93MM03	K		3/1/0/f/5			
Stochastic Analysis and its Applications	BMETE95MM04	K			3/1/0/v/5		
Mathematical Statistics and Information Theory	BMETE95MM05	K		3/1/0/v/5			
Commutative Algebra and Algebraic Geometry	BMETE91MM01	KV			3/1/0/f/5		
Representation Theory	BMETE91MM02	KV				3/1/0/f/5	
Differential Geometry and Topology	BMETE94MM00	KV	3/1/0/v/5				
Obligatory courses of specialization (30 ECTS credits)							
Multivariate Statistics	BMETE95MM15	K	3/1/0/v/5				
Nonparametric Statistics	BMETE95MM20	K	2/0/0/v/3				
Statistical Program Packages 2	BMETE95MM09	K	0/0/2/f/2				
Markov Processes and Martingales	BMETE95MM07	K			3/1/0/v/5		
Stochastic Differential Equations	BMETE95MM08	K				3/1/0/v/5	StochAnal, MarkovProc
Financial Processes	BMETE95MM14	K				2/0/0/f/3	
Limit- and Large Deviation Theorems of Probability Theory	BMETE95MM10	K		3/1/0/v/5			
Stochastic Models	BMETE95MM11	KV				2/0/0/f/2	
Advanced Theory of Dynamical Systems	BMETE95MM12	KV				2/0/0/f/2	
Obligatory common subjects (30 ECTS credits)							
Individual Projects 1	BMETE92MM01	K		0/0/4/f/4			
Individual Projects 2	BMETE92MM02	K			0/0/4/f/4		
Mathematical Modelling Seminar 1	BMETE95MM01	K	2/0/0/f/1				
Mathematical Modelling Seminar 2	BMETE95MM02	K			2/0/0/f/1		
Report	BMETE90MM90	KR	0/0/0/a/0				
Preparatory Course for Master's Thesis	BMETE90MM98	K			0/2/0/f/5		Report
Master's Thesis	BMETE90MM99	K				0/8/0/f/15	PrepMThe-sis
Elective professional courses (10 ECTS credits must be completed)							

Exam type: v = exam, f = midterm exam, a = signature
Subject type: K = obligatory, KV = elective , V = optional, KR = criterium

Curriculum of MSc in Computational and Cognitive Neuroscience

Subject			Lecture / Practice / Laboratory / Exam type / Credit				
Name	**Code**	**Type**	**1**	**2**	**3**	**4**	**Requisities**
Theoretical foundations							
Informatics	BMETE92MC19	K	0/2/0/f/3				
Introduction to Cognitive Science	BMETE47MC01	K	2/0/0/f/3				
Introduction to Experimental Psychology	BMETE47MC25	K	2/0/0/v/3				
Mathematics	BMETE92MC15	K	2/2/0/v/5				
Neurobiology 1 – Foundations and Neurobiology of Perception	BMETE47MC22	K	2/0/2/v/5				
Psycholinguistics	BMETE47MC36	K	2/0/0/v/3				
Statistics and Methodology	BMETE92MC20	K	2/0/2/v/5				
Advanced Courses							
Cognition and Emotion	BMETE47MC26	K		2/0/0/f/3			
Cognitive Psychology Laboratory	BMETE47MC27	K		0/0/8/v/9			
Epistemology	BMEGT41M410	KV		2/0/0/v/3			
Evolutionary Psychology	BMETE47MC07	K		2/0/0/f/3			
Intelligent Systems	BMEVITMM031	KV		2/0/0/f/3			Informatics
Neurobiology 2 – Sensory and Motor Processes	BMETE47MC23	K		2/0/0/v/3			Neuro-biology 1
Neuropsychology	BMETE47MC06	K		2/0/2/v/5			Neuro-biology 1
Philosophy of Science	BMEGT41M411	KV		2/0/0/v/3			
Specialized Courses							
Brain in Trouble	BMETE47MC34	K			2/0/0/f/2		
Cognitive Informatics in Human Vision	BMEVITMM032	KV			2/0/0/v/3		Informatics
Cognitive Neuropsychiatry	BMETE47MC30	K			2/0/0/v/3		Neuro-psichology
Historical Reconstruction of Scientific Thinking	BMEGT41M413	KV			2/2/0/v/5		
Introduction to Cultural Studies	BMEGT43M410	KV			2/0/0/f/3		
Introduction to Matlab Programming	BMETE92MC14	KV			0/2/0/f/3		Informatics
Memory and the Psychology of Learning	BMETE47MC29	K			0/3/0/f/3		Int.Exp.Sci.
Neurobiology 3 – Higher Cognitive Functions	BMETE47MC24	K			2/0/0/v/3		Neuro-biology 2
Philosophy of Mind	BMETE47MC18	KV			2/0/0/f/3		
Pragmatics and Cognitive Linguistics	BMETE47MC15	KV			2/0/0/f/3		Psycho-linguistics
Reading Seminar in Psycholinguistics 1	BMETE47MC31	K			0/2/0/v/3		Psycho-linguistics
Reading Seminar in Psycholinguistics 2	BMETE47MC32	K			0/2/0/v/3		Psycho-linguistics
Reading Seminar in Psycholinguistics 3	BMETE47MC33	K			0/2/0/f/3		Psycho-linguistics
Social Cognition	BMETE47MC28	K			2/0/0/v/3		
Speech Communication	BMEVITMJV62	KV			4/0/0/v/4		
Theory of Science	BMEGT41M412	KV			2/0/0/f/3		
Others							
Optional courses		V	2/0/0/f/3	2/0/0/f/3			
Preparatory Course for Master's Thesis	BMETE47MC35	K			0/12/0/f/12		
Research Seminar	BMETE47MC20	K				0/0/10/f/10	
Master's Thesis	BMETE47MC21	K				0/20/0/f/20	

Exam type: v = exam, f = midterm exam, a = signature
Subject type: K = obligatory, KV = elective , V = optional

Description of BSc Subjects in Physics

MATHEMATICS

Mathematical Methods in Physics 1

BMETE92AF35 – 4/2/0/v/6

Dr. Tamás Tasnádi

The course gives an introduction to mathematical tools used in the Experimental Physics 1-2 courses without giving precise proofs. The aim of the course is to develop the calculation facility of the students and enable them to use mathematical methods in physical problems. One fourth of the lectures and the practices are devoted to practice the subject on specific problems. The course is jointly held by the Institutes of Mathematics and Physics. Themes: Complex numbers, basic laws of algebra, algebraic, trigonometric, and exponential forms of complex numbers, complex operations. Vectors, matrices: operations (scalar, cross, diadic product), determinant and its properties, trace, Levi-Civita symbol, linear system of equations, inverse matrix, Gauss elimination, eigenvalue, eigenvector, characteristic polynomial. Differentiation: definition, basic rules, higher order derivatives, Taylor series, partial derivative, total derivative, Young's theorem, differentiation of vectors, divergence, gradient, curl, nabla symbol, Jacobian matrix. Integration: definitions, definite, indefinite, partial, u-substitution, multiple integral, path, surface, volume integrals, Gauss, Stokes theorem.

Mathematical Methods in Physics 2

BMETE92AF36 – 4/2/0/v/6

Dr. Tamás Tasnádi

The course gives an introduction to mathematical tools used in the Experimental Physics 1-2 courses without giving precise proofs. The aim of the course is to develop the calculation facility of the students and enable them to use mathematical methods in physical problems. One fourth of the lectures and the practices are devoted to practice the subject on specific problems. The course is jointly held by the Institutes of Mathematics and Physics. Themes: curvilinear coordinates, covariant, contravariant operations, transformation, cylindrical, spherical coordinates, derivatives. Linear algebra: basis, dual vector space, symmetric operators, similarity transformations, invariants, matrix polynomial, matrix functions, spectral decomposition. Complex analysis: poles, residue theorem, contour integral. Distributions: Dirac delta, operations. Fourier transformation: applications: Fourier-series, convolution, Green's theorem.

Analysis for Physicists

BMETE93AF00 – 4/2/0/v/6

Dr. Tibor Illés

Rational and real numbers, sets, convergence of real series. Functions of one variable: continuity, properties of continuous functions, monotonicity, properties of monotonic functions, differentiability, significant limits, elemental functions and their inverse functions, intermediate value theorems, properties of differentiable functions, function analysis. Taylor polynomial, definite and indefinite integral, technique of integration, usage of integration, improper integral, simple differential equations. Infinite series. Convergence criteria.

Multivariate Analysis for Physicists

BMETE93AF01 – 4/2/0/v/6

Dr. Tibor Illés

Function of 2 real variables. Continuity, level curves, differentiation. Young theorem, total differential. Local, global and conditional extremum. Implicit functions. Functions of several variables. Derivative vector, directional derivative. Geometric visualization, level surfaces, chain rule. Integration: double, triple integrals, integral transformations. Cylindrical, spherical coordinates. Spatial curves. Arc length, curvature, torsion. Surfaces. Tangent plane, normal vector, surface area. Scalar and vector fields. Line and surface integrals. Divergence and curl, theorems of Gauss and Stokes, Green formulae. Conservative vector fields, potentials. Some applications of vector analysis. Functional sequences, series. Power, Taylor, Laurent, Fourier series. Software applications for solving some elementary problems.

Probability Theory for Physicists

BMETE95AF00 – 2/2/0/v/4

Dr. Péter Bálint

Introduction: empirical background, sample space, events, probability as a set function. Enumeration problems, inclusion-exclusion formula, urn models, problems of geometric origin. Conditional probability: basic concepts, multiplication rule, law of total probability, Bayes formula, applications. Independence. Discrete random variables: probability mass function, Bernoulli, geometric, binomial, hypergeometric and negative binomial distributions. Poisson approximation of the binomial distribution, Poisson distribution, Poisson process, applications. General theory of random variables: (cumulative) distribution function and its properties, singular continuous distributions, absolutely continuous distributions and probability density functions. Important continuous distributions: uniform, exponential, normal (Gauss), Cauchy. Distribution of a function of a random variable, transformation of probability densities. Quantities associated to distributions: expected value, moments, median, variance and their properties. Computation for the important distributions. Steiner formula. Applications. Joint distributions: joint distribution, mass and density functions, marginal and conditional distributions. Important joint distributions: polynomial, polyhypergoemetric, uniform and mutlidimensional normal distribution. Conditional distribution and density functions. Conditional expectation and prediction, conditional variance. Vector of expected values, Covariance matrix, Cauchy-Schwartz inequality, correlation. Indicator random variables. Weak Law of Large Numbers: Bernoull Law of Large Numbers, Markov and Chebyshev inequality. Weak Law of Large numbers in full generality. Application: Weierstrass approximation theorem. Normal approximation of binomial distribution: Stirling formula, de Moivre-Laplace theorem. Applications. Normal fluctuations. Central Limit Theorem.

FUNDAMENTAL PHYSICS

Experimental Physics 1

BMETE13AF02 – 4/4/0/fv/8

Dr. Péter Vankó

Basic concepts of kinematics, kinematics of points. Force, Newton's laws, momentum. Gravity, the equivalence principle, SI units. Dynamics, frames of reference, the principle of relativity, inertial forces. Work, kinetic and potential energy. Point-mass systems, conservation laws in mechanics. Statics, kinematics and dynamics of rigid bodies. Elasticity. Fluids: statics, surface phenomena, frictionless and viscous flow, drag. Oscillations: free, damped and driven harmonic oscillators. Superposition of vibrations. Coupled vibrations. Waves, classical wave function. Harmonic waves, phase and group velocity. Wave equation in elastic rods, energy transport in waves. Polarization. Reflection and refraction. Interference, coherence, diffraction. Standing waves. Wave equation in gases and on strings. Standing wave equation, whistles, strings, the physics of music. Doppler effect. Ultrasonic medical diagnostic.

Experimental Physics 2

BMETE13AF03 – 4/4/0/fv/8

Dr. Pál Koppa

The basic electric phenomena, electric charge, Coulomb's law. Electric field strength. Electric potential, the first law of electrostatics. Flux, the second law of electrostatics in vacuum. Calculation of the electric field of simple charge distributions. Conductors in electric field. Potential and capacity of charged conductors. Electric dipoles. Polarization, the first and second laws of electrostatics in insulators. The dielectric displacement vector, electric susceptibility and permittivity. The energy density of the electric field. Electric current, Ohm's law, resistance, conductivity and mobility. Kirchhoff's laws. Joule's Law. Mechanisms of conduction in different materials. Contact phenomena. Basic magnetic phenomena, magnetic induction. Forces in a magnetic field. Magnetic dipole moment. Magnetic field of currents, Biot-Savart law and the first law of magnetostatics in vacuum. Calculation magnetic field of simple current arrangements. Induction flux, second law of magnetostatics in vacuum. Interaction of currents, unit of current in SI. The magnetization vector, the first and second laws of magnetostatics in materials. Magnetic susceptibility and permeability. The magnetic field strength vector. Electromagnetic induction. Lenz's law, eddy currents. Self-induction, mutual induction. The energy of magnetic field. Displacement current, Maxwell's equations. The fundaments of special relativity. Electromagnetic oscillations. Electromagnetic waves. Refraction, reflection and interference of light waves. Diffraction, Fraunhofer diffraction on a slit and on a grating. X-ray diffraction. Fresnel diffraction.

Experimental Physics 3

BMETE15AF21 – 3/2/0/fv/5

Dr. Orsolya Újsághy

Thermodynamics: Temperature, Temperature scales. Equation of States of the ideal gas. Basics of the kinetic theory of gases, pressure, temperature, kinetic energy. Maxwellian velocity distribution. Real gases and the van der Waals equation. Transport properties of gases: mean free path, diffusion, heat conduction, viscosity. State of a system, equation of state. Quasi-static and reversible processes. Heat, internal energy, work, first law of Thermodynamics. Specific heat, enthalpy. Isothermal, isobaric, isochoric, adiabatic processes of ideal gases. Thermodynamic cycles. Second law of Thermodynamics. Efficiency of the Carnot Engine. Entrophy. Basics of statistical mechanics: microstate, macrostate, interpretation of the entropy. Conditions for thermodynamic equilibrium in homogeneous systems. Thermodynamical potentials. Fundamental equations, Maxwell relations, Gibbs-Helmholtz equations. Third law of Thermodynamics. Chemical potential, Euler equations, Gibbs-Duhem relation. Phase transitions, Clapeyron equation. Gibbs phase rule. Introduction to Quantum Mechanics: Black-body radiation, Photoelectric effect, Compton-effect. Atomic spectra, Thomson, Rutherford, and Bohr model of the atom. De-Broglie wavelength. Wave function, Schrödinger equation. Quantum tunneling. Quantum numbers, Pauli principle.

Experimental Nuclear Physics

BMETE80AF18 – 2/1/0/v/3

Dr. Rita Dóczi

Composition of the atomic nucleus, nuclear force, mass defect and stability of the nucleus, binding energy. The liquid drop model and the semi-empirical mass formula. Two ways to release nuclear energy. Types of radioactive decay, exponential decay law, radioactive decay chains; alpha, beta and gamma decay. Types of nuclear reactions, conservation of quantities with nuclear reactions, direct nuclear reactions and compound nucleus reactions. Microscopic and macroscopic cross sections. Types and properties of the neutron induced nuclear reactions. The energy dependence of the cross section of neutron induced nuclear reactions. Neutron slowing-down. Fast neutrons, epithermal neutrons, thermal neutrons. Interaction of radiation with matter: interaction of charged particles (alpha and beta radiation), neutron and gamma radiation with matter, the exponential attenuation of the radiation. Basic properties of the nuclear radiation detectors: gas-filled detectors, scintillation detectors, semiconductor detectors, thermoluminescent dosimeters, solid-state nuclear track detectors. Neutron detectors. Nuclear fission. Fission products, fission neutrons; the energy balance of the fission process. Chain reaction with neutrons, time-behaviour of the chain reaction, effective neutron multiplication factor, the basic constituents of a thermal-neutron reactor. Nuclear reactions capable to produce fissile material. Types of particle accelerators.

ADVANVED PHYSICS

Mechanics 1

BMETE15AF23 – 2/2/0/fv/5

Dr. Gergely Zaránd

Hamiltonian mechanics: Newton axioms, motions of systems of point particles and conserved quantities (first integrals). Motion in one dimension. Forces of inertia. Rigid body and tensor of inertia, Euler equations. Constraints, generalized coordinates, D'Alambert's principle and Lagrange-formalism. Charged particle in an electromagnetic field. Lagrange theory of a symmetrical top. Hamilton's principle. Motion in central potential, two-body problem, stellar motion, scattering theory and cross-section. Theory of small oscillations. Hamilton formalism. Liouville's theorem. Continuum mechanics: Deformations, strain and Stress tensor. Continuity equation. Lagrange's equation of motion. Viscous fluids and Navier-Stokes equation, laminar flow. Sound waves in isotropic solids. In practical course: General description of the motion of point particles (curvilinear coordinates). One-dimensional damped oscillations, motion in one dimension. Forces of inertia, motion on the rotating Earth. Rigid body and tensor of inertia, Euler angles. Principle of virtual work. Lagrange I and Lagrange II equations. Theory of small oscillations. Hamilton formalism. Deformations, strain and Stress tensor. Laminar flow.

Quantum Mechanics 1

BMETE15AF27 – 2/2/0/fv/5

Dr. László Szunyogh

This course serves to ground the concepts and methods of Quantum Mechanics. Topics to be covered: Experimental backgrounds of Quantum Mechanics. Mathematical apparatus: Hilbert space, operators, properties of Hermitian operators, eigenvalue problem of operators. Schrödinger equation, wavefunctions, probability density. Eigenvalues and eigenfunctions of the coordinate and linear momentum operators. Quantum theory of measurements, Heisenberg's uncertainty principle. Tunneling effect. Harmonic oscillator, step operators. Eigenproblem of angular momentum operators, addition of angular momenta. Central potential, radial Schrödinger equation. Hydrogen atom. Approximation methods: variational principle, stationary and time-dependent perturbation theory. The spin: experimental evidences, spin operators, Pauli equation. Identical particles, Pauli principle. Atoms and periodic table. In practical course: Mathematical basis, Hilbert space, operators and their eigenproblem. Solution of the Schrödinger equation for simple systems. One-dimensional potential barrier, tunneling effect. Sommerfeld polynomial method. Harmonic oscillator. Eigenvalue problem of the angular momentum operators. Energy eigenvalues and eigenstates of the Hydrogen atom. Rayleigh–Ritz variational approach. Rayleigh–Schrödinger stationary perturbation theory. Dirac's time-dependent perturbation theory. Many particle systems: Helium atom, Hartree method.

Electrodynamics 1

BMETE15AF25 – 2/2/0/fv/5

Dr. Gábor Takács

Electrostatics: point charge and charge distribution, Gauss's Law, Maxwell's equations for electrostatics. Potential, Poisson and Laplace equations, boundary conditions. Green's function, capacitance, method of images. Electric dipole and quadrupole, multipole expansion. Dielectrics, polarization, electric displacement field, surface charge density. Energy of electrostatics field. Magnetostatics: current density, charge conservation. Biot-Savart law. Maxwell's equations for magnetostatics. Vector potential. Magnetic dipole. Magnetostatics in the presence of matter. Boundary conditions, surface current density. Linear and nonlinear materials, hysteresis. Quasistatic fields: electromotive force, Faraday's law, Lenz's law. Inductance. Quasistatic magnetic field in conductors, skin effect. Energy of magnetic field. Dynamics: displacement current, full Maxwell's equations in vacuum and matter. Potentials, gauge fixing, d'Alambert equation. Energy and momentum of the elctromagnetic field. Plane waves, polarization, energy and momentum. Electromagnetic waves in matter, reflection and refraction. Retarded and advanced Green's functions. Dipole approximation, Larmor formula. Thomson and Rayleigh scattering.

Statistical Physics 1

BMETE15AF29 – 2/2/0/fv/5

Dr. Gergely Zaránd

Micro- and macro-states, closed systems, equilibrium and ergodicity. Principle of equal probabilities, Boltzmann entropy, connection to thermodynamics. Statistical physical ensembles and their equivalence. Thermodynamic potentials and fluctuations. Ideal gases, Fermi-Dirac, Bose-Einstein and Maxwell-Boltzmann statistics. Black body radiation. Interacting systems, pair correlation functions, screening. Virial expansion. Van der Waals equation, mean field theory and critical behaviour.

Introduction to Solid State Physics

BMETE11AF05 – 2/2/0/fv/4

Dr. István Kézsmárki

Symmetries of crystals, crystal structures, Bravais lattices. Theory of diffraction, structural factor, atomic scattering factor. X-Ray, electron and neutron scattering experiments. Lattice vibrations in harmonic approximation, dynamical matrix, normal coordinates, dispersion relation, density of states. Quantum description of lattice vibrations, energy and momentum of phonons, experimental measurement of the dispersion relation. Bose-Einstein statistics, heat capacity of solid bodies, Debye approximation. Drude model of electrons, transport and optical properties. Fermi-Driac statistics, Sommerfeld expansion, heat capacity, magnetic susceptibility of an electron gas. Electrons in the periodic potential of a crystal, Bloch electrons. Band structure in the nearly free and tight binding approximation, effective mass. In practical course: Crystal structures, Bravais lattices: basis, unit cell, reciprocal lattice, packing faction. Theory of diffraction: structural factor, atomic scattering factor. Non-crystalline solids, liquid crystals. Real crystals, classification of defects, thermodynamics of point defects. Lattice vibrations in harmonic approximation: dispersion relation, effects of lattice vibration in the scattering pattern. Quantum description of lattice vibrations, energy and momentum of phonons, density of state, melting point of the crystal (Lindemann criterion). Bose-Einstein statistics, heat capacity of solid bodies, Debye approximation. Drude model of electrons, transport and optical properties. Fermi-Driac statistics, Sommerfeld expansion, heat capacity, magnetic susceptibility of an electron gas. Electrons in the periodic potential of a crystal, Bloch electrons. Band structure in the nearly free and tight binding approximation, effective mass.

Applied Solid State Physics

BMETE11AF11 – 2/0/0/v/2

Dr. Szabolcs Csonka

Band structure of metals and semiconductors, electron transport, electron scattering mechanisms, 2 dimensional electron gases, Si technology (FET, SSD memory), semiconductor heterostructure (semiconductor laser, MEMT), nanoelectronics, single electron transistor. Magnetic materials, origin of magnetic momentum and interaction between moments, magnetic structures. Magnetism of metals, spin polarized bands, spintronics devices (spin valve, MRAM). Spin transistor, magnetic semiconductors.

Optics

BMETE12AF35 – 2/2/0/v/4

Dr. Gábor Erdei

Models of light, Fermat-principle, Huygens-principle. Reflection and transmission of light at planar surfaces. Total reflection, evanescent wave. Geometrical optics. Paraxial optics, matrix optics. Concept of principle planes. Interference; single beam, multiple beam (Michelson, Mach-Sender). Resolution of optical gratings. Description ef systems of thin films by matrix formalism. Antireflection coating, interference mirror. Fabry-Perot interferometer. Diffraction, Fresnel- Kirchoff and Rayligh-Sommerfeld formulas. Fraunhofer and Fresnel diffraction. Square and round apertures. Fraunhofer diffraction image of a sinusoidal grating. Polarization. Polarization sensitive optical elements. Birefringence. Ordinary and extraordinary beams. Propagation of light in anisotropic media. Polarization prisms. polarizing and phases shifting plates. Interaction of light and matter. Energy levels, inverse population. Spontaneous emission, induced emission and absorption. Lasers, resonators, amplification, pumping. Temporal and spatial coherence. Acoustooptics. Modes of planar waveguides. Ray optics description. Propagation constant. Graphic solution of the mode equation.

LABORATORY WORK, MEASUREMENT TECHNIQUES, ELECTRONICS

Introductory Laboratory Exercises

BMETE11AF27 – 0/0/2/f/2

Sándor Bordács

Basic error analysis. Evaluation and plotting of the experimental data, linear regression, non-linear curve fitting. Simple experiments to practice data evaluation and error analysis. Basic functions of multimeters, oscilloscopes, function generators and data acquisition cards are introduced to the students. Students must attend to 6 laboratory practices each of them is 4 hour long.

Laboratory Exercises in Physics 1

BMETE11AF28 – 0/0/3/f/4

Dr. Péter Vankó

Basic instruments, procedures and methods. Evaluation of measurements, error calculation, protocol writing. Measurement of basic electrical, mechanical, optical and thermal quantities. Data collection (manual and by computer interfaces). Basic use of power supplies, sound generators, multimeters, oscilloscopes, etc. Measurements related to Experimental physics 1 and 2.

Laboratory Exercises in Physics 2

BMETE11AF29 – 0/0/4/f/5

Dr. Péter Vankó

Basic instruments, procedures and methods. Evaluation of measurements, error calculation, protocol writing. Measurement of complex electrical, mechanical, optical and thermal quantities. Advanced data collection. Advanced use of power supplies, sound generators, multimeters, oscilloscopes, etc. Measurements related to Experimental physics 1, 2 and 3.

Electronics

BMETE12AF27 – 2/0/0/f/2

Dr. Gábor Kiss

The primary aim is to teach the operation and planning of the basic circuits used in the experimental and applied physics. This subject is based on the thematics of Experimental physics 2 and Practice in experimental physics 2, giving knowledge in the physical bases of linear electronics (Maxwell-equations, Kirchoff-laws, resistance, capacity, inductivity, complex impedance, transient phenomena, RLC circuits). The detailed physics of semiconductor devices is tought later (Theoretical solid state physics, Applied solid state physics). In Electronics only the phenomenological models of semiconductor devices are treated. Thematics: Brush-up the physical bases of linear electronics. Linear electronic elements: ideal resistor, capacitor, inductor, distributed (parazite) parameters, volt and amper meters, voltage and current sources. Basic AC and DC circuits: bridges, voltage dividers, filter circuits, transformers. Introduction into the calculational methods of complex linear AC and DC circuits. Analysis methods of non-liner circuits. Small-signal models, notion of distorsion. Characteristics of diodes, bipolar and fiel-effect transistors, small and large signal models of the devices. Active analogue circuits, bipolar and field effect transistor amplifiers, rectifiers. Feedback and its application. Parameters of operation amplifiers and their applications. Inverting and non-inverting amplifiers, summarizing, differentiating and integrating circuits, schmitt-trigger circuit, oscillators. Special complex circuits (power supplies, regulators), protection of circuits.

Laboratory of Electronics

BMETE80AF03 – 0/0/2/f/2

Dr. Gábor Pór

This is a practical course, where students build basics electronics circuits like Smitt trigger, Miller effect and electronics of coincidence measurement. We pay attention mainly to electronics applied in nuclear measuring chains including signal formation differential and integral electronics, analog digital converters, transfer function signal/noise ratio, dead time, and jitter. Students get practice in electronics oscilloscopes, measuring automatically amplitude and spectrum. Using LABVIEW they learn how to build a spectrum analyzer in one day, measuring propagating perturbations to estimate velocity of natural convention in the water. All practice should be reported in form of well formatted measuring report including error estimation as well.

Measurement Techniques

BMETE11AF30 – 2/0/0/v/2

Dr. András Halbritter

Voltage and current sources/meters. Measurement of resistance, four probe method. Voltage and current amplifier circuits. A/D and D/A converters, data acquisition cards. Analog and digital oscilloscopes, sampling modes, triggering, waveform measurements, aliasing. Suppression of disturbing signals: electrostatic and inductive coupling, grounding and guarding, twisted pairs, thermo electric power and offset compensation, stray capacitance. Wave propagation in coaxial lines, telegraph equations, reflections at the cable termination. Fourier analysis considering finite temporal window: spectral leakage, frequency resolution and amplitude accuracy of various window functions. The role of finite sampling, sampling theorem. Discrete Fourier transform, and its implementation by the fast Fourier transform algorithm. Spectrum analyzers: FFT, swept tuned and hybrid devices. Phase sensitive measurements: lock-in amplifiers, phase locked loops. The application of PID control from temperature controllers to scanning probe microscopes. Electronic noise phenomena, thermal noise, noise limit of current amplifier circuits, cross correlation noise measurement. Fundamental measurement units (SI) and their definitions. Measurement standards: atomic clocks, conversion between voltage, current and frequency (josephson effect, Quantized Hall effect, elcetron pump), measurement of mass by Watt balance, measurement of temperature by the speed of sound and the thermal noise. Magnetic field sensors: inductive, magnetoresitive, spin valve, and Hall sensors, SQUID magnetometers. Distance and position sensors: linear differential transformers, capacitive tansducers, LASER and ultrasound based measurement of distance, LIDAR systems. Temperature sensors: thermocouples, resistance thermometers, thermistors. Light sensors: photo diodes, CCD sensors, CMOS active pixel sensors, bolometers. Measurement of acceleration: MEMS accelerometers and gyroscopes, piezoelectric accelerometers.

Advanced Laboratory Exercises in Physics 1

BMETE11AF32 – 0/0/4/f/5

Dr. Ferenc Fülöp

Advanced level experiments related to various topics of the modern physics and the current research activities in the

BME TTK: experiments in basic quantum physics; measuring basic physical constants; optical measurements, experiments in wave optics; mastering of modern measurement techniques.

Advanced Laboratory Exercises in Physics 2

BMETE11AF33 – 0/0/4/f/5

Dr. Ferenc Fülöp

Advanced level experiments related to various topics of the modern physics and the current research activities in the BME TTK: experiments in solid state physics, material sciences, optical phenomena and nuclear physics; investigation of ionising radiations and radiation detectors; acquirement of modern measurement techniques.

Advanced Laboratory Exercises in Physics 3

BMETE12AF21 – 0/0/4/f/5

Dr. Ferenc Ujhelyi

Advanced laboratory experiments related to the modern physics and the research fields of BME TTK mainly in the following fields: Semiconductor physics, material science, surface physics, vacuum techniques. Advanced optical measurements. Nuclear measurements. Modern measurement methods.

Computer programming, numerical methods (10 credits)

Programming

BMEVIEEA024 – 2/0/2/f/4

Dr. László Pohl

Synopsys of the subject, requirements, algorithm, data, language, programming languages, why the C? specification, design, coding, testing, documenting, algorithm choice questions in connection with GCD (trial and error, prime factors, Euclidean formula), elements of algorithms: sequence, branching, cycles, n! calculation: algorithm selection, parts, data structure, narrative description of the algorithm, algorithm by block diagram, encoding; a small analysis: mandatory elements of a C program, the frame, the main function, return 0; the purpose and significance of indenting, scanf for reading integer values, printf for writing integer values. Storage units: variables, constants, functions; mandatory declaration / definition, syntax / semantics: Syntax diagram, syntax of an integer value, Basic syntax rules: free writing mode (white spaces), a != A, #preproc, / * comment * /, regular identifiers; predefined types, why we use int and double, constant int definition in dec, oct, hex forms, lack of the logic type, logic value of numbers. Instructions: ;, declaration/definition, expression instruction, conditional instruction, cycle (now just the while), control statements (switch/case just mentioned), {}, block diagram of if..else and while. Conditions: relational operators ('==' != '=', the dangers), logic operators !, &&, ||. Supplement and deepen the knowledge of the past week. control structures, instructions, built-in types, number representation. Use of library functions. Basic operators: arithmetic, integer, real, type cast, assignment, sizeof, relational, logic, bitwise, shortcut, ?:. Iterative solutions, =, pre/post ++ --, dangers of post, arrays, 1D, 2D, strings, pointers. 1D dynamic array (example of use), (only breefly, at the level of usage: getchar, putchar, EOF, ctrl+z/ctrl+d) filter program template, enum type, finite automaton example: writing out the comments from a C code, ly counter. Functions, memory areas allocated in the program, what is/will be where, the heap, behavior of the stack, the consequences of the differences. Storage classes (for local variables), the function call mechanism, multiple return values: void descart2polar(double, double, double*, double *), why forbidden to return local variable address. Struct, ., ->, typedef, direct selection sort, bubble sort, for structure array also, comparing functions, strcmp, sorting by text. Function pointers, useage of qsort. Making of string, int and double comparing funtion (by a structure array sorting example), introducing recursive structure, ONLY drawn. Unidirectional, bidirectional, "arranged according to several criteria" list, binary tree, coded only the search in the list by cycle. Managing lists, insertion, search, deleting functions, the two possible head handling: head=insert(head..., and insert (&head,..., interpretation of recursion by n!, binary tree management, inorder traversal only in code level. I/O, FILE fopen, fclose, feof, f/sprintf, f/sscanf, getc/s, Putc/s, parameters of main. In short, what is missed: the comma op, (union, bitfield vararg), the C preprocessor. Backup (if there is no need to make up missed lectures then: making programs from multiple source file).

Programming 2

BMEVIEEA026 – 2/0/2/f/4

Dr. László Pohl

Overview, C repeat, process of function call, const, make, purpose and possibilities of profiling. Number representation questions in simulations, inaccuracy, instability, InF, NaN, different real types, fitting function versions. Function overload, default arguments, inline function to replace macros, the reference type, dynamic memory management: new, new [], delete, delete []. Object-oriented programming concepts, principles, objects, classes, member variables and member functions, the this pointer, encapsulation, visibility and data hiding (complex number class). Constructors and destructors, exception handling, operator overload by member function and by global function (rational number class). Dynamic classes with members, copy constructor, assignment operator, the destructor. (Vector and matrix classes). Member variable initialization, constants and static members, namespaces, C++ I/O, overload of >> and << operator. Standard Template Library (STL) vector class, application examples, behavior of vector and simple C array as parameters/return value. STL string, vector algorithms (find, sort, transform, accumulate ...), further application examples. Function and class templates. Inheritance I. Objectives, derived class, base class, visibility, constructors/destructors. Succession II. Virtual functions, abstract classes, virtual destructor, heterogeneous collection. Some interesting elements of C++11.

Numerical Computations for Physicists

BMETE92AF01 – 0/0/2/f/2

Dr. Sándor Szabó

In this course we use the Matlab and Maple softwares to solve linear algebraic, one- and multivariable analysis problems. We consider the following topics. Linear Algebra: Solution of linear systems, Eigenvalues, eigenvectors, Column space, row space, rank, Gram-Schmidt orthogonalisation process, Inverse, determinant. Analysis: Solution of nonlinear systems by numerical methods, calculating integrals by quadratures, multiple integrals. Interpolation, limit, differentiation, determining potential function. Differential equations: Numerical (Euler, Runge-Kutta methods) and symbolical methods. Matlab: Programming in Matlab, Vectors, matrices, functions, graphics. Maple: Basic commands, LinearAlgebra, DEtools, VectorCalculus and plots packages.

OTHERS

Chemistry

BMEVEFKA144 – 4/0/0/v/4

Dr. Mihály Kállay

General chemistry (introduction, basic chemical terms, notion of mole, reaction equations, stoichiometry, basics of chemical calculations, types of concentration). Basics of inorganic chemistry (constitution of atoms and molecules, types of chemical bonds, types of chemical formulae, the periodic table, states of matter, properties of the elements, most important inorganic compounds). Basics of chemical thermodynamics (basic terms, internal energy, work, heath, the first law of thermodynamics, enthalpy, heat of reaction, standard enthalpies, Hess's law, second law of thermodynamics, entropy, free energy, free enthalpy, standard free enthalpies, free enthalpy of the ideal gas, chemical potential, mixtures, activities, equilibria, thermodynamic equilibrium constant). Chemical kinetics (notion of reaction rate, molecularity of reactions and reaction order, first and second order reactions, stepwise reactions, the effect of temperature on the reaction rate). Electrochemistry (properties of electrolytes, electrolytic dissociation of water and the concept of pH, galvanic cells, Nernst equation, types of electrodes, electrochemical power sources, zinc coal cells, batteries, fuel cells, electrolysis). Organic chemistry (hydrocarbons, aromatic compounds, halogen derivatives, alcohols, amines, ethers, aldehydes, ketones, carbonic acids, anhydrides, esters, carbohydrates, proteins, nucleic acids – definition, nomenclature, structure, most important reactions). Colloid chemistry (basics of colloid chemistry, dispersions, macromolecular and micellar solutions, gels, stability of colloids, preparation of colloids, examination methods of colloid systems). Materials science (basics of polymer chemistry, types of polymers, structure of polymers, polymerisation reactions, most important plastics, composites, ceramics, liquid crystals). Chemical examination and analytic methods (spectroscopic methods, classical analytic procedures, chromatography, electroanalysis).

Radiation Protection and its Regulatory Issues

BMETE80AF24 – 2/0/0/f/2

Dr. Csilla Pesznyák

Basic knowledge of radioactivity. Interactions between ionizing radiation with matter. The physical, chemical, biochemical and biological effect of radiation energy. The effects of radiation on whole organisms, tissues and cells, as well as on cellular causes leading to the death of normal and malignant cells. Dose definitions. External and internal exposure. The appearance of different radionuclides in organisms. The basic principles of radiation protection. The radiation dose limit system. Regulations of radiation protection. Dose and dose rate measurement and their calculation in direct and indirect ways. The relationship between emissions and immissions. Technical radiation protection. Handling accidental situations. The occurrence of natural radioactivity in inorganic and living environment. The ingredients of public exposure from natural sources. The applications of artificial radioisotopes and how they get into the environment. The forms of non-ionizing radiation and their possible physiological effects. The applications of non-ionizing radiations and their system of limitations. Safety issues in the application of lasers. Radiation protection of particle accelerators.

Management and Business Economics

BMEGT20A003 – 2/0/0/f/2

Dr. János Kövesi

The course introduces the essentials of management as they apply within the contemporary work environment and gives a conceptual understanding of the role of management in the decision making process. Particular attention is paid to management theories, corporate finance, leadership, teamwork, quality management, management of technology, economics calculation and operations management. For problem formulation, both the managerial interpretation and the mathematical techniques are applied. Principles of management: Organizational resources. The enterprise as an organization. Functions of managerial processes. Managerial roles. Role of an engineer. Team work, communication in an organization. Lifecycle management and its managerial aspects. Costing: costing, cost effectiveness, traditional costing systems. Break even analyses, standard costing, activity based costing. Quality management: Principles of quality management, the brief history of quality management systems. Overview of quality assurance systems based on ISO 9001:2000. Overview of quality assurance systems based on Total Quality Management System.

ADVANCED MATHEMATICS

Modern Mathematical Methods in Physics

BMETE15AF31 – 2/2/0/v/4

Dr. Péter Lévay

Definition of generalized functions (distributions). D-space, convergence properties. Regular and singular distributions. Manipulating distributions. Convergence in D' space. Multiplying functions and distributions. The derivative and integral of distributions. The derivative and integral of distributions with respect to parameters. Regularization of distributions. Dirac-delta series. Convolution of distributions, properties of convolutions. Multivariable distributions. Fourier transform of distributions. Properties of Fourier transform. Fourier transform of shifted, rescaled and derived distributions. Fourier transform of convolution. Solving initial value problems via Fourier transform. Green-function of linear differential operators. Titchmarsh-theorem, dispersion relations. Basic solutions and Green functions of famous partial differential equations of mathematical physics. (Poisson equation, wave equation, Schrödinger equation etc.). Applications. The lectures are connected to a practice with an aim to apply the material of the lectures for problem solving.

Introduction to Experimental Data Handling

BMETE80AF25 – 2/0/0/v/2

Dr. Dániel Péter Kis

Basic concepts of probability theory. Measurement results, distribution function, mean value, standard deviation, and covariance. Poisson distribution, Gauss distribution, Student distribution, chi square distribution, confidence intervals. Parameter estimation. Concept of statistics, estimated parameters. Properties of estimates: unbiasedness, efficiency, consistence. Method of least squares. Maximum likelihood method. Normal equations and their solution. Estimating the deviation of estimated parameters. Examples of evaluation of measurements. Linear regression. Curve smoothing. Handling nonlinear fittings, iteration. Corrections, e.g. dead time correction. Basic concepts of metrology. Systematic and statistical error. Consideration of corrections. Concept of measurement uncertainty, methods of estimation. Examples of forms of presenting measurement results. Preparing diagrams. Erroneous measurements. Detection and handling outliers.

Functional Analysis for Physicists

BMETE92AF02 – 4/2/0/v/6

Dr. Dénes Petz

Vector spaces (linear maps, algebraic dual of a vector space, matrix of linear maps). Tensor product of vector spaces (symmetric and anti symmetric tensor products, bases, determinant). Normed spaces (examples, Hölder's and Minkowski's inequalities, continuity and boundedness of linear maps, norm of operators). Banach spaces (convergence, rearrangement and unconditional convergence of absolute convergent sequences; the exponential function, Neumann series). Main theorems in Banach spaces (open mapping theorem, uniform boundedness theorem, application to Fourier series). Dual space (dual of lp spaces, Hahn-Banach theorem, dual of the space of continuous functions). Hilbert space (expansion in a basis, Riesz lemma, projection theorem, Riesz representation theorem). Special functions (Hermite, Legendre polynomials, expansions). Tensor product of Hilbert spaces and their operators (difference between algebraic and Hilbert tensor product, tensor product of L2 spaces, norm of elementary tensor). Adjoint (adjoint of bounded linear operator, self-adjoint operators, unitary operators, projections, examples). Topologies (Weak topology on Hilbert space, pointwise and pointwise weak convergence of operators, monotonic sequence of self-adjoint operators, topological group of unitaries). Spectrum of bounded operator (parts of the spectrum, spectral radius, resolvent set, properties of the spectrum (nonempty, closed)). Compact operators (ideal of compact operators, Hilbert-Schmidt integral operator, Green's function, Riesz-Schauder theorem). Fourier transformation (definition on L1, its extension to a unitary transformation of L2, its spectrum, differentiability of the image, Schwartz space and its topology, dual space of the Schwartz space, distributions). Unbounded operators (adjoint, symmetric operators, Laplace operator, examples). Spectral theorem. One parameter unitary groups.

Group Theory for Physicists

BMETE11AF35 – 2/2/0/v/4

Dr. Titusz Fehér

The aim of the course is to introduce the principles of group theory to physics students: we learn how the symmetries of a system can be used to describe it, and how the symmetries of nature manifest themselves in laws of physics. We apply the concepts of group and representation theory to practical problems. Theory: Symmetries in nature and physics. Definition and basic properties of groups. Some special groups. Homomorphism, isomorphism. Subgroups, cosets, Lagrange's theorem. Normal subgroup, quotient group, first isomorphism theorem. Conjugate, conjugacy classes, centralizer. Group action, orbit, stabilizer. Representations and their properties, equivalent representations, irreducible representations. Schur's lemma. Character of representations, properties of characters, character tables. Direct sum of representations and their reduction. Product representations. Lie groups, infinitesimal generators, Lie algebras. Topological properties, universal covering group. Rotation group and its representations. Lorentz group and other matrix groups. Calculation: Description of normal modes, crystals, and quantum mechanical wave functions using group theory. Selection rules.

ADVANCED PHYSICS

Mechanics 2

BMETE15AF32 – 2/2/0/fv/5

Dr. Gergely Zaránd

Relativistic mechanics: Lorentz-transformations, four-vectors and Minkowski space, relativistic collisions, relativistic action and equations of motion. Relativistic particle in an electromagnetic field. Lagrange-theory of continuum mechanics: Lagrange density of a string, Euler-Lagrange equations, energy density. Application to quantum mechanics and to harmonic media, Klein-Gordon equations. Hamiltonian formulation of continuum mechanics. Symmetries: Noether's theorem, symplectic formulation of Hamiltonian mechanics. Poisson's brackets, integrability. Canonical transformations, Hamilton-Jacobi equations, action-angle variables. Nonlinearity, second harmonic generation, parametric resonance. Basics of dynamical systems and chaos.

Quantum Mechanics 2

BMETE15AF36 – 2/2/0/fv/5

Dr. László Szunyogh

This course conveys advanced knowledge on Quantum Mechanics according to the following topics: The WKB approach, quasi-classical quantization. Scattering theory, scattering amplitude and cross section, Green functions, Lippmann-Schwinger equation, Born series, method of partial waves. Motion in electromagnetic field, Aharonov-Bohm effect, Landau levels. Time evolution and pictures in Quantum Mechanics (Schrödinger, Heisenberg and Dirac pictures). Adiabatic motion and Berry phase. Relativistic Quantum Mechanics, Klein-Gordon equation, Dirac equation, continuity equation, Lorentz invariance, spin and total angular momentum. Free electron and positron. Non-relativistic limit, spin-orbit interaction.

Electrodynamics 2

BMETE15AF34 – 2/2/0/fv/5

Dr. Gábor Takács

Electrostatics: Solving Laplace's equation in spherical and cylindrical coordinates. Grounded sphere in external field, electric field near a sharp cone. Multipole expansion in spherical harmonics. Magnetic and quasistatic fields: magnetic scalar potential, solution methods in nonlinear materials. Electromagnetic waves in vacuum and matter. Microscopic model for polarizability. Dispersion, plasma frequency, Kramers-Kroing relations. Wave guides, resonant cavity. Losses, quality factor. Radiation field of oscillating charges. Electric dipole and quadrupole, magnetic dipole radiations. Scattering of electromagnetic waves, cross section. Scattering on solids and gases. Lienard-Wiechert potential of moving charge, field strength, radiated power, angular distribution, spectrum. Synchrotron radiation. Cherenkov and transitional radiations. Elements of relativistic electrodynamics.

Fluid Mechanics

BMEGEÁTAF11 – 2/0/0/f/3

Dr. Gergely Kristóf

Properties of Fluids, Newton's law of viscosity. Cavitation, description of fluid flow, force fields. Characterisation and visualisation of flows, free (irrotational) vortex, continuity theorem, hydrostatics. Fluid acceleration, Euler-equation, Bernoulli-equation, total, static, and dynamic pressure. Basic examples for the Bernoulli-equation: flow rate measurement using a Venturi-tube, measurement of pressure, velocity, and volume flow rate. Syphon, rotating pipe pump, unsteady discharge from a vessel. Euler equation in the streamline coordinate system, vortex theorem, floating bodies. Momentum theorem and its applications, jet contraction, Borda-Carnot expansion, Pelton turbine. Kutta-Joukowsky theorem, Allievi theorem, Euler turbine equation, propeller, wind turbine. Non-newtonian fluids, momentum equation, Navier-Stokes equation, laminar flow in a pipe, laminar / turbulent flow. Hydraulics, dimension analysis, Bernoulli-equation with losses, friction factor, losses in pipe components. Bernoulli equation for compressible fluids, similarity of flows, boundary layer, mixing length model of turbulence, flat plate boundary layer. Energy equation, speed of sound, wave propagation in gases. Discharge from a vessel, use of a Laval nozzle and its simplified calculation. Force acting on solid bodies.

Classical and Quantum Chaos

BMETE15AF39 – 2/0/0/v/2

Dr. Imre Varga

Hamiltonian formalism, integrability in general, examples in physics for chaotic behavior in case of continuous and discrete dynamics; Continuous, non-autonomous differential equations; Anharmonic, dissipative oscillator; Mappings, Poincare-mapping; Periodically excited systems; Billiards. For some of these cases: application of techniques introduced for the analysis of chaos: Lyapunov exponent, invariant measures; Frobenius-Perron equation. Stability analysis; Bifurcations, attractors, strange attractors; Kolmogorov-entropy; KAM-theorem; Chaotic dynamics and its traces in quantum mechanics. Semiclassical quantization, WKB method; Gutzwiller-trace formula; Spectral statistics, Loschmidt-echo.

Theory of Relativity

BMETE15AF38 – 2/0/0/v/2

Dr. Péter Pál Lévay

Minkowski spacetime, four vectors. Lorentz and Poincaré groups. Time dilation, Lorentz contraction, relativity of simultaneity.Addition of velocity, rapidity. Causality, Zeeman's theorem. Proper time, four velocity, four acceleration. Relativistic dynamics. Hyperbolic motion. Principle of Equivalence. Geodesic hypothesis. Principle of covariance. Local systems of inertia. Riemann and pseudo Riemann geometry, Christoffel symbols. Geodesics. Covariant derivative, parallel transport. The Newtonian limit. Connection between the metric tensor and the gravitational potential. Geodesics from a variational principle. Riemann tensor and its properties. Riemann tensor and its connection with parallel transport. Geodesic deviation. Ricci tensor, scalar curvature. Bianchi identity, Einstein tensor. Energy-momentum tensor. Conservation of energy and momentum. Einstein's equation, Einstein-Hilbert action, cosmological term. Schwarzschild's solution. The perihelium precession of Mercury.

COMPUTER PROGRAMMING

Computer Controlled Measurements

BMETE11AF37 – 0/0/2/f/2

Dr. András Halbritter

The participants gain experience in computer controlled measurements and in the programming of scientific instruments and data acquisition system. To this end the following topics are covered: communication with the instruments via serial, GPIB, and USB ports. Programming of data acqusitin cards. Programming of complex measurement control platforms, plotting and saving the data, programming of timelines, in situ data analysis. The course consists of 4 hour long computer laboratory exercises every second week. In the first part of the semester fundamental programming skills are obtained through simple example programs. In the second part the participants individually program complex measurement control and data analysis platforms, like nonlinear curve fitting by Monte Carlo method, full computer control of a digital multimeter, digital oscilloscope program using a data acquisition card.

The Fundaments and Applications of Finite Element Modeling

BMETE12AF24 – 0/0/2/f/2

Dr. Szabolcs Beleznai

Summary of theoretical and practical aspects of the finite element method to solve practical physical problems. The most important subjects are: numerical solution of the most common physical problems described by ordinary and partial differential equations: Poisson-Laplace equation, Heat transfer, Particle convection, Diffusion, Helmholtz equation, Wave equation, Eigenvalue problems, Complex problems.

Computer Solution of Technical and Physical Problems

BMETE11AF36 – 0/0/2/f/2

Dr. Gábor Varga

In the frame of this course several areas of technical and physical problems (one and many particle problems, Poisson equation, fluid flow, sheet deformation, heat transport, wave equation, Schrödinger equation) are investigated. Investigated problems can be described by ordinary or partial differential equations. For every problem computer program is written. During the computer implementation not only the physical models but the needed numerical methods are analysed. MATLAB program language is applied as a programming tool. The course is complemented at beginning of the semester with optional MATLAB training.

Monte Carlo Methods

BMETE80AF26 – 2/1/0/f/3

Dr. Sándor Fehér

Random number generation. Experimental and algorithmic methods. Generation of uniformly distributed pseudorandom numbers on computers. Multiplicative, congruential and other algorithms. Statistical tests of random number series. Randomness, independency. Chi-square test. One- and two-dimensional frequency tests, digit test, gap test, poker test, run test, test of subseries. Sampling discrete random variables by Monte Carlo method. Techniques for acceleration of sampling. Sampling continuous random variables. Methods for sampling one-dimensional density functions. Inverse cumulative function method, acceptance-rejection algorithm, composition method, table look-up techniques. Application of Monte Carlo methods for particle transport simulation. Methods for choosing uniformly a random point from the surface of a sphere. Sphere slicing, cube rejection and Marsaglia's algorithm. Free flight sampling in homogeneous, regionally homogeneous and inhomogeneous media. Woodcock's method. Analog and non-analog simulation of particle transport. Variance reduction techniques. Statistical weight, implicit capture, spatial importance, biasing, splitting, Russian roulette. Monte Carlo integration. Interpolation of multivariable functions using Monte Carlo method.

OPTICS

Spectroscopy

BMETE12AF28 – 2/0/0/v/2

Dr. Sándor Lenk

Classification of spectroscopic techniques: gamma, X-ray, UV-VIS-NIR-FIR, radiofrequency, NMR, particle- and mass spectroscopy. Optical spectroscopy: emission, absorption, fluorescence, Raman, multiphoton, laser. Optical spectrometers: prism, grating, Fourier, Fabry-Perot, acousto-optic, photoacoustic. Non optical spectrometers: gamma spectrometer, X-ray spectrometer, nuclear magnetic resonance, mass spectrometers. Application of spectrometers in metrology.

Laser Technique

BMETE12AF07 – 2/0/0/f/2

Dr. Ferenc Ujhelyi

Light and material interaction, spontaneous emission, absorption, stimulated emission. Coherent optical amplifier. Pumping methods in practice. Saturation of gain. Properties of materials with homogeneous and inhomogeneous gain. Continuous and pulsed laser operation, gain and phase condition, Feedback system, properties of the optical resonator, definition of the modes. Gain- and Q-swithing, mode locking. Properties of the laser light, bandwidth, coherence, propagation, brightness. Types of laser: solid state, semiconductor, gas, fluid, and others. Laser applications: industrial, medical, data communication, and metrology.

Microscopy

BMETE12AF09 – 2/0/0/f/2

Dr. Pál Maák

The scope of the course is to make the microscopic techniques and approaches familiar to the students as well as to get insight into the development of microscopy from classical to the newest technical achievements. Detailed topics: History of the microscope, development of the combined microscope. Classification of the old and new microscopy techniques. Geometric optical basis of the optical microscope. Abbe theory of image formation. Estimation of the lateral resolution based on diffraction theory. Build-up of the compound microscope, roles of the imaging and illuminating systems. Specific properties of the objective and ocular. Role of the immersion fluid. Errors and aberrations in imaging, depth of field, brightness. Methods of optical design to eliminate aberrations. Illumination techniques: bright field, oblique, dark field illuminations. Role of diaphragms. Special condensers. Role of sample preparation. Phase contrast and polarization microscopy: physical optical background, diffraction theory and practical realization. Use of the microscope in the practice – laboratory demonstration. Theoretical and practical limitations of the increase of the lateral resolution: techniques to overcome the fundamental diffraction limit. Techniques for image registration. Analysis of the registered images, image processing based on optical and electronic methods. Fluorescence microscopy. Overview of new research directions in microscopy: confocal, X-ray, UV, differential interference contrast, electron, atomic force, tunneling. Confocal and multi-photon microscopes: operation principles in detail, parameters, experimental results. Scanning and transmission electron microscopes: theory, parameters, applications. Practical laboratory work on scanning electron microscope, sample preparation, limitations. Discussion of tunneling and atomic force microscopes, parameters, practical tutorial.

Materials science

Foundations of Biophysics

BMETE12AF10 – 2/0/0/f/2

Dr. Attila Barócsi

The aim of the course is to familiarize students with the fundamental physical properties that govern biological (living) systems having higher complexity to inert physical systems and illustrate the physical modelling of such biological systems. Unlike medical courses, the present one aims at providing extensive biological information to the topics of physics with the prerequisite that students are familiar with the basics of classical and modern physics. Detailed topics: Biological basics of biophysics (criteria of life, the cell, descriptive genetics). Material structure and its relation to function (bond types, the water, biological macromolecules, molecular basics of the genetic code). Interaction of biophysical systems with radiation (light absorption in macromolecules, biological impact of optical and X-ray radiations, radiobiology). Thermodynamics of biological processes (thermal homeostasis, irreversible thermodynamics, cellular respiration and photosynthesis). Metabolism and transport (transport phenomena, drift, diffusion and osmosis). Biological membranes (ion transport, electric phenomena, stimulated processes, propagation of stimulus, the patch-clamp measuring technique). Biophysics of sensory organs (receptors): vision and hearing. Collective phenomena (traffic-like motion, ASEP models, fundamental mechanisms of molecular motors).

Fundaments and Applications of Materials Science

BMETE12AF25 – 2/0/0/v/2

Dr. Ferenc Réti

The aim of the subject is to give a basic knowledge in the modern materials science and its use in different areas of physics and engineering. Topics: Materials science and engineering. Modern materials, requirements in their use. Role of primary and secondary bonding in properties of materials. Importance of thermal processes, thermodynamics, thermochemistry, Hess principle, Born-Haber cycle. Chemical potential, equilibrium constant. Reaction rate equations. Arrhenius and Eyring equation. Importance of crystal imperfections e.g. in electrical and mechanical properties. Equilibrium concentration of crystal imperfections. Sensors in engineering. Principles, physical and chemical sensors. Pressure sensors, thermometers, strain gauges, magnetic sensors. Non-destructive testing. Flaw detection by ultrasound, X-ray. Magnetic tests. Practical examples. Alternative energy sources and energy carriers; contradictions of the field. Hydrogen economy, bio-ethanol. Fuel cells as continuous power sources.

Microtechnology and Nanotechnology

BMETE12AF08 – 2/0/0/f/2

Dr. Gábor Kiss

Definition of microtechnology, nanotechnology and molecular nanotechnology, their comparison and interrelation. Conditions of the technology. Micro- and nanophysics. Thin layer deposition methods: physical (vacuum evaporation, laser ablation evaporation, molecular beam epitaxy, sputtering). Doping (diffusion, ion implantation). Litography (photo, X-ray, electron beam, ion beam). Layer removing technologies: wet chemical" etching, dry etching (plasma, ion beam). Layer characterisation methods: X-ray diffraction, transmission electron microscopy, scanning electron microscopy, secondary ion mass spectrometry, X-ray photoelectron spectroscopy, Auger electron microscopy, scanning tunneling microscopy, atomic force microscopy. Conventional electronic devices: bipolar transistor, field effect transistor. Thick layer technology: screen printing, burning, thick layer pastes. Nanometer devices: single electron devices, resonant tunnel effect devices, micro-electromechanical systems, sensors, image detectors, displays.

NUCLEAR TECHNOLOGY

Nuclear Physics

BMETE80MD00 – 3/1/0/v/5

Dr. Csaba Sükösd

Stability of the nucleus, mass defect. Semi-empirical binding energy formula. Types and basic theory of radioactive decays. Nuclear models: Fermi-gas, Shell-model, Basics of collective model. Nuclear forces. Nuclear reactions. Cross sections and their two additivities. Mechanism of fission and fusion. Main types and working principles of accelerators.

Nuclear Measurement Techniques

BMETE80MD01 – 1/1/0/v/3

Dr. Imre Szalóki

Electromagnetic and particle radiations, basic interactions between radiations and matter. General measuring properties of radiation detectors. Detectors: ionization chambers, proportional counters, GM counters, scintillation detectors, semiconductor and solid state detectors. Special detectors: detection of neutrons, detectors for dosimetry, TLD, particle detectors. Detection of gamma-, alpha-, beta and X-rays, nuclear spectrometers. Counting statistics and error prediction. Evaluation of gamma- and X-ray spectra. Electronics of nuclear spectrometers. Nuclear accelerators.

Nuclear Safety

BMETE80MD05 – 2/0/0/v/2

Dr. Szabolcs Czifrus

Introduction into nuclear safety – basic terms, safety functions, physical barriers, defence in depth. Plant states, design basis of a nuclear plant. Safety of nuclear plants – safety systems, comparison of different reactor types. Deterministic analysis – methods, postulated initiating events. Probabilistic analysis – methods. Level 1, 2, and 3 PSA. Application of PSA in nuclear design. Design basis accidents – course of an LB LOCA accident in PWR reactors. Severe Accidents – typical phenomena during SA. International Nuclear Event Scale (INES) – classification of events. Exercise: group work for classification. Lessons learned from incidents, accidents. The Fukushima accident. National and international regulation of nuclear safety. Standards, limits.

Radioactive Waste Management

BMETE80MD07 – 2/0/0/v/2

Dr. Péter Zagyvai

Overview of dose concept, hazardous effects of ionizing radiations and elements of health physics regulations. Definitions of radioactive wastes. International guidance and national regulations on radioactive waste management. Classifications of radioactive wastes, role and significance of radioactive wastes in the system of radiation protection. Classification and radioactive waste according to their generation. Characteristic components of waste streams, radiation protection and technological properties of representative waste components. Nuclear analytical procedures applied for waste qualification and quantitation. Operations of radioactive waste processing. Collection, classification, storage, volume reduction, conditioning, transport. Methods for qualification of processed wastes. Examples of compound procedures for waste processing and management. Long-term interim storage and final disposal of radioactive wastes. Qualification of disposal, radiotoxicity. Special waste processing methods of closed fuel cycle systems: reprocessing, transmutation.

Plasma Physics

BMETE80MD02 – 3/1/0/v/4

Dr. Gergő Pokol

General introduction to plasma physics. Energy generation with fusion reactors, Lawson criterion, parameters of fusion plasmas. Inertial fusion. Collisionless motion of charged particles in magnetic field. Thermodynamic equilibrium, ionization and radiative processes in the plasma. Magnetic confinement: configurations. Particle collisions in plasma, transport processes. Plasma theory: kinetic description, fluid description, MHD. Equilibrium and instabilities in magnetically confined plasma, plasma waves. Laboratory plasmas: breakdown, plasma heating, plasma-wall interaction. Plasma diagnostics, measurement methods. Recent results, achievements in fusion plasma confinement.

Description of BSc Subjects in Mathematics

Basics of Mathematics

BMETE91AM35 – 2/0/0/v/3

Dr. Miklós Ferenczi

Notations, formal languages, formalism in mathematics. Mathematics and the deductive systems. Propositional logic. The language of propositional logic. Logical operations, tautologies, logical equivalences. A calculus in propositional logic. Completeness and its importance. First order logic. Language of first order logic: terms, formulas, quantifiers, equality. Structure, model, algebra. Valuation in a model. The concept of logical consequence. Axioms and theorems. Standard and non-standard models. Calculus, deductive and refutation systems. Completeness. Direct and indirect proofs. On the concepts induction and recursion. The real numbers as ordered field with suprema. The construction of the real numbers. Non-standard real numbers, infinitesimals. Set theory. Ordered pairs, relations, functions. Equivalence- and ordering relations. Equivalence of sets. Countable and non-countable cardinalities. Cantor's diagonalization procedure. Continuum hypothesis. Classes, Russel paradoxon. Well-ordering. The axiom of choice and its importance.

Calculus 1

BMETE92AM36 – 6/2/0/v/9

Dr. Miklós Horváth

Real numbers, sets and mappings. Important inequalities. Real sequences and limits. Convergent and divergent sequences. Monotone and bounded sequences. Subsequences, accumulation points. Theorems of Bolzano and Weierstrass, limsup, liminf. Cauchy theorem. Important limits. Numerical series; convergence and properties. Series of positive numbers. Comparison test, ratio test, nth root test. Absolute and non-absolut convergent series. Alternating series, Leibniz series. Estimations for series. Product of series. Theorem of Mertens and Abel. Real functions. Limits and continuity. Continous functions on bounded closed intervals. Theorems of Bolzano and Weiersrass. Uniformly continous functions, Heine's theorem. Differentiation. Properties of derivatives. Inverse functions. Higher derivatives. Mean value theorems. Elementary functions. Polinomials, exponential, logarithm, trigonometric functions. Function tests, sketching the graphs of functions. Taylor polinomial. Indefinite integral (antiderivatives). Techniqus of integraton. Integration by parts, substitutions, trigonometric integrals, partial fractions. Riemann integral. Propertiesof the integral, upper, lower sums and oscillation sums. Connection with the derivative, Newton-Leibniz rule. Applications of the integral. Mean value theorem. Improper integral.

Introduction to Algebra 1

BMETE91AM36 – 6/2/0/v/9

Dr. Erzsébet Horváth

Elementary number theory: integers, divisibility, division with remainders, greatest comon divisor, Euclidean algorithm, irreducible numbers and prime numbers. Fundamental Theorem of Arithmetic. Linear Diophantine equations, modular arithmetic, complete and reduced remainder systems, solution of linear congruences. Complex numbers, algebraic and trigonometric forms, Binomial Theorem. Relation between the complex numbers and the geometry of the plane. Roots of unity, primitive roots of unity. Polynomials with one variable, operations, Horner-scheme, rational root test, Fundamental Theorem of Algebra. Irreducibility of polinomials, Schönemann-Eisenstein criterion. Multivariate polynomials, complete and elementary symmetric polynomials, Viete formulas, roots of cubic polynomials. Systems of linear equations in two and three variables, Gaussian and Gauss-Jordan elimination. R^n and its subspaces. Linear combinations, linear independence, spanned subspace, basis, dimension. Coordinate systems, row space, column space, nullspace of a matrix. Subspace of solutions, solutions in the row space. Matrix operations, inverse matrix, base change matrix. Operations with special matrices, PLU decomposition. Solution of systems of equations with the help of PLU decomposition. Determinant as the volume of the parallelepiped. Basic properties, determinant of a matrix. The notion of permutations, transpositions, cycles, expansion of the determinant. Laplace Expansion Theorem, Mutiplication Theorem of Matrices, formula for the inverse of a matrix, Cramer's Rule. Basic properties of matrix rank. Linear maps and their matrices: the matirx of a projection to a subspace. Similar matrices. Optimal solution of inconsistent systems of linear equations, normal equation, solution in the row space and its minimality. Moore-Penrose generalized inverse.

Introduction to Geometry

BMETE94AM17 – 2/0/0/v/3

Dr. Jenő Szirmai

Euclid's Axioms and Postulates, Hilbert's axioms, points, straight lines, planes, distances, angles etc. Euclidean plane: Geometric transformations, synthetically. Vector geometry, linearly dependent, linearly independent vectors, scalar and cross product, Cartesian coordinate system, Lagrange-Jacobi identities. Coordinate geometry, analytic description of planes and straight lines, distances, angles, etc. Euclidean space: Geometric transformations (congruences), analytically. Homogeneous coordinates, uniform treatment of geometric transformations. Affinities, similarities. Spherical geometry: geodesic curves, angles, angle-sum formula for spherical triangles, spherical trigonometry. Definition of polyhedra, Euler theorem. Special polyhedra: convex, regular polyhedra, Archimedean solids, Catalan solids etc. Cauchy's rigidity theorem, and other interesting polyhedra.

Informatics 1

BMETE91AM42 – 1/0/2/f/4

Dr. Ferenc Wettl

The aim of the course is to study the basic notions of information technology. Basics of hardware (CPU, memory, mass storage, ...), the hardware environment of the Institute. Basics of operating systems: program, process, file, folder, file system of Linux and Windows (bash, mc, Windows Total Commander). Graphic user interface, terminal user interface, bash language. Internet, network, IP address, wifi, Internet security. Data on machine: number representation, character encodings. Computer algebra, symbolic calculation (Sage, Mathematica, ...), variable, recursion instead of iterative programming, deepening the secondary school function concept (factorial, Fibonacci sequence, Euclidean algorithm, exponentiation, quick exponentiation...). Programming paradigms in computer algebra languages. HTML, the markup language concept, homepage. CSS, separation of the content and presentation. Editing mathematical text: TeX, LaTeX, mathematics on the web. Presentation of math (beamer). Basic concepts of graphic file formats, graphics in mathematical text (TikZ).

Calculus 2

BMETE92AM37 – 6/2/0/v/8

Dr. József Pitrik

Finite dimensional normed vector spaces. Sequences in normed vector spaces, convergence. Theorems of Bolzano and Weierstrass. Multivariable calculus. Continuity. Partial derivatives, directional derivatives. Differentiability and the chain rule. The differential of a function and its geometrical meaning, linear approximation.Tangent plane and the gradient. Higher derivatives. Schwarz's theorem. Extremas of multivariable functions. Absolute minima and maxima. Maxima and minima with subsidiary conditions, Lagrange's method of undetermined multipliers. Inverse and imlicit functions. Multiple integrals, fundamental rules. Jordan-measurable sets and their measure. Double integrals, polar transform. Integrals over regions in three and more dimensions. Transformations of multiple integrals. Vector fields and their analysis. Differential calculus of vector fields. Curves and surfaces in three dimension. Line integrals of vector fields. The fundamental theorem of line integrals, independence of path. Potential function. Green's theorem. The Curl and Divergence of a vector field. Parametric surfaces and their areas. Oriented surfaces. Surface integrals of vector fields. Stokes' theorem. The divergence theorem. Sequences and series of functions. Pointwise and uniform convergence. Weierstrass M-test. Consequences of uniform convergence. Power series. Taylor series, binomial series. Fourier series. Inner products on periodic functions. The Fourier and Plancherel theorem. Periodic convolution. Applications.

Introduction to Algebra 2

BMETE91AM37 – 6/2/0/v/8

Dr. Alex Küronya

Scalar product and its properties in Rn. Orthogonal and orthonormal bases, Gram-Schmidt ortogonatization process, orthogonal matrices, orthogonal transformations. Householder reflections, Givens rotations. The existence of QR decomposition and its calculation. Optimal solution of systems of linear equations with the help of QR decomposition. Scalar product in Cn. Unitary, normal and selfadjoint matrices and transformations. Eigenvalues, eigenvectors and eigenspaces of matrices and linear transformations. Characteristic equation, solution of the eigenvalue problem. Applications. Algebraic and geometric multiplicity, eigenvalues of special matrices, eigenvalues of similar matrices. Cayley-Hamilton Theorem. Diagonilizability of matrices and its equivalent formulations, (real and complex cases), diagonalizibility of special matrices, relation to the eigenvalues. Unitary and orthogonal diagonalizibility. Schur decomposition, spectral decomposition. Bilinear functions, standard form, signature, Main Axis Theorem. Quandratic forms, definity. Classification of local extrema of a function, geometric applications, graphical presentation. Multilinear functions and maps, total derivative as multilinear map, multivariate Taylor formula, determinant as multilinear function. Singular Value Decomposition of matrices, polar decomposition, applications of SVD, generalized inverse from the SVD. Normal forms of matrices, existence, unicity, determination of the normal form. Generalized eigenvectors, Jordan chain, Jordan basis. Norms of real and complex vectors, matrix norms, basic properties, calculation of norms. Matrix functions (convergence just mentioned, and illustrated), matrix exponential functions. Vector spaces over arbitrary fields. Existence of basis, dimension, infinite dimensional vector spaces (e.g. function spaces), isomorphic vector spaces. Notion of Euclidean space, properties, isomorphism between Euclidean spaces. Dual space. Application of vector spaces over finite fields in coding theory, cryptography and combinatorics.

Combinatorics and Graph Theory 1

BMEVISZA025 – 2/2/0/v/6

Dr. Tamás Fleiner

Enumerative combinatorics (permutations and combinations, binomial theorem, theorems on the binomial coefficients). Significant methods for enumeration, pigeonhole principle and the sieve. Basic Graph Theoretical notions (vertex, edge, degree, isomorphism, path, cycle, connectivity). Trees, Cayley's formula, Prüfer-sequences. Kruskal's greedy algorithm. Characterization of bipartite graphs. Matchings, theorems of Kőnig, Hall and Frobenius, Tutte theorem, Gallai's theorems. Network flows, the Ford-Fulkerson algorithm, Edmonds-Karp algorithm. Menger's theorems, higher vertex and edge connectivity of graphs, Dirac's theorem. Euler's result on Eulerian tours and trails. Hamiltonian cycles and paths, necessary condition for the existence. Sufficient conditions (theorems of Dirac, Ore, Pósa and Chvátal). Planarity, relation to embeddability on the sphere and the torus, stereographic projection, Euler polyhedron theorem, Kuratowski's theorem, Fáry theorem. BFS and DFS algorithms for shortest paths (Dijkstra, Ford, Floyd), PERT.

Geometry

BMETE94AM18 – 4/0/0/v/6

Dr. Ákos G. Horváth

Axiomatic methods, introduction to the absolute geometry, hyperbolic, spherical and projective planes. n-dimensional Euclidean geometry, convex polytopes, regular polytopes. n-dimensional classification of surfaces of second-order.

Informatics 2

BMETE91AM43 – 1/0/2/f/4

Dr. Ferenc Wettl

The course aims to learn the programming through understanding the Python language. Introduction to programming and Python language, data types, expressions, input, output. Control structures: if, while. Flowchart, structogram, Jackson figures. Complex control structures. Fundamental algorithms (sum, selection, search extrema, decision ..., many practical examples). Lists. For cycle. Newer algorithms (sorting, splitting into two lists ...). Exception handling. Abstraction of a part of the program, name it, using as a building block = function. Function call process, parameters, local variables, passing by value. Abstraction: complex data types from simple ones, for example fraction (numerator + denominator), complex numbers (real & imaginary part). OOP concepts: object, method. File management. Command-line arguments. Recursion (painting of an area, building a labyrinth). Algorithms efficiency, quick sorting, binary search versus linear search, O(n). Data structures: binary tree (algorithms), effectiveness: search trees (Morse tree). Mathematical libraries. Modules.

Physics 1 for Mathematicians

BMETE13AM16 – 2/0/0/f/2

Dr. László Udvardi

Review of the physics we learned in secondary school: Newton's laws, Conservation laws. Inertial frame of reference, general transformation between two Inertial frame of reference. Galilei transformation, Lorentz transformation. Introduction to special relativity: Lorentz contraction, time dilation, proper time, invariant quantities. Four vectors. Accelerated Reference Frames, Fictitious force: Coriolis force, Foucault pendulum, centrifugal force. Demonstration experiments. Primer to geometrical optics, Fermat's principle, Euler-Lagrange equation. Hamilton's principle, Lagrange function, equation of motion. Relation between the symmetry of the Lagrangian and the conservation laws, Noether's theorem. Application of the law of conservation, motion in central field. Kepler problem.

Analysis 1

BMETE92AM38 – 4/1/0/v/7

Dr. Attila Andai

Metrics and metric spaces. Topology of metric spaces. Basic properties of metric and normed spaces. Metric subspaces and isometrics. Sequences in metric spaces. Convergence of sequences in metric spaces. Separable metric spaces. Convergent sequences in normed spaces. Product of metric and normed spaces. Compact sets, relative compact sets and their its basic properties in metric spaces. Characterization of compact metric spaces. Cantor's intersection theorem. Bolzano-Weierstrass theorem. Product of compact metric spaces. Equivalence of norms in finite-dimensional vector spaces. Limit of functions in metric spaces. Definition of continuity in terms of epsilon-delta and limits, and their equivalence. Topological characterization of continuity. Homeomorphism. Uniform continuity. Basic properties of continuous functions on compact spaces. Weierstrass's maximum-minimum principle. Characterization of compact sets in finite-dimensional normed spaces. Fundamental theorem of algebra. Approximation by Bernstein polynomials. Complete metric spaces. Contractions and Banach fixed point theorem in metric spaces. Totally bounded metric spaces and the Hausdorff characterisation theorem. Completeness of finite-dimensional normed spaces. Connected and path-connected metric spaces. Nowhere dense sets and Baire's category theorem. Banach spaces. Characterization of Banach spaces with absolutely convergent series. Linear and multi-linear maps between normed spaces and their continuity and norm. The normed space of linear and multi-linear maps between normed spaces. Positive, negative, definite and indefinite multi-linear maps. Bounded linear operators and functionals. Hahn-Banach theorem and some consequences. Banach-Steinhaus theorem. Open mapping theorem. Closed graph theorem. Bounded inverse theorem. Derivation of functions between normed spaces.

Algebra 1

BMETE91AM38 – 4/1/0/v/7

Dr. Alex Küronya

Groups, semigroups. Basic properties of groups, group homomorphism, subgroups, cosets. Langrange's Theorem. Examples: diherdral groups, quaternion group, symmetric groups, alternating groups. Decomposition of permutations into disjoint cycles, transpositions. Permutation groups, group actions, transitivity, Cayley's Theorem. Cyclic groups, order of a group element. Cauchy's Theorem. Direct product of groups. Normal subgroups, factor group, Homomorphism Theorem, Noether's Isomorphism Theorems. Important subgroups: derived subgroup, centre, class equation. Subgroup chains, Sylow's Theorems, description of the structure of groups of small size. Nilpotent groups. Fundamental Theorem of Finite Abelian Groups. Free groups. Free algebras over rings, ideals, maximal and prime ideals. Description of the polynomial ring R[x]. Principal ideal domains. Noether rings, unique factorization domains (UFD). Factor rings, field extensions, construction of finite fields. Modules over rings, submodules, module homomorphisms. Semisimple modules and rings. The structure of matrix algebras over division rings. Vector space and module constructions: factor module, direct product, direct sum, tensor product. Linear fuction and the dual space.

Probability Theory 1

BMETE95AM29 – 2/2/0/v/6

Dr. Péter Bálint

Introduction: empirical background, sample space, events, probability as a set function. Enumeration problems, inclusion-exclusion formula, urn models, problems of geometric origin. Conditional probability: basic concepts, multiplication rule, law of total probability, Bayes formula, applications. Independence. Discrete random variables: probability mass function, Bernoulli, geometric, binomial, hypergeometric and negative binomial distributions. Poisson approximation of the binomial distribution, Poisson distribution, Poisson process, applications. General theory of random variables: (cumulative) distribution function and its properties, singular continuous distributions, absolutely continuous distributions and probability density functions. Important continuous distributions: uniform, exponential, normal (Gauss), Cauchy. Distribution of a function of a random variable, transformation of probability densities. Quantities associated to distributions: expected value, moments, median, variance and their properties. Computation for the important distributions. Steiner formula. Applications. Joint distributions: joint distibution, mass and density functions, marginal and conditional distributions. Important joint distributions: polynomial, polyhypergoemetric, uniform and mutlidimensional normal distribution. Conditional distribution and density functions. Conditional expectation and prediction, conditional variance. Vector of expected values, Covariance matrix, Cauchy-Schwartz inequality, correlation. Indicator random variables. Weak Law of Large Numbers: Bernoull Law of Large Numbers, Markov and Chebyshev inequality. Weak Law of Large numbers in full generality. Application: Weierstrass approximation theorem. Normal approximation of binomial distribution: Stirling formula, de Moivre-Laplace theorem. Applications. Normal fluctuations. Central Limit Theorem.

Programming Exercises for Probability Theory

BMETE91AM46 – 0/0/0/f/1

Dr. Ferenc Wettl

The aim of the course is to maintain the students' programming skills through programming problems associated with the topics of Probability Theory course helping the understanding of the basic concepts of probability simulations of random events at the same time.

Differential Equations 1

BMETE93AM15 – 2/2/0/v/6

Dr. Katalin Nagy

Ordinary differential equations. Explicitly solvable equations, exact and linear equations. Well-posedness of the initial value problem, existence, uniqueness, continuous dependence on initial values. Approximate solution methods. Linear systems of equations, variational system. Elements of stability theory, stability, asymptotic stability, Lyapunov functions, stability by the linear approximation. Phase portraits of planar autonomous equations. Laplace transform, application to solve differential equations. Discrete-time dynamical systems.

Informaitcs 3

BMETE91AM44 – 2/0/2/f/4

Dr. Alex Küronya

The aim of the course is to understand the basic elements of C++ language fundamental in effective scientific calculations. Compiling C++ programs, programming environments for C++. Input/Output. Built-in data types: int, double, char, bool, complex. Control commands: if, switch, for, while, do. Exception handling (recall Python). Functions. Extending operators (fractions struct), references (a += b, cout << fraction, cin >> fractions). Object-oriented programming in C++: object, class, encapsulation, member functions, constructors, destructors (in complex class with re + im or r + fi data members). Using arrays in C++. Pointers, relationship with arrays. File management. Basic algorithms: search, sort, etc. Command-line arguments. Dynamic memory management, new[], delete[]. Inheritance. Templates. Libraries. Header files.

Mathematical Statistics 1

BMETE95AM31 – 2/0/2/v/5

Dr. Marianna Bolla

Statistical sample, descriptive statistics, empirical distributions. Most frequently used probabilictic models, likelihood function, sufficiency, maximum likelihood principle. Theory of point estimation: unbiased and asymptotically unbiased estimators, efficiency, consistency. Methods of point estimation: maximum likelihood, method of moments, Bayes principle. Interval estimation, confidence intervals. Theory of hypothesis testing, likelihood ratios. Parametric inference: u, t, F tests, comparing two treatments. Two-way classified data, contingency tables, chi-square test. Nonparametric inference: Wilcoxon and sign tests, Spearman correlation. Regression analysis. Linear regression, method of least squares, Pearson correlation. Multivariate regression, multiple correlation. Linear models, analysis of variance for one- and two-way classified data. Practical considerations: selecting the sample size, test for normality, resampling methods.

Analysis 2

BMETE92AM39 – 2/2/0/v/5

Dr. Attila Andai

Ring, σ-ring, and σ-algebra of sets. Set functions. Concept of Lebesgue measure. Outer measure. Measurable sets. Measure generated by an outer measure. Example for not Lebesgue-measurable set. Measure space, measurable functions. Null sets. The concept of convergence in measure and almost everywhere (ae) and relations between them. Integral of measurable functions. Beppo-Levi theorem, Fatou's lemma, Lebesgue's dominated convergence theorem. Lp-spaces, and Hölder and Minkowski inequality. Absolute continuity of the integral. Riemann sphere. Limits and properties of complex valued sequences. Limit and continuity of complex functions. Power series of elementary functions. Euler's formula. Complex logarithm function. Differentiability of complex functions. Cauchy-Riemann equations. Regularity of complex functions and elementary properties of regular functions. Harmonic functions, harmonic conjugate. Complex integral, integration by substitution. Newton-Leibniz formula. Goursat lemma. Cauchy's integral theorem and integral formula on convex domain. Index of a curve. Simply-connected subsets. Cauchy integral theorem and integral formula. Primitive functions. Morera's theorem. Power series of regular functions. Liouville theorem and fundamental theorem of algebra. Multiplicity of roots. Laurent series. Isolated, removable and essential singularities of complex functions. Laurent series. Concept of residue and the residue theorem. Residue theorem with logarithmic functions. Argument principle. Rouche's theorem. Open mapping theorem. Maximum and minimum principles.

Differential Geometry 1

BMETE94AM19 – 2/1/0/f/4

Dr. Krisztiánné Koós

Definition of curve, parametrisation, reparametrisation, length and arclength, invariance of length under isometries, tangent vector, curvature, Fox-Milnor's theorem, normal, vector, signed curvature and turning angle, total curvature and convexity, the four vertex theorem, isoperimetric inequality, Frenet-Serret frame, torsion, fundamental theorem of curves. Definition of a regular embedded surface, Gaussian curvature, principal curvatures, intrinsic geometry, Theorema Egregium, Christoffel symbols, PMC equations, fundamental theorem of surfaces, covariant derivative, Lie bracket, Riemann curvature tensor, geodesic curvature, geodesics, Gauss-Bonnet theorem.

Operations Research

BMETE93AM19 – 2/2/0/v/5

Dr. Marianna Eisenberg-Nagy

Introduction to operations research; convex sets, polyhedron, polytope Krein-Milmann theorem. Separation, Farkas' lemma. Linear programming problem, basis, basic solution, optimal solution. Simplex algorithm. Two-phase simplex algorithm, degeneration, index selection rules. Modified simplex algorithm. Sensitivity testing. Weak and strong duality theorem. Network flow problems, algorithms. Network simplex algorithm. Transportation problem, assignment problem, the Hungarian method. Integer programming: Branch and bound method, dynamic programming, cutting plane procedures. Game theory: matrix games.

Theory of Algorithms

BMEVISZAB01 – 2/2/0/v/4

Dr. Katalin Friedl

Pattern matching: naive algorithm, the fingerprinting method of Rabin and Karp, solution by finite automata. Deterministic and non-deterministic finite automata and their equivalence. Regular expressions, regular languages, and their connections to finite automata. Finite automaton as lexical analyser. Context free grammars. Parse tree, left and right derivation. Ambiguous words, grammars, languages. The importance of unambiguous grammars for algorithms. Pushdown automaton. Connection between pushdown automata and context free grammars, how to get a PDA from a CF grammar. The main task of a parser. The general automaton: Turing machine. Church-Turing thesis. The classes P, NP, coNP, their relations. Karp reduction and the notion of NP completeness. Theorem of Cook and Levin. 3SAT, 3COLOR are NP complete languages. Further NP complete languages: MAXSTABLE, HAM-CYCLE, HAM-PATH, TSP, 3DH, SUBSETSUM, PARTITION, KNAPSACK, SUBGRAPHISO. The problem of GRAPHISO. Linear and integer programming. LP is in P (without proof), IP is in NP. LP and IP as algorithmic tools, translation of combinatorial problems to integer programming. Another tool: branch and bound. Dynamical programming (example: knapsack, longest common substring). The objective in approximation algorithms. Bin packing has fast and good approximations (FF, FFD, theorem of Ibarra and Kim). Fro the TSP even the approximation s hard in general but there is efficient 2-approximation in the euclidean case. Comparison based sorting: bubble sort, insertion sort, merge sort, quick sort.

Lower bound for the number of comparisons. Other sorting methods: counting sort, bin sort, radix sort. Linear and binary search. The binary search is optimal in the number of comparisons. Notion of search tree, their properties and analysis. Red-black tree as a balanced search tree. The 2-3 tree, and its generalization, the B tree. Comparisons of the different data structures.

Programming Exercises forTheory of Algorithms

BMETE91AM47 – 0/0/0/f/1

Dr. Ferenc Wettl

The aim of the course is to maintain the students' programming skills through programming problems associated with the topics of Algorithm Theory course helping the understanding of the basic concepts of algorithms.

Algebra 2

BMETE91AM39 – 4/0/0/v/4

Dr. Erzsébet Lukács

Field extensions, construction and uniqueness of simple algebraic extensions, finite and algebraic extensions. Normal extensions, splitting field, separable extension, finite fields, Wedderburn's theorem, Galois group, irreducibility of the cyclotomic polynomials, Galois groups of radical extensions, Galois correspondence, Fundamental theorem of Galois theory. Applications of Galois theory: Fundamental theorem of algebra, ruler and compass constructions, solvability of equations by radicals, Abel–Ruffini theorem. Existence and uniqueness of algebraic closure, transcendental extensions, transcendence of e, Gelfand-Schneider theorem. - Review of the basic concepts of number theory, Euler ϕ function. Linear congruences and systems of congruences, binomial congruences of higher degree, discrete logarithm, congruences of prime power moduli. Quadratic congruences, Legendre and Jacobi symbol, quadratic reciprocity. Prime numbers: Euclid's theorem, gaps between primes, Chebyshev's theorem, harmonic series of primes, Dirichlet's theorem for (nk + 1). Arithmetic functions: d(n), $\sigma(n)$, $\phi(n)$. Multiplicativity, convolution, Möbius function, the Möbius inversion formula. Prime number theorem, magnitude of the nth prime, prime tests, Rabin–Miller test, RSA function. Diophantine equations: linear diophantine equations, Pythagorean triples, Fermat's two squares theorem, Gaussian integers.

Optimization Models

BMETE93AM16 – 2/0/2/f/4

Dr. Boglárka Gazdag-Tóth

Introduction to mathematical modeling, to mathematical programming problems, and their classification. Model reformulations: rewrite complex transportation problem to simple transportation problem, rewrite maximum flow problem to minimum cost maximal flow problem. Modeling problems in economy. Integer modeling tricks, set covering, set partitioning problems. Modeling Facility Location problems. Numerical errors. Dynamic programming. Scheduling problems, heuristics, approximations, online versions. Decision Theory. Inventory tasks.

Stochastic Processes

BMETE95AM41 – 5/0/0/v/6

Dr. Károly Simon

Basic notions: finite dimensional marginals, Kolmogorov's fundamental theorem, strongly and weakly stationary processes, processes with stationary and/or independent increments. Discrete Markov chains: linear algebra of stochastic matrices, classification of states. Finite Markov chains: stationary measures and ergodic behaviour. Reversibility, random walk on graphs. Urn models. Countable Markov chains: transience, null-recurrence, positive-recurrence. Random walks on Zd: Polya's theorem. Random walks on countable graphs, branching processes, discrete time birth-and-death processes, queuing problems. Random walks on Z1: the reflection principle and limit distribution of the maximum, difference equations. Continuous time, discrete space Markov processes: the Poisson process, jump rates, exponential clocks. Stochastic semigroup: Kolmogorov-Chapman equations, infinitesimal generator. Complements of measure theory: filtrations, adapted processes, natural filtration. The general notion of conditional expectation (Kolmogorov's theorem), fundamental properties. Discrete time martingales: sub/super/martingales, stopping times, stopped martingales. Optional stopping theorem, Wald identity, martingale convergence theorem, submartingale inequality, maximal inequality. Azuma-Hoffding inequality, applications. The Brownian motion: defining properties, covariances. Sketch of Paul Levy's construction, basic analytic properties. Applications.

Creating Mathematical Models

BMETE95AM12 – 0/2/0/f/2

Dr. Domokos Szász

The aim of the seminar to present case studies on results, methods and problems from applied mathematics for promoting. The spreading of knowledge and culture of applied mathematics. The development of the connections and cooperation of students and professors of the Mathematical Institute, on the one hand, and of personal, researchers of other departments of the university or of other firms, interested in the applications of mathematics. The speakers talk about problems arising in their work. They are either applied mathematicians or non-mathematicians, during whose work the mathematical problems arise. An additional aim of this course to make it possible for interested students to get involved in the works presented for also promoting their long-range carrier by building contacts that can lead for finding appropriate jobs after finishing the university.

Micro- and Macroeconomics

BMEGT30A410 – 3/0/0/f/4

Dr. Katalin Petró

Applied Numerical Methods with Matlab

BMETE92AMxx – 2/0/2/f/4

Dr. Tamás Tasnádi

Usage of MATLAB (all discussed numerical methods will be introduced and tested in MATLAB). The discussed topics are: error calculation, direct and iterative solution of linear systems of equations: Gauss elimination, Gauss transform factorizations of matrices, conditionality of linear systems of equations, Jacobi, Seidel and SOR iteration; convergence of the iteration, error estimation, optimization type methods for solving linear systems of equations, estimation of the eigenvalue, power method for the eigenvalue, eigenvector problem of matrices, inverse power method, transforming matrices to special forms, Jacobi method for determining eigenvalues and eigenvectors, QR method for determining eigenvalues, simple interpolation with polynomials, Hermite interpolation, interpolation with third degree spline, approximation according to least squares with polynomials and trigonometric polynomials, trigonometric interpolation, basics of fast Fourier transform, numerical integration, Newton-Cotes formula and its usage, Gaussian quadrature, solution of non linear systems of equations, roots of polynomials, numerical solution to the initial value problems of ordinary differential equations, basic terms of one step methods, Runge-Kutta methods, stability, convergence and error estimation of one step methods, multi step methods.

Differential Geometry 2

BMETE94AM20 – 3/1/0/v/4

Dr. Szilárd Szabó

Differentiable manifolds, tangent space, tangent bundle. Integral curve of a vector field. Vector bundles and related algebraic constructions (direct sum, tensor product, dual, homomorphisms). Differential forms, pull-back, exterior product, exterior derivation. Integration on compact oriented manifolds, Stokes' theorem. Lie-derivative, Lie-Cartan formula. Riemannian metric, examples. Geodetics, exponential map. Lie groups and algebras. Hopf-Rinow theorem and its consequences. Connections on a vector bundle, parallel transport, integrability. Levi-Civita connection, the Riemann curvature tensor. Properties of the curvature tensor, Ricci curvature. First and second variation of arc length, Jacobi vector fields.

BSc Thesis Project

BMETE90AM47 – 0/0/10/f/10

Dr. Miklós Horváth

This course is for graduate students to prepare their graduate thesis in which they prove that they can use the acquired knowledge independently and creatively.

Tools of Modern Probability Theory

BMETE95AM33 – 4/0/0/v/4

Dr. Imre Tóth

The goal of the course is to teach the most important tools that modern probability theory uses from combinatorics, linear algebra, real analysis, measure theory, complex analysis, functional analysis and geometry. We demonstrate the use of these tools through examples, but the emphasis is on developing the tools. A part of the knowledge acquired will be utilised in the masters program. Combinatorics: method of generator functions. Stirling formula. Euler gamma function. Topology: convergence on metric spaces and topological spaces. Compactness. Product space, product topology. Tychonoff's theorem. Linear algebra: inner product spaces. Cauchy-Schwartz inequality. Calculating powers of matrices, analytic matrix-calculus. (Application: Markov transition probabilities.) Transformations of functions: Laplace transform. Fourier expansion, Fourier transformation. Discrete Fourier tranformation. (Application: characteristic function.) Legendre transform. Measure theory: exchanging integral and derivative. Uniform convergence and continuity. (Application: differentiability of the characteristic function.) Jensen inequality. Absoulte continuity, Radon-Nikodym theorem. (Application: conditional expectation.) Push-forward of measures, integration by substitution. (Application: distribution of random variables, expectation of random variables.) Product space, product measure. Fubini's theorem. (Application: independence.) Decomposition of measures, conditional measure, factor measure. Complex analysis: Residue theorem, Laurent expansion. (Application: calculating convolutions and characteristic functions.) Analytic extensin, Vitali's theorem. Functional analysis: spectrum of bounded operators, resolvent, spectral radius. Hahn-Banach theorem. Ck spaces, Arsela-Ascoli theorem. Continuous linear functionals, Riesz-Markov theorem. Dual spaces, weak star topology, tightness. Fourier transform once again, Riesz-Fischer theorem.

Measure Theory

BMETE92AM42 – 4/0/0/v/4

Dr. Miklós Horváth

Recapitulation: sigma-algebra, outer measure, measure. Signed measure, Hahn decomposition. Radon measures, approximation theorem. Lebesgue-Stieltjes measure. Measurable functions. Convergence in measure. Theorems of Egoroff and Lusin. Integration in measure spaces. Absolute continuity of the integral. Integration of sequences of functions: theorems of Beppo-Levi, Fatou and Lebesgue. Products of measure spaces, Fubini theorem. Lp spaces. Absolutely continuous and singular measures, Radon-Nikodym derivative, Lebesgue decomposition. Absolutely continuous functions, Newton-Leibniz formula. Total variation. Functions of bounded variation, decomposition into absolutely continuous and singular parts.

Individual Research Project 1, 2

BMETE90AM48, 49 – 0/0/0/f/2

Dr. Miklós Horváth

Under the guidance of a chosen tutor, the student works on understanding a paper or a book chapter about contemporary mathematics. The goal is to get familiar with basic methods and abilities of research like exact understanding of mathematics in English, use of libraries and of the net etc. At the end of the semester the student makes a written English summary in a few pages and gives a short presentation in a seminar talk.

Partial Differential Equations

BMETE92AM45 – 2/2/0/v/4

Dr. János Karátson

Classification of partial differential equations (PDEs). First order linear PDEs. Convection transport processes. First order quasilinear PDEs. Parabolic Cauchy problems. Heat conduction problem, qualitative properties. Hyperbolic Cauchy problems. Wave equation in one space dimension: vibrating string, travelling and standing waves. Wave equation in two and three space dimensions using surface integral. Elliptic boundary value problems. Elliptic models: stationary heat distribution, elastic torsion. Uniqueness of the solution. The problem of the notion of solution. Theoretical background: Hilbert spaces, Fourier series, symmetric operators. Fourier series expansion for elliptic boundary value problems using eigenfuctions. Theoretical background: distributions, Sobolev spaces. Weak solution of elliptic problems. Weak eigenvalue problem. Parabolic and és hyperbolic initial-boundary value problems. Elliptic fundamental solution, mathematical description of the potential for a point source, Green's function.

Convex Geometry

BMETE94AM22 – 2/2/0/v/4

Dr. Zsolt Lángi

Introduction: affine and convex sets, affine dependence, independence, affine and convex combinations, affine hull, isolation theorem, characterization of closed, convex sets as the intersection of closed half spaces. Convex hull, theorems of Radon, Helly and Carathéodory, their applications. Linear functionals and their connection with hyperplanes, Minkowski sum, separation of convex sets with hyperplanes, supporting hyperplanes, faces of a convex body, extremal and exposed points, theorems of Krein-Milman and Straszewicz. Indicator function, algebras of closed/compact convex sets, valuations, Euler characteristic and the proof of its existence. Convex polytopes and polyhedral sets, their connection, face structure of polytopes, combinatorial equivalence. The f-vector of polytopes, Euler characteristic of polytopes, theorem of Euler. Polar of a set, fundamental properties of polarity, properties of the polar of a polytope, dual polytope. Moment curve, cyclic polytopes and their face structure, Gale's evenness condition. Hausdorff distance of convex bodies. Affine transformations, Banach-Mazur distance. Ellipsoid as an affine ball. Unique existence of largest volume inscribed, and smallest volume circumscribed ellipsoid of a convex body. The Löwner-John ellipsoid, John's theorem for general, and centrally symmetric convex bodies.

Combinatorics and Graph Theory 2

BMEVISZA026 – 2/2/0/v/4

Dr. Tamás Fleiner

Geometric and abstract duality, weak isomorphism (2-isomorphism) and the Whitney theorems. Vertex and edge coloring, Mycielsky's construction, Brooks' theorem. 5-colour theorem, Vizing's theorem, connection of edge-colouring to matchings, Petersen's theorem. List colouring of graphs, Galvin's theorem. Perfect graphs, interval graphs and the perfect graph theorem. Ramsey's theorem, Erdős-Szekeres theorem, Erdős' lower bound and the probabilistic method. Turán's theorem, Erdős-Stone theorem, Erdős-Simonovits theorem. Hypergraphs, Erdős-Ko-Rado theorem, Sperner's theorem and the LYM inequality. De Bruijn-Erdős theorem, finite planes, construction from finite field, and from difference sets. Generating functions, Fibonacci numbers, Catalan numbers. Posets, Dilworth's theorem.

Description of MSc Subjects in Physics

BASIC COURSES

Fundamentals of Photonics

BMETE12MF49 – 2/1/0v/4

Dr. Attila Barócsi

Based on general knowledge in optics, the course aims at getting students familiarized with the rapidly expanding field of modern photonics. Photonics is advancing into the forefront of applications where electronic devices approach their speed and bandwidth limits. The course expressively, recalling only the necessary mathematic, physical and optical tools, reviews the photonic devices describing their operation and illustrating their application. Topics: Connection between optics and photonics, the necessity of photonics evolution. Photon generation by spontaneous and stimulated emission: LED, laser diode, optical amplifier. Amplified spontaneous emission and superluminescent LED. Outlook: single photon sources. Manipulation of light in optical fibers: fiber based photonic devices, fiber amplifier. Photonic crystal fibers and their special applications. Outlook: supercontinuum laser. The electro-optic effect and its applications: electro-optic Pockels and Kerr effect. Elektroabsorption. Magneto-optics: Faraday effect and optical isolator. Outlook: optical Kerr effect, self focusing and self-phase modulation. The acusto-optic effect and its applications: modulators, light deflectors, filters and special devices. Integrated photonic devices and "light circuits". Optical switches and interconnects. Measuring tools at optical frequencies: optical time and frequency measurements. Atomic clock and frequency comb. Biophotonics: optical manipulation of biological samples: optical trap, "optical oscilloscope", FRET, superresolution). Outlook: optogenetics. Photodetectors and solar cells. Single-photon detectors.

Nuclear Physics

BMETE80MF00 – 3/0/0/v/4

Dr. Dániel Péter Kis

This course describes the main chapters of the low-energy nuclear physics building on the experimental nuclear physics knowledge gained while earning a BSC degree in Physics. The following topics are discussed: measurement and systematics of the most important parameters of nuclei in ground state, nuclear models, nuclear forces, nuclear reactions, theoretical description of nuclear decay modes, nuclear fission, nuclear fusion and its use for energy production, nuclear cosmology, nuclear astrophysics.

Nanotechnology and Materials Science

BMETE11MF36 – 3/0/0/v/4

Dr. Szabolcs Csonka

This course gives an introduction to state-of-the-art fabrication and measurement techniques of nanotechnology and material science by explaining examples of recent research results. Main topics: Concept of nanotechnology, characteristic length scales, and surprising behaviors observed at the nanoscale. Imaging tools for nano: scanning probe microscopy, electron microscopy. Fabrication of nanostructures by top- down approaches: lithography, layer deposition and special nanofabrication techniques. Fabrication of nanostructures with bottom-up methods: self-assembly. Silicium technology, semiconductor heterostructures, 2D electron gases. Important applications from the field of optics and electronics. New concepts in electronics: spintronics, memristors, molecular electronics and quantum electronics. Mapping the structure of matter by scattering experiments. Optical spectroscopy methods to study electric and vibrational properties of matter. Surface characterization methods. Modern classes of matter (carbon nanostructures, multifunctional materials, 2D crystals, etc.) and their applications.

Particle Physics

BMETE15MF43 – 2/1/0/v/4

Dr. Gábor Takács

The course aims to survey the fundamental phenomena, models and experimental methods of particle physics. Topics covered: Discovery of particles, their properties and classification. Locality, relativistic fields. Dirac equation. Electromagnetic interaction, gauge invariance. Strong interaction. Isospin symmetry. Fundamentals of SU(3) quark model of hadrons. Discovery of colour, basics of quantum chromodynamics. Weak interactions. Neutrinos. Parity and CP violation, CPT invariance. Basics of Fermi theory. FCNC problem, GIM mechanism. The W and Z intermediate bosons and the Higgs particle. Particle accelerators. Principles of particle detection. Open problems and perspectives in particle physics.

Statistical Physics 2

BMETE15MF44 – 2/1/0/v/4

Dr. Gergely Zaránd

Critical phenomena: scaling and critical exponents, basics of renormalization group, correlation functions, Ginzburg criterion. High temperature expansion. Time dependent correlations: correlation functions in equilibrium, classical fluctuations, Onsager relations. The density operator, Neumann equation, Neumann entropy. Kubo formula, fluctuation-dissipation theorem. Non-equilibrium dynamics: Brown motion, diffusion, Langevin equation, Fokker-Planck equation. Master equation H theorem, principle of maximum entropy. Detailed balance and Monte-Carlo simulations, simulated annealing. Interacting quantum systems: quantum gases, superfluidity, Gross-Pitaevskii equation. Fermi liquid theory.

Computer Simulation in Physics

BMETE15MF45 – 2/1/0/f/4

Dr. János Török

The course is based on the statistical physics and programming skills learned in the BSc programme gives insight into basic simulation techniques of physics. Main topics: Monte Carlo method (pseudo random numbers, importance sampling, Metropolis algorithm, boundary conditions, ensambles, averages, characteristic time), Phase transitions (finite-size scaling, critical slowing down, optimizations, quantum spin chain), Discrete models (percolation, lattice models, noise, instability), Schrödinger equation (Lánczos method), molecular dynamics (interactions, solvers, event driven MD, instabilities). Networks and applications (clustering, page rank). Algorithmically defined models (self-organized criticality, game models, Nash-equilibrium).

Investments

BMEGT35M004 – 2/0/0/f/2

Dr. Mihály Ormos

Markowitz's portfolio theory: maximization of expected utility, risk-aversion and rationality, diversification, diversifiable and non-diversifiable risk, efficient portfolios. CAPM by Sharpe: risk-free opportunity, homogeneous expectations, market portfolio and the capital market line, beta and the security market line. Market efficiency: efficient capital market, efficient market hypothesis (EMH), levels of market efficiency (weak form, semi-strong form, strong form). Market microstructure: theory and empirics. Behavioral finance: behavioral finance models, criticisms of behavioral finance, heuristics, framing, anomalies.

Applied Numerical Methods with MATLAB

BMETE92MFxx – 4/0/2/f/6

Dr. Róbert Horváth

Usage of MATLAB (all discussed numerical methods will be introduced and tested in MATLAB) The discussed topics are: error calculation, direct and iterative solution of linear systems of equations: Gauss elimination, Gauss transform factorizations of matrices, conditionality of linear systems of equations, Jacobi, Seidel and SOR iteration; convergence of the iteration, error estimation, optimization type methods for solving linear systems of equations, estimation of the eigenvalue, power method for the eigenvalue, eigenvector problem of matrices, inverse power method, transforming matrices to special forms, Jacobi method for determining eigenvalues and eigenvectors, QR method for determining eigenvalues, simple interpolation with polynomials, Hermite interpolation, interpolation with third degree spline, approximation according to least squares with polynomials and trigonometric polynomials, trigonometric interpolation, basics of fast Fourier transform, numerical integration, Newton-Cotes formula and its usage, Gaussian quadrature, solution of non linear systems of equations, roots of polynomials, numerical solution to the initial value problems of ordinary differential equations, basic terms of one step methods, Runge-Kutta methods, stability, convergence and error estimation of one step methods, multi step methods.

ADVANCED GENERAL COURSES

Group Theory for Physicists

BMETE11AF40 – 2/2/0/v/5

Dr. Titusz Fehér

The aim of the course is to introduce the principles of group theory to physics students: we learn how the symmetries of a system can be used to describe it, and how the symmetries of nature manifest themselves in laws of physics. We apply the concepts of group and representation theory to practical problems. Theory: Symmetries in nature and physics. Definition and basic properties of groups. Some special groups. Homomorphism, isomorphism. Subgroups, cosets, Lagrange's theorem. Normal subgroup, quotient group, first isomorphism theorem. Conjugate, conjugacy classes, centralizer. Group action, orbit, stabilizer. Representations and their properties, equivalent representations, irreducible representations. Schur's lemma. Character of representations, properties of characters, character tables. Direct sum of representations and their reduction. Product representations. Lie groups, infinitesimal generators, Lie algebras. Topological properties, universal covering group. Rotation group and its representations. Lorentz group and other matrix groups. Calculation: Description of normal modes, crystals, and quantum mechanical wave functions using group theory. Selection rules.

Electrodynamics 2

BMETE15AF34, 42 – 2/2/0/fv/5

Dr. Gábor Takács

Electrostatics: Solving Laplace's equation in spherical and cylindrical coordinates. Grounded sphere in external field, electric field near a sharp cone. Multipole expansion in spherical harmonics. – Magnetic and quasistatic fields: magnetic scalar potential, solution methods in nonlinear materials. – Electromagnetic waves in vacuum and matter. Microscopic model for polarizability. Dispersion, plasma frequency, Kramers-Kroing relations. – Wave guides, resonant cavity. Losses, quality factor. – Radiation field of oscillating charges. Electric dipole and quadrupole, magnetic dipole radiations. – Scattering of electromagnetic waves, cross section. Scattering on solids and gases. – Lienard-Wiechert potential of moving charge, field strength, radiated power, angular distribution, spectrum. Synchrotron radiation. Cherenkov and transitional radiations. – Elements of relativistic electrodynamics.

Quantum Mechanics 2

BMETE15AF36, 43 – 2/2/0/fv/5

Dr. László Szunyogh

This course conveys advanced knowledge on Quantum Mechanics according to the following topics: The WKB approach, quasi-classical quantization. Scattering theory, scattering amplitude and cross section, Green functions, Lippmann-Schwinger equation, Born series, method of partial waves. Motion in electromagnetic field, Aharonov-Bohm effect, Landau levels. Time evolution and pictures in Quantum Mechanics (Schrödinger, Heisenberg and Dirac pictures). Adiabatic motion and Berry phase. Relativistic Quantum Mechanics, Klein-Gordon equation, Dirac equation, continuity equation, Lorentz invariance, spin and total angular momentum. Free electron and positron. Non-relativistic limit, spin-orbit interaction.

Mechanics 2

BMETE15AF32, 44 – 2/2/0/fv/5

Dr. Gergely Zaránd

Relativistic mechanics: Lorentz-transformations, four-vectors and Minkowski space, relativistic collisions, relativistic action and equations of motion. Relativistic particle in an electromagnetic field. Lagrange-theory of continuum mechanics: Lagrange density of a string, Euler-Lagrange equations, energy density. Application to quantum mechanics and to harmonic media, Klein-Gordon equations. Hamiltonian formulation of continuum mechanics. Symmetries: Noether's theorem, symplectic formulation of Hamiltonian mechanics. Poisson's brackets, integrability. Canonical transformations, Hamilton-Jacobi equations, action-angle variables. Nonlinearity, second harmonic generation, parametric resonance. Basics of dynamical systems and chaos.

Computer Solution of Technical and Physical Problems

BMETE11AF41 – 0/0/2/f/3

Dr. Gábor Varga

In the frame of this subject basic models of different technical and physical applications are investigated (among others: one and many body problems, Poisson equation, flow dynamics, plate deformation, heat conductivity, wave equation, Schrödinger equation). Relating to these problems on computer implemented MATLAB programs are written.

During the computer implementation not only the physical aspects of the models are analyzed but the required numerical methods too. The programming tool is the MATLAB program language.

Theory of Relativity

BMETE15AF46 – 2/0/0/v/3

Dr. Péter Lévay

Minkowski spacetime, four vectors. Lorentz and Poincaré groups. Time dilation, Lorentz contraction, relativity of simultaneity. Addition of velocity, rapidity. Causality, Zeeman's theorem. Proper time, four velocity, four acceleration. Relativistic dynamics. Hyperbolic motion. Principle of Equivalence. Geodesic hypothesis. Principle of covariance. Local systems of inertia. Riemann and pseudo Riemann geometry, Christoffel symbols. Geodesics. Covariant derivative, parallel transport. The Newtonian limit. Connection between the metric tensor and the gravitational potential. Geodesics from a variational principle. Riemann tensor and its properties. Riemann tensor and its connection with parallel transport. Geodesic deviation. Ricci tensor, scalar curvature. Bianchi identity, Einstein tensor. Energy-momentum tensor. Conservation of energy and momentum. Einstein's equation, Einstein-Hilbert action, cosmological term. Schwarzschild's solution. The perihelium precession of Mercury.

Fundaments and Applications of Materials Science

BMETE12AF31 – 2/0/0/v/3

Dr. Ferenc Réti

The aim of the subject is to give a basic knowledge in the modern materials science and its use in different areas of physics and engineering. Topics: Materials science and engineering. Modern materials, requirements in their use. Role of primary and secondary bonding in properties of materials. Importance of thermal processes, thermodynamics, thermochemistry, Hess principle, Born-Haber cycle. Chemical potential, equilibrium constant. Reaction rate equations. Arrhenius and Eyring equation. Importance of crystal imperfections e.g. in electrical and mechanical properties. Equilibrium concentration of crystal imperfections. Sensors in engineering. Principles, physical and chemical sensors. Pressure sensors, thermometers, strain gauges, magnetic sensors. Non-destructive testing. Flaw detection by ultrasound, X-ray. Magnetic tests. Practical examples. Alternative energy sources and energy carriers; contradictions of the field. Hydrogen economy, bio-ethanol. Fuel cells as continuous power sources.

Microtechnology and Nanotechnology

BMETE12AF33 – 2/0/0/f/3

Dr. Gábor Kiss

Definition of microtechnology, nanotechnology and molecular nanotechnology, their comparison and interrelation. Conditions of the technology. Micro- and nanophysics. Thin layer deposition methods: physical (vacuum evaporation, laser ablation evaporation, molecular beam epitaxy, sputtering). Doping (diffusion, ion implantation). Litography (photo, X-ray, electron beam, ion beam). Layer removing technologies: wet chemical" etching, dry etching (plasma, ion beam). Layer characterisation methods: X-ray diffraction, transmission electron microscopy, scanning electron microscopy, secondary ion mass spectrometry, X-ray photoelectron spectroscopy, Auger electron microscopy, scanning tunneling microscopy, atomic force microscopy. Conventional electronic devices: bipolar transistor, field effect transistor. Thick layer technology: screen printing, burning, thick layer pastes. Nanometer devices: single electron devices, resonant tunnel effect devices, micro-electromechanical systems, sensors, image detectors, displays.

Computer Controlled Measurements

BMETE11AF38 – 0/0/2/f/3

Dr. András Halbritter

The participants gain experience in computer controlled measurements and in the programming of scientific instruments and data acquisition system. To this end the following topics are covered: communication with the instruments via serial, GPIB, and USB ports. Programming of data acqusitin cards. Programming of complex measurement control platforms, plotting and saving the data, programming of timelines, in situ data analysis. The course consists of 4 hour long computer laboratory exercises every second week. In the first part of the semester fundamental programming skills are obtained through simple example programs. In the second part the participants individually program complex measurement control and data analysis platforms, like nonlinear curve fitting by Monte Carlo method, full computer control of a digital multimeter, digital oscilloscope program using a data acquisition card.

QUANTUM PHYSICS

Quantum Field Theory

BMETE15MF46 – 3/2/0/v/6

Dr. Gábor Takács

Relativistic invariance, classical fields, Noether theorem. Klein-Gordon and Dirac equations. Majorana and Wey spinors. Free quantum fields (scalar, Dirac, electromagnetic); relativistic quantum particles. Feynman path integral, functional formalism, covariant perturbation theory, Feynman diagrams. Reduction formulae, scattering theory. Fundamentals of renormalisation theory. Scale dependence, renormalisation group. Relation to statistical physics. Critical phenomena, scaling. Spontanous symmetry breaking. Effective potential. Goldstone theorem. Gauge invariance, nonabelian gauge theories. Higgs mechanism. Outline of the standard model. Semiclassical approximation. Instantons, vacuum decay. Topological excitations.

Quantum Information Processing

BMETE11MF42 – 2/0/0/v/3

Dr. András Pályi

Quantum bit, quantum computing, quantum algorithms. Spin-qubits in solids: quantum dots, interactions, energy scales. Realization of single- and two-qubit quantum-logical gates. Mechanisms of information loss: relaxation, dephasing, decoherence. Experiments.

Quantum Optics

BMETE15MF49 – 2/1/0/v/4

Dr. Gábor Takács

The course gives an introduction to quantum optics. The main topics are: Coherence in classical optics. Radiation transitions in quantum matter, atoms and semiconductors. Photodetection, photon statistics, light with super- and sub-Poisson statistics. Hanbury-Brown-Twiss experiment, photon antibunching. Coherent and squeezed states, Wigner functions. Resonant atom-light interactions, density operator, Rabi oscillation. Atoms in a resonator, Purcell effect, strong coupling. Cold atoms, Bose condensation, optical lattices. Quantum cryptography and quantum informatics. Entanglement, quantum teleportation, Bell inequalities.

Many-Body Physics 1

BMETE15MF50 – 3/1/0/v/5

Dr. Gergely Zaránd

This course is the first and independent part of a two-semester many-body course. It gives an introduction to the basic machinery of field theoretical Green's function methods applied for interacting solid state physics systems at T = 0 temperature, and demonstrates its power through applications for some simple cases. Although this is a basic course required for several advanced theoretical courses (The physics of one-dimensional systems, Many-body physics II, Localization theory, etc.), students taking this course must have a BSc level knowledge of quantum mechanics and statistical physics. The course focuses on the following topics: second quantized formalism, Green's functions and their connection to measurable quantities, Heisenberg-, Schrödinger-, and interaction picture, perturbation theory, diagram technique (Wick theorem, Feynman diagrams), resummation techniques (self-energy, Dyson equation, vertex function, skeleton diagrams), equation of motion methods.

Many-Body Physics 2

BMETE15MF54 – 2/0/0/v/3

Dr. Gergely Zaránd

This course is the second part of a two-semester many-body course. It gives an introduction to the finite temperature Green's function method applied for interacting solid state physics systems. This technology is one of the standard tools used in modern solid state physics. The course focuses on the following topics: Matsubara Green's functions (analytical properties, spectral functions, etc.), imaginary time perturbation theory, diagram technique (Wick theorem, self-energy, vertex function, skeleton diagrams), applications (quantum transport, polarons, Peierls instability, Hartree-Fock method, RPA).

Quantum Monte Carlo Methods

BMETE15MF40 – 2/0/0/f/3

Dr. Csaba Tőke

The course provides an introduction to the stochastic modeling of interacting quantum-mechnical many-particle systems, which became popular due to the immense growth of computing power since the late 1970's. We review the basic algorithms: the variational Monte Carlo method (VMC), the diffusion Monte Carlo method (DMC), the path-integral Monte Carlo method (PIMC), and possibly the Green's function Monte Carlo method (GFMC), the Hirsch-Fye algorithm, and the continuous time quantum Monte Carlo method, as well as the range of problems that can be analyzed by these techniques, the major fields where Monte Carlo methods are indispensable, and have proven very successful (the interacting electron gas, liquid an superfluid Helium, the phase diagram of hydrogen, quantum chemistry, and nanostructures). After completing the course the students should be prepared to implement their own quantum Monte Carlo codes, thereby analyze interacting quantum-mechnical problems by stochastic methods.

Statistical Field Theory

BMETE15MF39 – 2/0/0/v/3

Dr. Gábor Takács

The course gives an introduction to the applications of relativistic quantum field theory to statistical systems. The main topics are: Critical phenomena, scaling, scale invariance. Field theory description. Scale invariance and conformal invariance in arbitrary dimensions. Two-dimensional conformal field theories. Virasoro algebra. Classification of operators, operator-state correspondence. State space and partition function. Operator algebra. Correlation functions in conformal field theories. Description of the vicinity of the critical point. Renormalisation group flows. Relevant and irrelevant perturbations. Conserved quantities. Integrable quantum field theories. Analytic S matrix theory, bootstrap. Form factors and correlation functions in integrable quantum field theories. Finite size effects. Thermodynamical Bethe Ansatz and Truncated Conformal Space Approach. Non-integrable models.

The Physics of One-Dimensional Systems

BMETE15MF05 – 2/0/0/v/3

Dr. Gergely Zaránd

This course gives a basic introduction to the physics and theoretical description of interacting one-dimensional electron and spin systems. One-dimensional systems display basic phenomena such as charge- and spin density wave formation, antiferromagnetism and exotic superconductivity, and are fundamental test-grounds for solid state physicists, since powerful field theoretical approaches can be used for them. Moreover, they are often realized in physical systems such as carbon nanotubes, quasi one-dimensional systems, or edge states. The course assumes the knowledge of basic Green's function methods (Many body physics I), and is organized along the following topics: one-dimensional systems in nature (the Hubbard model, instabilities within the random phase approximation, spin and charge density waves, mapping to the Heisenberg model), basic properties of spin chains (Haldene's conjecture, spin coherent states, spin liquids, the basics of Bethe Ansatz), the continuum limit (renormalization group and the Tomonaga-Luttinger model), bosonization (spin-charge separation, the Luttinger liquid phase), effects of disorder.

SOLID STATE PHYSICS

Modern Solid State Physics

BMETE11MF41 – 3/2/0/v/6

Dr. Attila Virosztek

This course describes the behavior of interacting many body systems (mainly electron systems) building on solid state physics and statistical physics knowledge gained while earning a BSC degree in Physics. The following topics are discussed: identical particles, second quantization, interacting electron systems in Bloch and Wannier representation, itinerant ferromagnetism, linear response theory, susceptibility of metals, spin density waves, Bose liquid.

Group Theory in Solid State Research

BMETE11MF12 – 2/0/0/v/3

Dr. György Kriza

Point groups, fundamental theorems on finite groups, representations, character tables. Optical spectroscopy: selection rules, direct product representations, factor group. Electronic transitions: crystal field theory, SO(3) and SU(2) groups, correlation diagrams, crystal double groups. Symmetry of crystals: space groups, International Tables of Crystallography. Electronic states in solids: representations of space groups, compatibility rules.

Superconductivity

BMETE11MF45 – 2/0/0/v/3

Dr. György Kriza

Elementary Phenomenology: Zero resistivity, Meissner effect, critical magnetic field, London equations, magnetic penetration depth, electrodynamics of superconductors. Bardeen-Cooper-Schrieffer Theory: Cooper pairs, BCS ground state, quasiparticle excitations, thermodynamic properties, transport properties, coherence effects, magnetic properties. Ginzburg-Landau Theory: GL free energy, GL equations, energy of normal-superconductor domain walls, Abrikosov vortices, magnetic properties of Type II superconductors, vortex flow and pinning. Josephson effect: Josephson junctions, dc and ac Josephson effect, Josephson junction in magnetic field, SQUID and its applications. Exotic superconductors: 1d and 2d superconductors, High-Tc superconductors, d-wave pairing, superconductivity and magnetism, phase diagram of vortices in layered superconductors.

Theory of Magnetism

BMETE11MF44 – 2/1/0/v/4

Dr. Attila Virosztek

Magnetic phenomena are considered as electron correlation effects. The Hubbard model is used to interpret the Mott metal-insulator transition. A variational theory is given which allows the understanding of heavy fermion behavior. The antiferromagnetic Heisenberg model is introduced as the effective hamiltonian of the large-U Hubbard model at half filling. Other kinetic exchange processes, including ring exchange with application to the magnetism of solid He3, are discussed. A detailed treatment of the two-site Coulomb processes allows the introduction of direct exchange. The survey of various mean field theories of magnetic order begins with the Stoner theory. Weak itinerant ferromagnets like ZrZn2 and MnSi are discussed in some detail.

Theory of Magnetism 2

BMETE11MF14 – 2/0/0/v/3

Dr. Attila Virosztek

The basic concepts and results from the first part of the course are assumed to be familiar. The variety of magnetic ordering phenomena is surveyed, the conditions of ordering, and the nature of the excited states over ordered ground states are discussed in various theoretical frameworks. The concept of the quantum critical point is used for rare earth systems with non-fermi-liquid behavior. Localized-spin order and spin wave theory is described both for ferromagnets and antiferromagnets. A detailed discussion of quantum fluctuations in the ground state is given, including recent results on the possibility of spin liquid ground states. A particular kind of magnetic cooperative behavior is shown to give rise to the integer and the fractional quantum Hall effect.

Magnetic Resonance

BMETE11MF43 – 2/1/0/v/4

Dr. Titusz Fehér

The course discusses one of the most important investigation methods in physics, chemistry and medical sciences. It is based on the electrodynamics and quantum mechanics studies required for the BSC degree. Topics include experimental methods of electron and nuclear magnetic resonance, Bloch equations, dipole-dipole interaction, motional narrowing, crystal fields and fine structure, hyperfine splitting, chemical shift, magnetic resonance in metals, superconductors and magnetically ordered materials.

Theoretical Nanophysics

BMETE15MF47 – 2/1/0/v/4

Dr. Gergely Zaránd

Mesoscopic and nanoscale systems represent one of the most intensely studied fields in modern solid state physics: by means of lithographic methods one can engineer semiconducting, metallic and superconducting devices, in which conduction electrons move coherently and quantum mechanics is at work, and can contact and manipulate molecules or nanoscale grains, and couple them to microresonators. The goal of this course is to survey theoretical tools that can be used to describe the physics of these nanoscale devices. The course assumes a solid knowledge of quantum mechanics, solid state physics and statistical physics, and focuses on the following topics: description of small grains (Coulomb interaction, coherence, single particle levels), basics of random matrix theory (level repulsion, universality classes), Coulomb blockade and spectroscopy (master equations, co-tunneling, Kondo effect), conductance and noise spectrum of point contacts, nanotubes and edge states, molecular transport, superconducting grains, Josephson-junctions and quantum bits, quantum spin manipulation. Solving problem sets in an integral part of this course. (Students are offered regular consultation.)

Electronic Structure of Solid Matter

BMETE15MF51 – 2/1/0/v/4

Dr. László Szunyogh

Building on the quantum mechanics and solid state physics studies within the Physics BSc program, this course aims to discuss modern theories and methods for the electronic structure of solid matter. The following topics will be outlined: Foundations of the static density functional theory. Variational and pseudopotential methods. Ab initio methods for correlated systems (LDA+U, self-interaction correction, DMFT). Point group symmetry in electronic states. Spin-orbit coupling and time-reversal symmetry. Surface states, the Bychkov-Rashba effect. Green's function technique within the tight-binding approximation. Alloy theory, the coherent potential approximation. Ab initio theory of metallic (itinerant) magnetism, the Stoner model. The method of disordered local moments.

Foundations of Density Functional Theory

BMETE15MF15 – 2/0/0/v/3

Dr. János Pipek

Many-body Fock space and density operator. Reduced density operators. Exact equations and the independent particle approximation for the interacting electron gas in the density operator picture. N-representability. The Fermi hole and localized orbitals. The electron density. Kato's theorem and cusp conditions. The v- and N-representability of the electron density. The Hohenberg-Kohn theorems. Existence of the universal density functional. Levy's constrained search. Scaling properties. The Kohn-Sham equations. Fractional occupation numbers. The chemical potential and electronegativity. Approximate methods. The gradient expansion. Recent functionals.

Topological Insulators

BMETE11MF34 – 2/0/0/v/3

Dr. András Pályi

An important finding of the previous decade is that even the (non-interacting) band theory of electrons in solids can provide fundamental novelties. Topological insulators are crystalline band-insulator materials accomodating conducting – occasionally perfectly conducting – surface states. In this lecture series we use simple models to introduce the topological invariants that are important in band theory, we provide theoretical tools to calculate those, and show how topology protects the surface states from certain perturbations. We provide insight into the general theory of topological insulators, and review a few related experimental arrangements and results. Topics: One-dimensional crystals with chiral symmetry: the Su-Schrieffer-Heeger model. Adiabatic dynamics in quantum mechanics, Berry phase, Chern number. Adiabatic charge pumping in a one-dimensional crystal. Quantum Anomalous Hall effect: the Qi-Wu-Zhang model. Two-dimensional time-reversal-invariant topological insulators: the Bernevig-Hughes-Zhang model. Quantized conductance of two-dimensional topological insulators.

Topological Insulators 2

BMETE11MF35 – 2/0/0/v/3

Dr. András Pályi

Based on the material covered in “Topological insulators”, in this course we discuss how to store and process quantum information in topological superconductors. Regarding single-particle excitations, superconductors can be regarded as band insulators in the Bogoliubov-de Gennes formalism. Under certain conditions, a superconductor can be topologically nontrivial. Such one- and two-dimensional materials can support topologically protected zero-energy bound states, called Majorana fermions. We review the theoretical and experimental status of these bound states, and the basis of utilizing those for storing and processing quantum information. We also give an outlook on strongly correlated, topologically ordered models. Topics: Superconductivity and the Bogoliubov-de Gennes formalism. Topological superconductivity in one dimension: Kitaev wire, Majorana modes and bulk-boundary correspondence. Electronic transport in topological superconductors: tunneling spectroscopy and the Josephson effect. Experimental realization of topological superconductors. Topological superconductivity in two dimensions: p+ip superconductors, bound states in vortices. Majorana modes and topological quantum information processing. Topological order: Kitaev’s toric code and honeycomb models.

STATISTICAL PHYSISC

Evolutionary Game Theory

BMETE15MF11 – 2/0/0/v/3

Dr. László Szunyogh

This course gives an introduction to the multi-agent evolutionary games building on statistical physics knowledge gained while earning a BSc degree in Physics. The following topics are discussed: Concepts of traditional game theory (strategy, payoff, matrix game, Nash equilibrium, etc.); Evolutionary games with population dynamics; Evolutionary games on lattices and graphs; Generalization of dynamical pair approximation. Many interesting phenomena are described by considering the repeated multiagent Prisoner’s Dilemma and Rock-Scissors-Paper games for different connectivity structures.

Phase Transitions and Criticality

BMETE15MF48 – 2/1/0/v/4

Dr. Gergely Zaránd

First and second order phase transitions, correlation length, self-similarity and universality. A few typical phase transitions (uniaxial magnets, liquid-gas transition, Mott transition). Mean field theory and critical exponents, Ginzburg criterion. Symmetries and Landau theory. Basics of renormalization group: decimation, the 1D Ising model, higher dimensions and critical point. Case of the 2D Ising model. Wilson’s theory: fixed points, critical surface, relevant and irrelevant operators. Scaling of the free energy, universal critical exponents, correlation functions of scaling operators. Finite size scaling, first order transitions. Quantum critical systems, discussion of the one-dimensional Ising chain. Quantum-classical mapping, higher dimensional phase diagrams. Superfluidity and the XY model, vortices and Kosterlitz-Thouless transition. Hubbard-Stratonovic transformation and continuum models. Goldstone-modes, large n limit. Quantum magnets.

Complex Networks

BMETE15MF38 – 2/0/0/v/3

Dr. János Kertész

The aim of the course is to give an introduction to the rapidly developing interdisciplinary field of complex networks. Complex systems and their scaffold. Percolation theory. Erdős-Rényi and small world graphs. Scale free networks. The configuration model. Networks growth models. Local and hierarchical structures. Communities. Spreading. Temporal networks. Social networks. Economic networks. Ecological networks. Project presentation.

The Physics of Disordered Systems

BMETE15MF53 – 2/1/0/v/4

Dr. Gergely Zaránd

Structural disorder: polymers, fractals, liquids, glasses and quasicrystals. Amorphous metals. Percolation. Disordered ferromagnets: hysteresis and Preisach model. Domain wall motion and avalanches. Barkhausen noise and mean field theory. Superparamagnets and Griffith-phase. Frustrated spin systems and spin glasses: phenomenology, TAP equations, Sherrington-Kirkpatrick model. Replicas, the replica symmetrical solution and replica symmetry breaking. Droplet theory. Localization transition (Anderson): doped semiconductors and the phenomenon of localization transition, Anderson’s theory, inverse participation ratio, local density of states. The scaling theory of localization. Multifractal properties and the critical wave function. Coulomb glass, many-body localization. Quantum glasses: The Bose glass, Fisher scaling and strong disorder fixed points. Solving problem sets is integral part of this course.

Random Matrix Theory and Its Physical Applications

BMETE15MF10 – 2/0/0/v/3

Dr. Imre Varga

Random matrix theory provides an insight of how one can achieve information relatively simply about systems having very complex behavior. The subject based on the knowledge acquired in quantum mechanics and statistical physics together with some knowledge of probability theory provides an overview of random matrix theory. The Dyson ensembles are defined with their numerous characteristics, e.g. the spacing distribution, the two-level correlation function and other quantities derived thereof. Then the thermodynamic model of levels is obtained together with several models of transition problems using level dynamics. Among the physical applications the universality classes are identified in relation to classically integrable and chaotic systems. The problem of decoherence is studied as well. Then the universal conductance fluctuations in quasi-onedimensional disordered conductors are investigated. Other models are investigated: the disorder driven Anderson transition and the random interaction model of quantum dot conductance in the Coulomb-blockade regime. We use random matrix models to investigate chirality in two-dimensional and Dirac systems and the normal-superconductor interface. The remaining time we cover problems that do not belong to strictly physical systems: EEG signal analysis, covariance in the stock share prize fluctuations, mass transport fluctuations, etc.

Classical and Quantum Chaos

BMETE15AF45 – 2/0/0/v/3

Dr. Imre Varga

Hamiltonian formalism, integrability in general, examples in physics for chaotic behavior in case of continuous and discrete dynamics; Continuous, non-autonomous differential equations; Anharmonic, dissipative oscillator; Mappings, Poincare-mapping; Periodically excited systems; Billiards. For some of these cases: application of techniques introduced for the analysis of chaos: Lyapunov exponent, invariant measures; Frobenius-Perron equation. Stability analysis; Bifurcations, attractors, strange attractors; Kolmogorov-entropy; KAM-theorem; Chaotic dynamics and its traces in quantum mechanics. Semiclassical quantization, WKB method; Gutzwiller-trace formula; Spectral statistics, Loschmidt-echo.

NANOTECHNOLOGY AND MATERIALS SCIENCE

Fundamentals of Nanophysics

BMETE11MF37 – 3/0/0/v/4

Dr. András Halbritter

The building blocks of nowadays electronic devices have already reached a few tens on nanometers sizes, and further miniaturization requires the introduction of novel technologies. At such small length-scales the coherent behavior and the interaction of electrons, together with the atomic granularity of matter induce several striking phenomena, that are not observed at the macroscopic scale. The course gives an introduction to a broad set of nanoscale phenomena following the topics bellow: Characteristic length-scales in nanophysics. Development of semiconductor industry, heterostructures, two dimensional electron gas systems, nanoscale fabrication techniques. Diffusive and ballistic nanowires, quantum wires, Landauer description of mesoscopic transport, conductance quantization. Interference phenomena in nanocircuits, decoherence. Integer and fractional quantized Hall effect. Noise as the signal: shot noise in quantum point contacts, charge measurement, classical and quantum chaos, Hanbury Brown & Twiss experiments with electrons and photons. Quantum dots and applications, artificial atoms, spin qubits. Carbon nanostructures, graphene, carbon nanotubes, fullerenes. Superconducting nanostructures, Andreev reflection, mesoscopic proximity effects. Spintronics, spin valve, spin torque, spin decoherence, spin injection, nonlocal measurements. Nanoelectromechanical systems.

Material Science Laboratory

BMETE12MF50 – 0/0/3/f/4

Dr. Olga Homokiné Krafcsik

The goal of the course is an introduction - in the field of materials science - to material characterization measurement methods and technologies on theoretical level and in practice also. On each laboratories a measurement method, technical conditions of sample preparation and measurement, evaluation and informations obtained from measurements will be introduced. Practical measurement examples and technological informations obtained from the measurement will be demonstrated. Int he lab, as far as possible, the students perform the sub-tasks independently. In some cases the measurements will be connected to a technological lab by a miniproject", in this way students can get an overview from sample preparation to measurement evaluation in a specialization field of materials science. The chosen methods will be demonstrated by experts in Budapest, on the latest available equipments. Planned measurements: vibrational spectroscopies, infrared spectroscopy, Raman spectroscopy, Electron diffraction, X-ray diffraction, NMR, ESR, Measurements on Semiconductor structures.

Selected Topics of the Modern Materials Science

BMETE12MF52 – 2/0/0/v/3

Dr. Ferenc Réti

The subject is based on the B.Sc knowledge in physics, treating selected topics of the modern materials science, using practical examples. Topics: Role of chemical bonds in the properties of materials. Single crystals, polycrystals and non-crytaline materials. Polymorphism and allotropy. Carbon and silicon in materials science; their modifications and properties. Mechanical properties of metals, ceramics, polymers, methods of their characterisation. Stress, elastic and plastic strain. Failure. Fatigue and the factors influencing it. Planning, risks, security factors. Crystal defects, their types, their importance in electrical and mechanical properties. Role of dislocations. Increase of hardness by reducing dislocation mobility. Driving force of phase transitions, the thermodynamic criteria. Crystalline and glassy transition. Modification of the prooperties of engineering materials by heat treatment. Phase diagrams, alloys, eutectics, intermetallics. The carbon-iron system, microstructures, steels. Properties and applications. Driving force of diffusion, its kinetics and mechanisms. Surface and intergranular diffusion, electromigration. The role of diffusion in microelectronics and solid phase chemical reactions. Monomers, oligomers, polymers. Structure of polymers, their molecular weight, shape of their molecules. Copolymers. Amorphous and crystalline and polymers. Composites. Corrosion, corrosion types, protection against corrosion.

Physics of Semiconductors 1

BMETE11MF26 – 2/0/0/v/3

Dr. Miklós Csontos

This course describes the behavior of modern semiconductor physics, – mostly those properties (electrical and optical), which provides understanding of present day electronics –, building on solid state physics and statistical physics knowledge gained while earning a BSC degree in Physics. Emphasize is paid to those new phenomena, which are unique of semiconductor materials and/or structures and provides much help for our understanding of condensed materials. The following topics are discussed: crystal structure and bonding, electron states, effective mass approximation, localized states, statistics of semiconductors, transport: phenomenological and microscopic, magnetic and high frequency transport, quantum hall Effect, thermal properties, inhomogeneous semiconductors, p-n junction, MOS structures, transport instabilities and Gunn effect, semiconductor lasers and light emitting diodes, principles of different applications: solar cell, optical communication, modern experimental techniques: deep level spectroscopy, lifetime measurements.

Chemistry in Nanotechnology

BMETE11MF38 – 2/0/0/v/3

Dr. István Lagzi

Basic principles of colloid science, suspensions, emulsions. Sols, gels and polymers. Measurement methods at nano- and microscales: TEM, SEM, cyroTEM, AFM, DLS, UV-VIS, etc. Synthesis of nanoparticles and their stabilization. Chemical, physical and biological methods (synthesis of particles by reduction). Size and shape-selective characterization of particles (sphere, rod, cube, octahedron, etc.). Monodispersity and polydispersity. Size and shape-selective purification of nanoparticles (centrifugation, gel electrophoresis, chromatography, etc.). Stabilization of nanoparticles. Interactions at nanoscale (van der Waals interaction, electrostatic interactions, steric interactions) and their use in stabilization of nanoparticles. Nanostructured materials, their properties and use. Special properties of nanoparticles (optical, electronic, magnetic, physical and chemical properties). The use of nanoparticles in chemistry (heterogeneous catlysis, solar cells, etc.). The use of nanoparticles in medicine (targeted drug delivery, antitumor drugs, the use of nanoparticles in medical diagnosis and medical optical imaging).

Nanotechnology Laboratory

BMETE12MF54 – 0/0/3/f/4

Dr. Olga Homokiné Krafcsik

The goal of the course is an introduction - in the field of nanotechnology - to material characterization measurement methods and technologies on theoretical level and in practice also. On each laboratories a measurement method, technical conditions of sample preparation and measurement, evaluation and informations obtained from measurements will be introduced. Practical measurement examples and technological informations obtained from the measurement will be demonstrated. In the lab, as far as possible, the students perform the sub-tasks independently. In some cases the measuremens will be connected to a technological lab by a miniproject”, in this way students can get an overview from sample preparation to measurement evaluation in a specialization field of nanotechnology. A significant part of the nanotechnology lab is a multi-day project, under which the students will produce nanocircuits by modern lithographic methods. The chosen methods will be demonstrated by experts in Budapest, on the latest available equipments. Planned measurements: Showing cleanroom facilities, Basic structure production by photolithography, preparation of a field-effect transistor from nanowires by electronbeam lithography, evaporation of contacts in UHV system, Characterization of the completed circuit by electron microscopy, AFM and electric transport measurements, Locating exfoliated graphene on Si substrate, optical microscope measurements, layernumber investigation by Raman-microscope, graphene sample investigation by AFM and STM, Investigations by TEM.

Optical Spectroscopy in Materials Science

BMETE11MF39 – 3/0/0/v/4

Dr. Sándor Bordács

Propagation of electromagnetic waves in isotropic medium, interfaces, complex response functions, Kubo’s formula, Kramers-Kronig relations; spectroscopy of atoms, X-ray emission and absorption spectroscopy; inter- and intraband excitations, excitons, plasmons, color centers; rotational and vibrational transitions, Fourier transform infrared and Raman spectroscopy; time-resolved spectroscopy, pump-probe experiments; near-field microscopy.

OPTICS AND PHOTONICS

Physics of Semiconductors 1

BMETE11MF26 – 2/0/0/v/3

Dr. Miklós Csontos

This course describes the behaviour of modern semiconductor physics, – mostly those properties (electrical and optical), which provides understanding of present day electronics, – building on solid state physics and statistical physics knowledge gained while earning a BSc degree in Physics. Emphasize is paid to those new phenomena, which are unique of semiconductor materials and/or structures and provides much help for our understanding of condensed materials. The following topics are discussed: crystal structure and bonding, electron states, effective mass approximation, localized states, statistics of semiconductors, transport: phenomenological and microscopic, magnetic and high frequency transport, quantum hall Effect, thermal properties, inhomogeneous semiconductors, p-n junction, MOS structures, transport instabilities and Gunn effect, semiconductor lasers and light emitting diodes, principles of different applications: solar cell, optical communication, modern experimental techniques: deep level spectroscopy, lifetime measurements.

Light Sources

BMETE12MF14 – 2/0/0/v/3

Dr. László Kocsányi

The goal of the course is to introduce physicist-, electrical engineer- and chemical engineer students to the science and technology of light sources. The thematic includes the overview of the usual photometric parameters, the survey of the development of lamps from incandescent light sources, through discharge lamps to LEDs, the basic physical processes, and the comparison of the advantages, disadvantages and possible fields of application of different lamp types.

Physical Optics

BMETE12MF37 – 4/0/0/v/5

Dr. Pál Koppa

The objective of the course is the introduction and application of light propagation models for the description of different optical phenomena. Based on the classical electromagnetic wave theory, we discuss the propagation in homogeneous isotropic and anisotropic media, thin films, dielectric waveguides, geometrical optical description and Fresnel-Kirchhoff diffraction theory. The acquired knowledge will be applied for problem solving in the areas of e.g. soliton propagation, slow light or photonic crystals.

Spectroscopy and Structure of Matter

BMETE12MF25 – 2/0/0/v/3

Dr. Péter Richter
This course organizes the knowledge obtained during the BSc training (electrodynamics of media, quantum mechanics, group theory, statistical physics, optics, optical measurement techniques) regarding the use of spectroscopy in materials characterization and structure elucidation. The methods covered are mainly optical techniques (infrared and visible/UV absorption and reflectance spectroscopy, Raman scattering, ellipsometry, optical rotation dispersion, circular dichroism) but other topics, as excitations of inner shells (X-ray and photoelectron spectroscopy, Mössbauer spectroscopy) will also be mentioned. The purpose of the course is to prepare the students to decide which spectroscopic methods to use for a given specific problem, and to be abel to basically interpret the results.

Laser Physics

BMETE12MF17 – 2/0/0/v/3

Dr. Pál Maák
Fenomenological, semiclassical (interaction of quantized material with classical electromagnatic field) and quantum theory (interaction of quantized material and field) of continous wave and pulsed laser oscillation. Properties of laser light. Laser types and laser applications. Problem solving on practices helps to develop a better understanding of the theory.

Optical Metrology

BMETE11MF21 – 2/0/0/v/3

Dr. János Kornis
The goal is to present an overview of the methods of optical metrology and present the most recent techniques and results. Topics: Elements of the optical measuring systems. Light sources, detectors, recording materials. Measurement of optical properties of the optical elements. Measurement of angle, length, and flatness by classical methods and using coherent optics. Heterodyne and phase stepping interferometry. Holography and speckle metrology. Digital holography. Application of optical signal processing in speckle metrology. Photo elasticity. Optical fiber sensors. Color measurement, optical metrology based on detection in different colors.

Physical Foundations of Optical Communications

BMETE11MF20 – 2/0/0/v/3

Dr. Zsolt Papp
This course gives an introduction to physics of optical communication building on knowledge of optics gained on a BSc course program in Physics. The following topics will be treated: optics (ray propagation in lenslike media, dispersion, etc.), laser physics (fiber-laser, optical fiber-amplifiers, DFB laser, etc.), nonlinear optics (nonlinear effects, phase-modulation, soliton, etc.), optical fibers – wave guiders (optical fibers, modes, dispersion, photonic crystals, couplers, etc.).

NUCLEAR TECHNOLOGY

Reactor Physics

BMETE80MD08 – 3/1/0/v/4

Dr. Máté Szieberth
Description of the neutron gas, Boltzmann transport equation, boundary conditions, concept of criticality, diffusion theory, one-group and multigroup approximations, time dependence, kinetics equation, neutron spectrum, slowing down theory, thermalization, fuel lattices, reactivity coefficients, burnup, numerical methods.

Thermal Hydraulics

BMETE80MD10 – 2/0/0/v/2

Dr. Attila Aszódi
Technoloical realization of heat removal for different reactor types; distribution of heat source; differential equation of heat conduction, solutions; hydraulics system of equations, heat transfer, boiling, instabilities, DNBR; two-phase flow; temperature distribution of fuel, clad and coolant; reactor safety, design base accidents, thermal limits, thermal-hydraulics codes.

Reactor Technology and Operation

BMETE80MD09 – 2/0/0/v/2

Dr. Szabolcs Czifrus
Structure of nuclear power plant reactors, main components. Nuclear power plant types. Possible technological schemes. Fuel and assembly types, applied materials. Pressurized water reactors (PWRs). Traditional and advanced PWRs. Boiling water reactors (BWRs). Heavy water reactors (HWRs). Other nuclear power plant types. Typical data of power reactors. Structural materials. Reactivity compensating materials. Shielding materials. Radiation damage. Reactivity coefficients, over and under moderation. Xenon and samarium poisoning. Spatial distribution of power density. Main components of reactor instrumentation and control.

Fusion Devices

BMETE80MD04 – 1/1/0/v/2

Dr. Gergő Pokol
The course starts with two introductory lectures: the first one summarizes the physics basis needed to understand the criteria for fusion energy producing devices, while the second reviews the main elements of fusion technology and their functions. This is followed by two lectures of introduction to stellarator technology through the German stellarator program, and three lectures dealing with the past, present and future of tokamaks. Spherical tokamaks are discussed in a separate lecture followed by lectures introducing the most important milestones of German, US and Japanese fusion programs. The last lecture presents the rapidly expanding Far-East fusion programs in the context of the history of superconducting tokamaks.

Nuclear Safety

BMETE80MD05 – 2/0/0/v/2

Dr. Szabolcs Czifrus
Introduction into nuclear safety – basic terms, safety functions, physical barriers, defence in depth. Plant states, design basis of a nuclear plant. Safety of nuclear plants – safety systems, comparison of different reactor types. Deterministic analysis – methods, postulated initiating events. Probabilistic analysis – methods. Level 1, 2, and 3 PSA. Application of PSA in nuclear design. Design basis accidents – course of

an LB LOCA accident in PWR reactors. Severe Accidents – typical phenomena during SA. International Nuclear Event Scale (INES) – classification of events. Exercise: group work for classification. Lessons learned from incidents, accidents. The Fukushima accident. National and international regulation of nuclear safety. Standards, limits.

Nuclear Techniques Laboratory

BMETE80MD03 – 0/0/4/f/5

Dr. Rita Dóczi

Critical experiment. Measurement of void coefficient. Neutron activation analysis. Determination of the values and spatial distribution of thermal neutron flux. Measurement of delayed neutron parameters. Study of shielding materials. Measurement of neutron and gamma dose rate. Analysis of xenon and samarium poisoning on simulator. Measurement of reactivity coefficients on simulator. Analyses with the APROS system code. Thermal hydraulics measurements on the TRATEL device. Particle Image Velocimetry.

MEDICAL PHYSICS

Nuclear Medicine

BMETE80MF97 – 2/0/1/v/3

Dr. Szabolcs Czifrus

Medical Imaging

BMETE80MF91 – 3/1/0/v/4

Dr Dávid Légrády

The lecture focuses on the mathematics of medical imaging with special attention to tomography. We discuss basic image property descriptors (contrast, noise, resolution, Modulation Transfer Function); basic image processing (smoothing, sharpening, contrast enhancement) and some more advanced techniques (image recognition with morphology); practical recap of Fourier transform ; the 2D Radon transform and some inversion options (direct Fourier reconstruction, Filtered Backprojection, Inversion with Riesz-potentials); the 3D Radon and X-ray transforms and their inversion. Direct algebraic image reconstruction (ART, pseudoinverse) and stochastic methods like ML-EM will also be treated for both Emission and Transmission tomography.

Magnetic Resonance and Clinical Applications

BMETE80MF90 – 2/0/0/v/2

Dr. Dávid Légrády

The lecture focusses on the principles of Magnetic Resonance Imaging. Discussed topics are the mathematics of spin physics, spin physics, classical approach and the Bloch-equations, NMR spectroscopy. Imaging principles, basic pulse sequences (Spin-Echo, Free Induction Decay), and principles of 3D imaging, 3D imaging artefacts. Hardware elements of MRI scanners, practical, clinical applications, safety measures. The oral lectures are complemented by visits to actual MRI scanners.

Magnetic Resonance and Clinical Applications 2

BMETE80MF75 – 2/0/0/v/3

Dr. Dávid Légrády

Based on the Magnetic Resonance Imaging lecture advanced mathematics and physics applicable at MRI imaging is presented. Advanced methods are shown for higher level artefacts and their corrections and advanced applications. Main topics are chemical shift and corrections (fat, saturation, SPSP techniques, etc.). Fast Echo Planar Imaging and artefacts. Steady-state sequences, details of coherent and incoherent equilibrium. RF and gradient spoiling. Effect of inhomogeneous RF field, slice profile. Signal to Noise ratio in terms of imaging parameters, noise statistics in real and k-space. Parallel imaging: SMASH, GRAPPA, SENSE.

Description of MSc Subjects in Mathematics

Advanced Linear Algebra

BMETE91MM05 – 2/0/0/v/3

Dr. Erzsébet Horváth

Tensor product (Kronecker product), symmetric and alternating product. The Hom functor, adjoint functors. Constructions of group representations via linear algebra. Differential forms and tensors in geometry and physics. Normal forms over number rings and fields. Nilpotent and semisimple endomorphisms, Jordan–Chevalley decomposition. Nonnegative matrices, elements of Frobenius–Perron theory. Singular value decomposition (SVD) and applications. (3 credits)

Algebraic and Arithmetical Algorithms

BMETE91MM08 – 3/1/0/f/5

Dr. Attila Nagy

Fundamental methods: operations with integers, polynomials, matrices. Fast Fourier transformation and applications. Elements of bilinear complexity. Chinese remainder theorem, modular arithmetic. Primality testing. Algorithms for factoring integers, and for discrete logarithms. Applications to cryptography. Efficient decomposition of polynomials over finite fields and algebraic number fields. Elliptic curves, their basic algorithms, applications. Modular algorithms and interpolation. Hermite, Cauchy, Padé approximation. Gröbner bases. (5 credits)

Algebraic Number Theory

BMETE91MM07 – 2/0/0/v/3

Dr. Ferenc Wettl

Motivation: Gaussian integers and Lagrange's theorem; real quadratic fields and the Pell equation. Algebraic numbers, algebraic integers, number fields, trace and norm. Lattices, orders, integral closure, fractional ideals. Dedekind rings, their basic properties, factorization of ideals, factorization in extensions. Introduction to the theory of valuations, valuations in number fields. The log map of Dirichlet, the unit theorem, Pell equations. Minkowski's theorem for lattices. Norm of ideals, finiteness of the class group. Integers in cyclotomic fields, Fermat's last theorem for regular prime exponents. The Hasse principle for quadratic forms. A glimpse into class field theory. (3 credits)

Algorithms and their Complexity

BMEVISZM031 – 3/1/0/f/5

Dr. Katalin Friedl

Algorithmic questions of coding theory. Geometric algorithms: closest pair of points, convex hull. Basic parallel algorithms: PRAM, Brent-principle. Distributed algorithms on reliable networks, the consensus problem on unreliable networks: link failures, benign but unreliable processors, Byzantine processors. Interactive proofs, IP=PSPACE. On-line algorithms. Parametric complexity: search trees with bounded depth, consequences of the graph minor theorem, W[1]-completeness. Basics of quantum computing. (5 credits)

Anaysis of Economic Time Series

BMEGT30M400 – 2/0/0/f/2

Dr. Dietmar Meyer

The course starts with a short introduction, which is followed by the generalization of the already known growth and conjuncture models. We discuss the issues of financing growth, the role of human capital, the dynamics of the budget deficit, endogenous population growth, healthcare economics and renewable resources. It is followed by the problem of the time consistency (both in finance and in budget policy), which – through different expectations – lead to the dynamic game theoretical approaches. This allows us to give the microeconomic background of the discussed macroeceonomic events. The course concludes with the discussion of the models of economic evolution. (2 credits)

Analytic Number Theory

BMETE95MM13 – 2/0/0/f/2

Dr. Csaba Sándor

The aim of the course is to present some of the most important results and methods in this area. Topics included are: Partitions, additive problems, representation functions. The method of generating functions. Average of additive representation functions: Erdős–Fuchs theorem. The density of sequences without 3-term arithmetic progressions. The Hardy–Ramanujan partition theorem. The Waring problem. Dirichlet series. L-series and their zeroes. Proof of prime number theorem. (2 credits)

Biomathematics

BMETE93MM11 – 2/0/0/f/2

Dr. Krisztina Kiss

Population dynamics: Lotka–Volterra and Kolmogorov models (a brief revision). Population genetics: Hardy–Weinberg, Fisher and Kimura laws, equations of selection, recombination, and mutation. Selection-migration models. Models for epidemics. HIV. Propagation of epidemics in space. Morphogenesis. Turing bifurcation. Pattern formation. (2 credits)

Combinatorial and Discrete Geometry

BMETE94MM02 – 3/1/0/f/5

Dr. Zsolt Lángi

The theorem of Helly, Radon and Caratheodory. The convex hull of points. Euler–Poincare formula for n-dimensional polyhedra. The diameter of a set of points. The theorem of Erdos–Szekeres and its consequences. Triangulation of simple polygons. Brower theorem on the fixpoint of a mapping, the Borsuk–Ulam theorem. Euler–Poincare formula for simplicial complexes. On the basis reduction problem of lattices. Algorithmic point of view, the reductions of Minkowski, Hermite, Korkine–Zolotareff and Lovász. Dirichlet–Voronoi cells and the short vectors of a lattice. Applications in coding theory. (5 credits)

Combinatorial Optimization

BMEVISZM029 – 3/1/0/v/5

Dr. Dávid Szeszlér

Basic concepts of matroid theory (independence, bases, circuits, rank). Dual, minors, direct sum, graphic and cographic matroids. Vector matroids, representability, binary and regular matroids, the theorems of Tutte and Seymour. Sum of matroids, the matroid partition algorithm, complexity of the matroid intersection problem. Polymatroid rank function, Lovász' theorem on polymatroid matching. Approximation algorithms. Scheduling problems. Applications in engineering: constructing reliable telecommunication networks, disjoint trees, connectivity augmentation, detailed routing of VLSI circuits, solvability of active linear networks, rigidity of bar-and-joint frameworks. (5 credits)

Commutative Algebra and Algebraic Geometry

BMETE91MM01 – 3/1/0/f/5

Dr. Alex Küronya

Closed algebraic sets and their coordinate rings, morphisms, irreducibility and dimension, Hilbert Nullstellensatz, the correspondence between radical ideals and subvarieties of affine space. Monomial orders, Gröbner bases, Buchberger algorithms, computations in polynomial rings. From regular functions to rational maps, local rings, fundamentals of sheaf theory, ringed spaces. Projective space and its subvarieties, homogeneous coordinate ring, morphisms, the image of a projective variety is closed. Geometric constructions: Segre and Veronese embeddings, Grassmann varieties, projection from a point, blow-up. Dimension of affine and projective varieties, hypersurfaces. Smooth varieties, Zariski tangent space, the Jacobian condition. Hilbert function and Hilbert polynomial, examples, computer experiments. Basic notions of rings and modules, chain conditions, free modules. Finitely generated modules, Cayley-Hamilton theorem, Nakayama lemma. Localization and tensor product. Free resolutions of modules, Gröbner theory of modules, computations, Hilbert syzygy theorem. (5 credits)

Control Systems

BMETE93MM07 – 2/0/0/v/3

Dr. Éva Gyurkovics

Basic notions of control systems. Examples of control systems. Properties of linear control systems: controllability, observability, stabilizability. Canonical forms, structure of linear systems. State observes. Realization. The problem of optimal control. Dynamic programming for finite control systems. Dynamical programming for general control systems. Hamilton-Jacobi-Bellman equations. Linear-quadratic optimal control problems. The tracking problem. Problems on infinite time intervals. (3 credits)

Differential Geometry and Topology

BMETE94MM00 – 3/1/0/v/5

Dr. Szilárd Szabó

Smooth manifolds, differential forms, exterior derivation, Lie-derivation. Stokes' theorem, de Rham cohomology, Mayer–Vietoris exact sequence, Poincaré duality. Riemannian manifolds, Levi–Civitá connection, curvature tensor, spaces of constant curvature. Geodesics, exponential map, geodesic completeness, the Hopf–Rinow theorem, Jacobi fields, the Cartan–Hadamard theorem, Bonnet's theorem. (5 credits)

Dynamic Programming in Financial Mathematics

BMETE93MM14 – 2/0/0/v/3

Dr. József Fritz

Optimal strategies, discrete models. Fundamental principle of dynamic programming. Favourable and unfavourable games, brave and cautious strategies. Optimal parking, planning of large purchase. Lagrangean mechanics, Hamilton–Jacobi equation. Viscous approximation, Hopf–Cole transformation, Hopf–Lax infimum-convolution formula. Deterministic optimal control, strategy of optimal investment, viscous solutions of generalized Hamilton-Jacobi equations. Pontryagin's maximum principle, searching conditional extreme values in function spaces. Optimal control of stochastic systems, Hamilton-Jacobi-Bellman equation. (3 credits)

Dynamical Systems

BMETE93MM02 – 3/1/0/v/5

Dr. Károly Simon

Continuous-time and discrete-time dynamical systems, continuous versus discrete: first return map, discretization. Local theory of equilibria: Grobman–Hartman lemma, stable-unstable-center manifold, Poincaré's normal form. Attractors, Liapunov functions, LaSalle principle, phase portrait. Structural stability, elementary bifurcations of equilibria, of fixed points, and of periodic orbits, bifurcation curves in biological models. Tent and logistic curves, Smale horseshoe, solenoid: properties from topological, combinatorial, and measure theoretic viewpoints. Chaos in the Lorenz model. (5 credits)

Econometrics

BMETE93MM10 – 0/0/2/f/2

Dr. Zsanett Orlovits

Introduction into econometrics. Bivariate connections: linear regression, least-square (LS) estimation and its statistical properties. Theorem of Gauss–Markov, forecasting. Multivariate linear regression, generalized Gauss-Markov theorem, forecasting, multicollinearity. Generalized LS, methods of instrumental variables. Time series analysis: stationarity, autocorrelation, white noise process, AR, MA, ARMA models. Parameter estimation (ML-estimation), forecasting. ARIMA models, trend and seasonality. Spectral representation, periodogram and its estimation, spectrum estimation. Multivariable models: VAR(1), ARMA, stationarity, stability, Lyapunov equation. Fractional integrated processes, ARFIMA models, long memory processes and their estimation. Stochastic volatility models: ARCH, GARCH, bilinear models, stationarity, estimation and state space representation. Applications: financial markets, biological data analysis. (2 credits)

Ergodic Theory and Dynamical Systems

BMETE95AM22 – 2/0/0/f/2

Dr. Domokos Szász

Measure-preserving transformations. Examples. Poincaré recurrence theorem. Ergodic maps. Examples. Stationary sequences as dynamical systems. Bernoulli-sequences. Kinetics and mixing. Algebraic automorphisms of the torus. Condition of mixing. Hopf's geometric method. Existence of invariant measures: Krylov–Bogolyubov theorem. Markov-maps: existence of invariant density. Kolmogorov–Arnold–Moser theorem. The homological equation. Formal equations for the invariant torus. Exercises. (2 credits)

Extreme Value Theory

BMETE95MM16 – 2/0/0/v/3

Dr. Béla Barabás

Review of the limit theorems, normal domain of attraction, stable low of distributions, alpha-stable domain of attractions. Max-stable distributions, Fisher–Tippet theorem, standard extreme value distributions, regularly varying functions and their properties, Frechet and Weibull distributions and characterization of their domain of attraction. Gumbel distribution. Generalized Pareto distribution. Peak over threshold. Methods of parameter estimations. Applications in economy and finance. (3 credits)

Financial Processes

BMETE95MM14 – 2/0/0/f/3

Dr. József Fritz

Discrete models. Optimal parking, strategy in advantageous and disadvantageous situations. Self-financing portfolio, arbitrage, completeness of a market model. American, European, Asian option. Binary model. Pricing non-complete market in discrete model. Balck–Scholes' theory: B-S formula via martingales. Itő representation theorem. Applications, admissible strategies. Capital Asset Pricing Model (CAPM). Portfolios. The beta coefficient, security market line, market and capital-market equilibrium. Option pricing by using GARCH models. Problems of optimal investments. Extreme value theory, maxima, records. (3 credits)

Fourier Analysis and Function Series

BMETE92MM00 – 3/1/0/v/5

Dr. Miklós Horváth

Completeness of the trigonometric system. Fourier series, Parseval identity. Systems of orthogonal functions, Legendre polynomials, Haar and Rademacher systems. Introduction to wavelets, wavelet orthonormal systems. Fourier transform, Laplace transform, applications. Convergence of Fourier series: Dirichlet kernel, Dini and Lischitz convergence tests. Fejer's example of divergent Fourier series. Fejér and Abel-Poisson summation. Weierstrass-Stone theorem, applications. Best approximation in Hilbert spaces. Müntz theorem on the density of lacunary polynomials. Approximations by linear operators, Lagrange interpolation, Lozinski-Harshiladze theorem. Approximation by polynomials, theorems of Jackson. Positive linear operators Korovkin theorem, Bernstein polynomials, Hermite-Fejér operator. Spline approximation, convergence, B-splines. (5 credits)

Fractals and Geometric Measure Theory

BMETE95MM06 – 2/0/0/f/3

Dr. Károly Simon

Introduction: Basics form general measure theory and from set theoretical topology. Covering and differerentiation. Vitali's and Besicovitch's covering theorems. Differentiation of measures. Fractals in space and on the plane: the most famous self similar and self-affine fractals. Box dimension and Hausdorff dimension. The dimension of self-similar fractals. Potential theoretic characterization of the Hausdorff dimension. Local dimension of measures. Multifractal analysis of self-similar measures. Dimension of random Cantor sets and Mandelbrot percolation. Brownian paths as random fractals. The dimension of the graph of the Brownian motion. The dimension and Lebesgue measure of Brownian paths in higher dimension. Intersection of independent Brownian paths starting from different points. A fractal geometry approach. (3 credits)

Game Theory

BMETE93MM09 – 2/0/0/f/3

Dr. Tibor Illés

Introduction into Game theory, especially into its non-cooperative variant. Game theory models such economic, political, military etc. situations where more than one actor optimizes his utility function, whose value also depends on the others' decisions. By now game theory has become the fundament of economics, which helps modelling monopoly, the design of auctions and other problems. The structure of the lectures is as follows: Non-cooperative game theory (Nash-equilibrium, Bayesian equilibrium). Cooperative game theory: Shapley value. Introduction into econometrics. Bivariate connections: linear regression, least-square (LS) estimation and its statistical properties. Theorem of Gauss–Markov, forecast. Multivariate linear regression, generalized LS, multicollinearity. Time series analysis. Applications: financial markets, biological data analysis. (3 credits)

General and Algebraic Combinatorics

BMEVISZM020 –3/1/0/v/5

Dr. Katalin Friedl

Combinatorics of the Young tableaux, tableau rings. Pieri formulas, Schur polynomials, Kostka numbers. Robinson–Schensted–Knuth correspondence. Littlewood-Richardson numbers, Littlewood–Richardson theorem. Important symmetric polynomials, their generating functions. Cauchy–Littlewood formulas. Garsia's generalization of the fundamental theorem on symmetric polynomials. Bases of the ring of symmetric functions. Topics from combinatorial optimization: greedy algorithm, augmenting methods. Matroids, their basic properties, matroid intersection algorithm. Approximation algorithms: set cover, travelling salesman, Steiner trees. Scheduling algorithms: single machine scheduling, scheduling for parallel machines, bin packing. (5 credits)

Global Optimization

BMETE93MM00 – 3/1/0/f/5

Dr. Boglárka Gazdag-Tóth

Different forms of global optimization problems, their transformation to each other, and their reduction to the one-dimensional problem. Comparison of the complexity of global optimization and linear programming problems. Classifications of the global optimization methods. Lagrange function, Kuhn–Tucker theorem, convex and DC programming. Basic models and methods of stochastic programming. Multi-start and stochastic methods for global optimization, their convergence properties and stopping criteria. Methods based on Lipschitz constant and their convergence properties. Branch and Bound schema, methods based on interval analysis, automatic differentiation. Multi-objective optimization. (5 credits)

Graphs, Hypergraphs and their Applications

BMEVISZM032 – 3/1/0/f/5

Dr. Gábor Simonyi

The theorems of Tutte and Vizing, application to the general factor problem, stable matchings, the theorem of Gale and Shapley, Dinitz's problem, list colouring, list colouring conjecture, Galvin's theorem, list colouring of planar graphs, the theorems of Thomassen and Voigt. Hypergraphs as generalizations of graphs, as set systems, as sets of 0-1 sequences. Generalizations of results from graph theory, Baranyai's theorem, Ryser's conjecture, Results of extremal set systems, Sperner's theorem, LYM inequality, Ahlswede–Zhang-identity, the theorems of Erdös–Ko–Rado and Kruskal–Katona. Ramsey's theorem for graphs and hypergraphs, applications in geometry. Applications of linear algebra, odd city theorem, Graham–Pollak theorem. Further geometric applications, Chvátal's art gallery theorem, Kahn–Kalai–Nilli's disproof of Borsuk's conjecture. Polyhedric description of problems of combinatorial optimization, polytope characterization of perfect graphs. (5 credits)

Group Theory

BMETE91MM03 – 3/1/0/f/5

Dr. Erzsébet Horváth

Permutation groups, group actions. Conjugacy classes, normalizer, centralizer, centre. Class equation, Cauchy's theorem. Group authomorphisms, semidirect product, wreath product. Group extensions. Sylow theorems. Finite p-groups. Solvable and nilpotent groups. Characterization of finite nilpotent groups. Transfer, normal p-complement theorems. Free groups, presentations. Free abelian groups, Fundamental theorem of finitely generated abelian groups, applications. Linear groups, classical groups. Elements of representation theory. (5 credits)

Homological Algebra

BMETE91MM06 – 2/0/0/f/2

Dr. Alex Küronya

Basic notions: chain complex, exactness, homology modules, homotopy, long exact sequences, functors, 3x3 lemma, 5-lemma, snake lemma, applications. Multilinear algebra over general rings, hom and tensor product, limits, p-adic numbers, profinite groups, adjoint functors. Derived functors, cohomological delta functors, projective and injective modules, resolutions. Tor and Ext: calculation of Tor for Abelian groups, flatness. Tor and Ext for some important rings, Künneth formulas, universal coefficient theorem, homological dimension, rings with small dimension. Cohomology of groups. Shapiro lemma, Hilbert's Theorem 90 for finite Galois extensions, the first cohomology group, blow up, restriction, transfer. Spectral sequences: definition, boundedness, the Lyndon–Hochschild–Serre spectral sequence, application to calculating group cohomology. (2 credits)

Individual Projects 1, 2

BMETE92MM01, 02 – 0/0/4/f/4

Dr. Márta Lángné Lázi

Within the framework of the subject the student is working on an application oriented research subject based on stochastic mathematics lead by an external supervisor. At the end of each semester the student writes a report about his results which will be also presented by him to the other students in a lecture. The activities to be exercised: literature research, modelling, computer aided problem solving, mathematical problem solving. (4 credits)

Insurance Mathematics 2

BMETE95MM17 – 2/0/0/f/3

Dr. Béla Barabás

Fundamental types of insurance: life and non-life. Standard types of non-life insurance, models. Individual risk model. Claim calculation and approximations. Most important distributions of the number of claim. Most important distributions of the claims payments. Complex risk model, recursive method of Panjer, compound Poisson distributions. Premium principles. Classical principles: Expected value, maximum loss, quantile, standard deviation, variance. Theoretical premium principles: zero utilizes, Swiss, loss-function. Mathematical properties of premium principles. Credibility theory, Bühlmann model. Bonus, premium return. Reserves, IBNR models. (3 credits)

Introduction to Economic Dynamics

BMETE93MM08 – 3/1/0/v/5

Dr. András Simonovits

The traditionally static economic theory has recently paid more and more attention to modelling dynamic economics. In comparison with physical and chemical systems, here the role of discrete time approach is much more important. The dynamic optimization is not only a technique but for many economists, it is the only valid approach. A further distinguishing feature that the present is determined not only by the past, by via expectations, by the future as well. In addition of the exposition of the necessary mathematical methods, the course stresses the most important economic models: optimal growth and overlapping generations. (5 credits)

Inverse Scattering Problems

BMETE92MM08 – 2/0/0/v/3

Dr. Miklós Horváth

The seeing process, radar, ultrasound-based medical investigations, geological prospecting of the Earth, investigation of interactions between elementary particles are just a few examples of inverse scattering problems. The course aims to present the mathematical background of such problems, on an introductory level. The main topics include: Time dependent description: wave operator, scattering operator, scattering matrix. Time independent description: scattering amplitude, Lippmann-Schwinger equation, Dirichlet-to-Neumann map, Sylvester-Uhlmann theorem. Acoustic and electromagnetic scattering. One- and three-dimensional quantum scattering problems. The many-body problem. (3 credits)

Limit- and Large Deviation Theorems of Probability Theory

BMETE95MM10 – 3/1/0/v/5

Dr. Bálint Tóth

1. Limit theorems: Weak convergence of probability measures and distributions. Tightness: Helly-Ptohorov theorem. Limit theorems proved with bare hands: Applications of the reflection principle to random walks: Paul Lévy's arcsine laws, limit theorems for the maximum, local time and hitting times of random walks. Limit theorems for maxima of i.i.d. random variables, extremal distributions. Limit theorems for the coupon collector problem. Proof of limit theorem with method of momenta. Limit theorem proved by the method of characteristic function. Lindeberg's theorem and its applications: Erdős–Kac theorem: CLT for the number of prime factors. Stable distributions. Stable limit law of normed sums of i.i.d. random variables. Characterization of the characteristic function of symmetric stable laws. Weak convergence to symmetric stable laws. Applications. Characterization of characteristic function of general (non-symmetric) stable distributions, skewness. Weak convergence in non-symmetric case. Infinitely divisible distributions:. Lévy–Hinchin formula and Lévy measure. Lévy measure of stable distributions, self-similarity. Poisson point processes and infinitely divisible laws. Infinitely divisible distributions as weak limits for triangular arrays. Applications. Introduction to Lévy processes: Lévy–Hinchin formula and decomposition of Lévy processes. Construction with Poisson point processes (a la Ito). Subordinators and Lévy processes with finite total variation, examples. Stable processes. Examples and applications. 2. Large deviation theorems: Introduction: Rare events and large deviations. Large deviation principle. Computation of large deviation probabilities with bare hands: application of Stirling's formula. Combinatorial methods: The method of types. Sanov's theorem for finite alphabet. Large deviations in finite dimension: Bernstein's inequality, Chernoff's bound, Cramer's theorem. Elements of convex analysis, convex conjugation in finite dimension, Cramer's theorem in Rd. Gartner–Ellis theorem. Applica-

tions: large deviation theorems for random walks, empirical distribution of the trajectories of finite state Markov chains, statistical applications. The general theory: general large deviation principles. The contraction principle and Varadhan's lemma. large deviations in topological vector spaces and function spaces. Elements of abstract convex analysis. Applications: Schilder's theorem, Gibbs conditional measures, elements of statistical physics. (5 credits)

Linear Programming

BMETE93MM01 – 3/1/0/v/5

Dr. Tibor Illés

System of linear equations: solution and solvability. Gauss-Jordan elimination method. System of linear inequalities. Alternative theorems, Farkas lemma and its variants. Solution of system of linear inequalities using pivot algorithms. Convex polyhedrons. Minkowski-, Farkas- and Weyl-theorems. Motzkin-theorem. – Primal-dual linear programming problems. Feasible solution set of linear programming problems. Basic solution of linear programming problem. Simplex and criss-cross algorithms. Cycling, anti-cycling rules: Bland's minimal index rule. Two phase simplex method. Revised simplex method. Sensitivity analysis. Decomposition methods: Dantzig–Wolfe. – Special type of pivot algorithms: lexicographic and lexicographic dual simplex methods. Monotonic build-up simplex algorithms. – Interior point methods of linear programming problems. Self-dual linear programming problem. Central path and its uniqueness. Computation of Newton-directions. Analytical centre, Sonnevend-theorem. Dikin-ellipsoid, affine scaling primal-dual interior point algorithm and its polynomial complexity. Tucker-model, Tucker theorem. Rounding procedure. – Khachian's ellipsoid algorithm. Karmarkar's potential function method. Special interior point algorithms. (5 credits)

Markov Processes and Martingales

BMETE95MM07 – 3/1/0/v/5

Dr. Márton Balázs

1. Martingales: Review (conditional expectations and tower rule, types of probabilistic convergences and their connections, martingales, stopped martingales, Doob decomposition, quadratic variation, maximal inequalities, martingale convergence theorems, optional stopping theorem, local martingales). Sets of convergence of martingales, the quadratic integrable case. Applications (e.g. Gambler's ruin, urn models, gambling, Wald identities, exponential martingales). Martingale CLT. Azuma-Höffding inequality and applications (e.g. travelling salesman problem). 2. Markov chains: Review (definitions, characterization of states, stationary distribution, reversibility, transience-(null-) recurrence). Absorbtion probabilites. Applications of martingales, Markov chain CLT. Markov chains and dynamical systems; ergodic theorems for Markov chains. Random walks and electric networks. 3. Renewal processes: Laplace transform, convolution. Renewal processes, renewal equation. Renewal theorems, regenerative processes. Stationary renewal processes, renewal paradox. Examples: Poisson process, applications in queueing. 4. Point processes: Definition of point processes. The Poisson point process in one and more dimensions. Transformations of the Poisson point process (marking and thinning, transforming by a function, applications). Point processes derived from the Poisson point process. 5. Discrete state Markov processes: Review (infinitesimal generator, connection to Markov chains, Kolmogorov forward and backward equations, characterization of states, transience-(null-)recurrence, stationary distribution). Reversibility, MCMC. Absorption probabilities and hitting times. Applications of martingales (e.g. compensators of jump processes). Markov processes and dynamical systems; ergodic theorems for Markov processes. Markov chains with locally discrete state space: infinitesimal generator on test functions. (5 credits)

Mathematical Chemistry

BMETE92MM09 – 2/0/2/v/5

Dr. János Tóth

A few tools of the applied mathematician. Special functions, Laplace transform, qualitative investigations, nonlinear systems, mathematical program packages, looking for the optimum, beyond elementary statistics, estimating the parameters of differential equations. Model types: static and dynamic, discrete and continuous, stochastic and deterministic, linear and nonlinear models. Problems of physical chemistry. Models and problems of homogeneous reaction kinetics. Stoichiometry: applied linear algebra and number theory. Mass action type kinetics: differential equations on graphs. Stationary points, oscillation, chaos. Sensitivity analysis. Reduction of models, lumping. Stochastic models of chemical reactions: Markovian pure jump processes. Applications in biochemistry, enzyme kinetics, pharmacokinetics, drug dosage and drug design. Quantitative structure activity relationships. Applying quantum chemistry. Neurobiological models. Reaction diffusion models. Pattern formation in chemical, biological and economic models. (5 credits)

Mathematical Modelling Seminar 1, 2

BMETE95MM01, 02 – 2/0/0/f/1

Dr. Domokos Szász

The aim of the seminar to present case studies on results, methods and problems from applied mathematics for promoting. the spreading of knowledge and culture of applied mathematics; the development of the connections and cooperation of students and professors of the Mathematical Institute, on the one hand, and of personal, researchers of other departments of the university or of other firms, interested in the applications of mathematics. The speakers talk about problems arising in their work. They are either applied mathematicians or non-mathematicians, during whose work the mathematical problems arise. An additional aim of this course to make it possible for interested students to get involved in the works presented for also promoting their long-range carrier by building contacts that can lead for finding appropriate jobs after finishing the university. (1 credit)

Mathematical Methods of Classical Mechanics

BMETE93MM12 – 2/0/0/f/2

Dr. Gábor Etesi

The basic problem of the calculus of variations. Euler–Lagrange differential equations. Geometrical methods in mechanics. Lagrange and Hamilton systems. Legendre transformation. Hamilton equations. Symmetries and conservation laws. (2 credits)

Matrix Analysis

BMETE92MM03 – 2/0/0/v/3

Dr. Dénes Petz

Vector spaces and linear operators, Hilbert spaces, orthonormal basis, the matrix of a linear operator, matrix norms, self-adjoint and unitary matrices, localization of eigenvalues and singular values, positive definite matrices, tensor product and Hadamard product, Schur theorem and applications, functional calculus, derivation, the exponential function, Lie-Trotter formula, matrix monotone functions, means of positive matrices, block-matrices, applications to differential equations, matrices with positive entries. (3 credits)

Multivariate Statistics

BMETE95MM15 – 3/0/1/v/5

Dr. Marianna Bolla

Multivariate central limit theorem and its applications. Density, spectra and asymptotic distribution of random matrices in multivariate statistics (Wishart-, Wigner-matrices). How to use separation theorems for eigenvalues and singular values in the principal component, factor, and correspondence analysis. Factor analysis as low rank representation, relations between representations and metric clustering algorithms. Methods of classification: discriminatory analysis, hierarchical, k-means, and graph theoretical methods of cluster analysis. Spectra and testable parameters of graphs. Algorithmic models, statistical learning. EM algorithm, ACE algorithm, Kaplan–Meier estimates. Resampling methods: bootstrap and jackknife. Applications in data mining, randomized methods for large matrices. Mastering the multivariate statistical methods and their nomenclature by means of a program package (SPSS or S+), application oriented interpretation of the output data. (5 credits)

Multivariate Statistics with Applications in Economy

BMETE95MM18 – 2/0/0/f/2

Dr. Marianna Bolla

Multivariate central limit theorem and its applications. Density, spectra and asymptotic distribution of random matrices in multivariate statistics (Wishart-, Wigner-matrices). How to use separation theorems for eigenvalues and singular values in the principal component, factor, and correspondence analysis. Factor analysis as low rank representation, relations between representations and metric clustering algorithms. Methods of classification: discriminatory analysis, hierarchical, k-means, and graph theoretical methods of cluster analysis. Spectra and testable parameters of graphs. Algorithmic models, statistical learning. EM algorithm, ACE algorithm, Kaplan—Meier estimates. Resampling methods: bootstrap and jackknife. Applications in data mining, randomized methods for large matrices. Mastering the multivariate statistical methods and their nomenclature by means of a program package (SPSS or S+), application oriented interpretation of the output data. (2 credits)

Non-Euclidean Geometry

BMETE94MM03 – 3/1/0/f/5

Dr. Ákos G. Horváth

Hyperbolic space: Models and their relations (Cayley-Klein-, Poincaré-, halfspace-, complex, vector-model). d = 2: trigonometry, area, scissor-congruence, area of ideal triangles, calculations. Hyperbolic discrete groups, Coxeter groups and tilings. d = 3: planes, spheres, horo- and hyperspheres in analytical form. Polyhedra, volume problem, Lobachevski function, Coxeter honeycombs. Spherical space: Analogous problems in d = 2,3 dimensions. Relativity theory: Linear space-time in 1+1 dimensions. Galilei space-time in affine plane, Galilei transform and speed addition. Lorentz space-time and Minkowski plane. Lorentz transform and speed addition. Time shortening. Space-time manifold: Differentiable manifold and tangential spaces (repetition). Riemann and pseudo-Riemann manifold. Tensors. Covariant derivative and curvature tensor. Ricci tensor and Einstein equation. Schwarzschild solution: Mercure precession, light deviation, red spectrum translation. (5 credits)

Nonlinear Hyperbolic Equations

BMETE93MM13 – 2/0/0/v/3

Dr. Katalin Nagy

Single conservation laws, the method of characteristics. The Burgers equation, shock waves, weak solutions. Hopf-Cole transformation, Hopf–Lax solution. The Oleinik entropy condition, convergence of the Lax–Friedrich scheme. Systems of conservation laws, the method of compensated compactness. (3 credits)

Nonlinear Programming

BMETE93MM04 – 3/1/0/v/5

Dr. Tibor Illés

1. Optimality conditions: first-order, second-order conditions (unconstrained optimization). Convexity, convex and concave functions. Point to set mappings, closed mapping, Global Convergence Theorem 2. Line search algorithms: order and rate of convergence, Armijo's rule. Fibonacci, harmonic division, Newton's method. Curve-fitting algorithms. 3. Unconstrained optimization: gradient method, Kantorovich-inequality, order of convergence. Newton's method. Conjugate gradient method, Fletcher–Reeves, PARTAN, Quasi-Newton methods. Gauss–Newton és Levenberg–Marquardt algorithms. 4. Constrained optimization: Constraint qualifications, First and Second Order Optimality Conditions. Primal methods, Zoutendijk's algorithm. Lagrange multipliers, Kuhn–Tucker theorem. Gradient pojection, reduced gradient method. Penalty, Barrier, and Augmented Lagrangian Methods. Duality. Interior Point Methods. (5 credits)

Nonparametric Statistics

BMETE95MM20 – 2/0/0/v/3

Dr. László Győrfi

Density function estimation. Distribution estimation, L1 error. Histogram. Estimates by kernel function. Regression function estimation. Least square error. Regression function. Partition, kernel function, nearest neighbour estimates. Empirical error minimization. Pattern recognition. Error probability. Bayes decision rule. Partition, kernel function, nearest neighbour methods. Empirical error minimization. Portfolio strategies. Log-optimal, empirical portfolio strategies. Transaction cost. (3 credits)

Numerical Methods 2 – Partial Differential Equations

BMETE92MM07 – 2/0/2/v/5

Dr. Róbert Horváth

Numerical methods of partial differential equations of elliptic type: finite difference method, multigrid method, finite element method. Numerical methods of time-dependent partial differential equations: finite element and finite difference methods for parabolic and hyperbolic problems, Ritz and Galerkin methods. Stability. CFL condition, von Neumann analysis. Lax equivalence theorem. Operator splitting methods with applications. Applications of partial differential equations and their numerical solutions: Maxwell's equations and their numerical solutions, pricing of financial derivatives, problems in solid mechanics, heat conduction equation and the qualitative investigation of the numerical solution, air-pollution transport models. (5 credits)

Operations Research Softwares

BMETE93MM06 – 0/0/2/f/2

Dr. Boglárka Gazdag-Tóth

The aim of this course is twofold. On the one hand it aims to advance the student's routine in programming by coding the basic algorithms of operations research. On the other hand its goal is to give perfection in the use of operations research software. The standard description of linear programming problems, the MPS data structure, and the most important algebraic modelling languages (GAMS, AMPL, AIMMS). Introduction and usage of the most important software packages in linear, integer, non-linear, and stochastic programming (CPLEX, MINOS, SNOPT, LOQO, LGO). (2 credits)

Partial Differential Equations 2

BMETE93MM03 – 3/1/0/f/5

Dr. Márton Kiss

The Laplacian in Sobolev space (revision). Weak and strong solutions to second order linear parabolic equations. Ritz–Galerkin approximation. Linear operator semigroups (According to Evans and Robinson). Weak and strong solutions to reaction-diffusion (quasilinear parabolic) equations. Ritz–Galerkin approximation. Nonlinear operator semigroups (According to Evans and Robinson). Only in examples: monotonicity, maximum principles, invariant regions, stability investigations for equilibria by linearization, travelling waves (According to Smoller). Global attractor. Inertial manifold (According to Robinson). (5 credits)

Potential Theory

BMETE92MM04 – 2/0/0/f/3

Dr. Ágota G. Horváth

Motivation: a little electrostatics, Dirichlet problem and Brownian motion. An extremal problem: logarithmic potential, Chebyshev constant and transfinite diameter. Electrostatics with external fields, weighted energy integral and potential. Equilibrium measure and the modified Robin constant. How to solve the Dirichlet problem, when the boundary conditions are not "nice"? Modified Poisson kernel with respect to singularities, lower semicontinuity, Perron-Wiener-Brelot solution, harmonic measure. Regularity, balayage, generalized Poisson integral. Brownian motion and harmonic measures. (3 credits)

Projective Geometry

BMETE94MM01 – 2/2/0/f/5

Dr. Ákos G. Horváth

Perspectivity in the practice, harmonic division, cross-ratios, the projective scale. The addition and multiplication of points on the base of the Desargues's theorem. The field defined by the above operations. Structures based on incidences. Projective and affine planes. The Galois-type geometries. The n-dimensional spherical space, projective space and affin space. The classifications of collineations and polarities by the normal form of Jordan. The projective geometrical base of the visualization by computer. The central projection of figures of dimension 3 and 4 and its visualization on the monitor. (5 credits)

Representations of Groups and Algebras

BMETE91MM04 – 3/1/0/f/5

Dr. Erzsébet Lukács

Group algebra, Maschke's theorem, Shur's lemma, Wedderburn–Artin theorem. Characters of finite groups, orthogonality relations, induction, Frobenius reciprocity, Mackey's theorem. Clifford theory. Applications: Burnside's theorem, Frobenius kernel, character tables. Elements of modular representation theory: blocks, Brauer characters, projective irreducible characters. Indecomposable modules, Krull–Schmidt–Azumaya theorem. Radical, head, socle of a module. Brauer graph. Module categories. Representations of finite dimensional algebras: Auslander–Reiten theory. (5 credits)

Representation Theory

BMETE91MM02 – 3/1/0/f/5

Dr. Alex Küronya

Differentiable manifolds, atlas, maps, immersion, submersion, submanifold, tangent space, vector field, Lie-derivative, topological background. Vector bundles, alternating forms on linear spaces, differential forms, their integration, Stokes theorem. Multilinear algebra (tensors, symmetric and alternating spaces, contraction) and applications to vector bundles. Lie groups and their basic properties; exponential map, invariant vector field, Lie algebra. Matrix Lie groups and their Lie algebras, examples. Representations of groups in general, characters, linear algebraic constructions. Continuous representations of Lie groups, connections among representations of Lie groups and the representations of their Lie algebras. Basics about Lie algebras, derivations, nilpotent and solvable algebras, theorems of Engel and Lie, Jordan-Chevalley decomposition, Cartan subalgebras. Semisimple Lie algebras, Killing form, completely reducible representations. The representations of sl2, root systems, Cartan matrix, Dynkin diagram, classification of semisimple Lie algebras. Representations of matrix Lie groups, Weyl chambers, Borel subalgebra. (5 credits)

Statistical Program Packages 2

BMETE95MM09 – 0/0/2/f/2

Dr. Csaba Sándor

The goal of the course is to provide an overview of contemporary computer-based methods of statistics with a review of the necessary theoretical background. 1. How to use the SPSS (Statistical Package for Social Sciences) in program mode. Writing user's macros. Interpretation of the output data and setting the parameter values accordingly. Definition and English nomenclature of the dispalyed statistics. 2. Introduction to the S+ and R Program Packages and surveying the novel algorithmic models not available in the SPSS (bootstrap, jackknife, ACE). 3. Practical application. Detailed analysis of a concrete data set in S+. (2 credits)

Statistics and Information Theory

BMETE95MM05 – 3/1/0/f/5

Dr. Marianna Bolla

Multivariate statistical inference in multidimensional parameter spaces: Fisher's information matrix, likelihood ratio test. Testing hypotheses in multivariate Gauss model: Mahalanobis' distance, Wishart's, Hotelling's, Wilks' distributions. Linear statistical inference, Gauss–Markov theorem. Regression analysis, one- and two-way analysis of variance as a special case of the linear model. ANOVA tables, Fisher–Cochran theorem. Principal component and factor analysis. Estimation and rotation of factors, testing hypotheses for the effective number of factors. Hypothesis testing and I-divergence (the discrete case). I-projections, maximum likelihood estimate as I-projection in exponential families. The limit distribution of the I-divergence statistic. Analysis of contingency tables by information theoretical methods, loglinear models. Statistical algorithms based on information geometry: iterative scaling, EM algorithm. Method of maximum entropy. (5 credits)

Stochastic Analysis and Applications

BMETE95MM04 – 3/1/0/v/5

Dr. Károly Simon

Introduction. Markov processes, stochastic semi-groups, infinitesimal generators, martingales, stopping times. Brownian motion. Brownian motion in nature. Finite dimensional distributions and continuity of Brownian motion. Constructions of the Wiener process. Strong Markov property. Self-similarity and recurrence of Brownian motion, time reversal. Reflection principle and its applications. Local properties of Brownian path: continuity, Hölder continuity, non-differenciability. Quadratic variations. Continuous martingales. Definition and basic properties. Dubbins-Schwartz theorem. Exponential martingale. Lévy processes. Processes with independent and stationary increments, Lévy-Hintchin formula. Decomposition of Lévy processes. Construction by means of Poisson processes. Subordinators, and stable processes. Examples and applications. Stochastic integration I. Discrete stochastic integrals with respect to random walks and discrete martingales. Applications, discrete Balck-Scholes formula. Stochastic integrals with respect to Poisson process. Martingales of finite state space Markov processes. Quadratic variations. Doob-Meyer decomposition. Stochastic integration II. Predictable processes. Itő integral with respect to the Wiener process, quadratic variation process. Doob-Meyer decomposition. Itő formula and its applications. (5 credits)

Stochastic Differential Equations

BMETE95MM08 – 3/1/0/v/5

Dr. Bálint Tóth

Introduction. Itő integral with respect to the Wiener process and continuous martingale, multi-dimensional stochastic integral. Local time. Local time of random walks on the line. Inverse local time, discrete Ray–Knight theorem. Local time of Brownian motion and Ray–Knight theorem. Tanaka formula and its applications. Skorohod reflection, reflected Brownian motion, a theorem by P. Lévy. Stochastic differential equations. SDEs of diffusions: Ornstein–Uhlenbeck, Bessel, Bessel-squared, exponential Brownian motion. SDE of transformed diffusions. Weak and strong solutions, existence and uniqueness. SDE with boundary conditions. Interpretation of the infinitesimal generator. Applications to physics, population dynamics, and finance. Diffusions. Basic examples: Ornstein–Uhlenbeck, Bessel, Bessel-squared, geometrical Brownian motion. Interpretation as stochastic integrals, and Markov processes. Infinitesimal generator, stochastic semi-groups. Martingale problem. Connection with parabolic and elliptic partial differential equations. Feyman–Kac formula. Time-change. Cameron–Martin–Girsanov formula. One-dimensional diffusions. Scale function and speed measure. Boundary conditions. Time-inversion. Application to special processes. Special selected topics. Brownian excursion. Two-dimensional Brownian motion, Brownian sheet. SLE. Additive functionals of Markov processes. (5 credits)

Stochastic Models

BMETE95MM11 – 2/0/0/f/2

Dr. Márton Balázs

Coupling methods: stochastic dominance, coupling random variables and stochastic processes, examples: connectivity using dual graphs, optimization problems, combinatorial probability problems. Percolation: definitions, correlation inequalities, duality, contour methods. Strongly dependent percolation: Winkler percolation, compatible 0-1 sequences. Basics of statistical physics: Gibbs measure, a few basic models. Card shuffling: completely shuffled deck, how many times should one shuffle? Random graph models: Erdős–Rényi, Barabási-Albert; basic phenomena Variants of random walks: scenery reconstruction, self-avoiding and self-repelling walks, loop-erased walks, random walk in random environment. Queueing models and basic behavior; stationary distribution and reversibility, Burke theorem; systems of queues. Interacting particle systems: simple exclusion on the torus and on the infinite lattice, stationary distribution, Palm distributions, couplings, other models. Graphical construction of continuous time Markov processes: Yule model, Hammersley's process, particle systems. Self-organized criticality: sandpile models: questions of construction, commutative dynamics, stationary distribution in finite volume, power law decay of correlations. Linear theory of stationary processes: strongly and weakly stationary processes, spectral properties, autoregressive and moving average processes. Analysis of time series, long memory processes. Models of risk processes. (2 credits)

Stochastic Programming

BMETE93MM05 – 3/1/0/v/5

Dr. Tamás Szántai

Statistical decision principles. Petersburg's problem. Bernoulli-principle and the newsboy's problem, Dutch dike heightening problem, 'safety first' principle, Marschak's decision principle, the Bayesian decision principle, Markowitz's principle, game theory, Neumann's theorem. Convexity theorems. The theory of logconcave measures. General convexity theorems. Concavity and logconcavity of multivariate probability distribution functions. Statical stochastic programming models. Maximalizing the probability. Single and joint probabilistic constraints in the stochastic programming problems, solution methods. Models containing conditional expected values. Models with random objective functions. Penalty models of stochastic programming and their solution techniques: cases of discrete and uniform probability distributions. Dynamical stochastic programming models. Two stage stochastic programming problem and its mathematical properties. Basis decomposition technique for the solution of two stage stochastic problems with discrete probability distributions. 'L-shaped' solution method by Wets. Stochastic decomposition and conditional stochastic decomposition. Stochastic quasigradient methods. Multi stage stochastic programming problems. The basis decomposition and the 'L-shaped' method in the case of multi stage stochastic programming problems. Some applications of stochastic programming. Production of electrical energy with random effects, capacity expanding. Reliability analysis of power-plants. Water level regulation of a lake. Optimal control of water reservoirs. The PERT problem. Financial models. (5 credits)

Theoretical Computer Science

BMETE91MM00 –3/1/0/f/5

Dr. Miklós Ferenczi

Foundations of logic programming and automated theorem proving. Finite models and complexity. Non classical logics in Computer Science: temporal dynamic and programming logics. Recursive functions and lambda calculus. Boole algebras, relational algebras and their applications. Some important models of computation. Basic notions of complexity theory, some important time and spaces classes. NP completeness. Randomised computation. Algorithm design techniques. Advanced data structures, amortised costs. Pattern matching in text. Data compression. (5 credits)

Theory of Operators

BMETE92MM05 – 3/1/0/v/5

Dr. Béla Nagy

The basic concepts of Hilbert spaces will be assumed to be known. Further: Closed and closable linear operators, closed graph theorem. The basics of the spectral theory for closed operators. Closed symmetric and self-adjoint operators. Symmetric operator and its self-adjoint extension. Operators defined by a Hermitian (sesquilinear) form. Closed normal operators. Finite rank and compact operators. Hilbert–Schmidt operators. Matrix operators. Integration with respect to a spectral measure. The spectral decomposition for closed self-adjoint operators and the properties of their spectra. The spectral decomposition of closed normal operators. The extensions of closed symmetric operators: deficiency indices and Cayley transforms. Extensions into a larger Hilbert space: theorem of M. Naimark. Self-adjoint extensions extensions and their spectra. Analytic vectors. Perturbation of self-adjoint operators. Scattering. The unilateral shift operator, Wold–Neumann decomposition. The bilateral shift. Contractions. Invariant vectors, canonical decomposition. Isometric and unitary dilation of a contraction. Operators in Banach spaces. Holomorphic functions and contour integrals. Holomorphic functional calculus for bounded and for closed operators. Compact operators. The Riesz–Schauder theory. Noether and Fredholm operators. Semi-groups of operators in Banach spaces. The operator theoretic foundations of linear systems. Banach algebras. Spectrum. Holomorphic functional calculus. Ideals. The Gelfand transform. The spectrum of an element in a C*-algebra. The commutative Gelfand–Naimark theorem. Representation of C*-algebras. (5 credits)

Wavelet Analysis

BMETE92MM06 – 2/0/0/f/2

Dr. Ky Nguyen Xuan

A wavelet is a kind of mathematical function used to divide a given function into different frequency components and study each component with a resolution that matches its scale. A wavelet transform is the representation of a function by wavelets. The wavelets are scaled and translated copies (known as “daughter wavelets”) of a finite-length or fast-decaying oscillating waveform (known as the “mother wavelet”). Wavelet transforms have advantages over traditional Fourier transforms for representing functions that have discontinuities and sharp peaks, and for accurately deconstructing and reconstructing finite, non-periodic and/or non-stationary signals. In this course the theoretical background of all that and some applications will be presented as well. (2 credits)

Description of MSc Subjects in Computational and Cognitive Neuroscience

Brain in Trouble

BMETE47MC34 – 2/0/0/f/2

Dr. Márta Zimmer

Low-level deficits of the visual system – vision loss in eyes, visual field defects, blindsight. Deficits of object- and face perception. Deficits of space- and motion perception. Defects of the motor system – tic, Tourette syndrome, HD, MS. Sleep disorders, epilepsy, coma. Memory deficits. Deficits of higher cognitive functions (speach, reading, counting). Alcohol, drugs – short- and long-term effects in the central nervous system. Defects of the consciuos processes. Anxiety, mood disorder, depression. Schizophrenia, negative symptoms, hallucinations, psychopathies, multiple personality disorder. Eating disorders – anorexia, bulimia. Effect of aging – developmental disorders, aging, dementia. (2 credits)

Cognition and Emotion

BMETE47MC26 – 2/0/0/f/3

Dr. Gyula Demeter

The primary objective of the course is to present an overview of current research on basic emotional and cognitive processes and underlying brain function. We strive to illustrate the complex relationships between cognition and emotion by presenting specific examples and clinical cases, and by highlighting the underlying brain circuits. We focus also on the major clinical disorders with dysfunctional brain networks. We try to answer questions, such as: Thought or feeling- what is first? or sooner? What are the neural and evolutionary determinants of anxiety? How did our emotions and cognitive abilities evolve? – Introduction and examples. The psychology of emotions. Brain and emotion. Brain and cognition. Interactions of cognition and emotion. The development of cognition and emotion. Sleep and emotional information processing. Cognition and emotion after brain damage. Cognition and emotion in psychiatric disorders. (3 credits)

Cognitive Neuropsychiatry

BMETE47MC30 – 2/0/0/v/3

Dr. Szabolcs Kéri

History of psychopathology and classification of mental disorders. The DSM and ROoC. Continuum hypotheses, fuzzy clusters, and latent categories. Fundamental neuronal systems in psychopathology: PFC and subregions, amygdala, hippocampus, basal ganglia and their large-scale networks (default mode, executive, mirroring). Neuronal connections, synaptic transmission and key neurotransmitters. Psychotropic drugs: mechanism of action. Neurodevelopmental processes, neurodegeneration, plasticity, neuroinflammation. Orientation to time, space, and person. Quantitative and qualitative disorders of consciousness. Delirium. Perception, aperception, gnosia: representations at the sensory, perceptual, and conceptual level and psychopathology. Classification and mechanisms of hallucinations: efferent copy, parasite foci. Neuroimaging results. Perceptual distortions, deja vu, jamais vu. Capgras and Fregoli syndrome. Mechanism of dissociation: disconnections, role of PFC/anterior cingulate/amygdala circuits. Cognitive distortions, schemas, and heuristics. Overvalued belief and false belief (delusion). Classification and mechanism of delusions: perception of social signals, early jump to conclusions, selective attribution, and mentalization. Role of early traumas, reinforcement, neurodevelopmental features, and social context. Alienation, disturbances of self-representation. Semantic networks and conceptual disorganization. Role of left inferior PFC and perisilvyan areas, relationship with executive functions. Classification and mechanism of obsessions: the anterior cingulate/OFC/striatal loops. Phobias: processing of social signals and the amygdala. Reinforcement and extinction. (3 credits)

Cognitive Psychology Laboratory

BMETE47MC20 – 0/0/8/v/9

Dr. Ferenc Kemény

The aim of the course is to keep students up-to-date on the most popular paradigms of human psychological research. To introduce the major methodologies and related softwares. The course covers three major issues: Psycholinguistics, Memory and Sleep research. Students learn computer programming (E-prime), with thich they will be able to plan and run experiments. Neuroscience methods like EEG and eye-tracking will also be demonstrated. Psycholinguistics: students design and conduct a traditional psycholinguistic experiment, and disseminate results in the format of a course paper. Memory: students plan and conduct an experiment on memory using either behavioural or eye-tracking methodology. Sleep research: students learn the basics of the discipline, with special focus on the overlap of sleep research and cognitive neuroscience, its research streams and most important methodologies. Along with the major research paradigms (e.g. sleep deprivation, biorhythms, the neurobiological background of sleep disorders, sleep and memory consolidation, sleep-related information processing) students learn how to register and analyse sleep-related EEG. (9 credits)

Evolutionary Psychology

BMETE47MC07 – 2/0/0/f/3

Dr. Péter Simor

Evolutionary sciences and their hierarchy. The origin and fate of the Darwinian heritage in psychology. The notion of adaptation. Modular and single factor based theories of evolutionary psychology. Hominid evolution and cognitive architectures. Sexual and natural selection. Cultural multiplicity and evolution. – Main topics: Units and mechanisms of evolution: groups, individuals, genes, memes. Sexual selection. Mate choice and human mating strategies. Innateness and development. Social development; kin relationships and conflict. Reciprocity, group behavior, cooperation, competition. Game theory and evolution. Thought, cognition, and mental representation. The evolution of language and communication. The evolution of emotion, and evolutionary psychopathology. Culture and evolution. (3 credits)

Informatics

BMETE92MC19 – 0/2/0/f/3

Dr. János Tóth

The aim is to provide and extremely powerful tool to solve calculation, simulations, drawing, presentation, etc. problems connected with the studies of the student, which will also come useful later in research. The tool Mathematica, Version7, at the time of writing this syllabus, is also useful to show the latest developments in different fields of applied computer science, such as programming paradigms (with emphasis on functional programming). Parts of mathematics will also be presented or repeated in this course. – Topics: Mathematical program packages. An intelligent calculator: application in elementary mathematics. Kernel, front end, packages, demonstrations. Numbers, solving equations. Plotting, graphics. Animation, manipulation, sound. The language of Mathematica. Lists and generalized lists. Functional programming. Rule based programming. Rewrite rules. Pattern matching. Procedural programming. Applications in mathematics: discrete, continuous, stochastic. Applications in linguistics. Elements of image processing. (3 credits)

Introduction to Cognitive Science

BMETE47MC01 – 2/0/0/f/3

Dr. Gyula Demeter

Fundamental concepts of cognitive science: mental representation, computers, and information processing. Brain and cognition; the role of neuroscience. Cognitive architectures: modularity and domain-general systems. Propositional and schematic representation; schemas, mental images, and skill acquisition. Connectionism: artificial neural networks as models of the mind. Knowledge representation in artificial intelligence. Language and cognition; knowledge of language; the problem of meaning. The role of philosophy: the nature of mind, knowledge and consciousness. Interpreted Cognitive Science: neurobiology, evolution and social interpretation. Adaptation and knowledge. Skill, competences, and emotions in knowledge. Applied cognitive science: artificial intelligence; human information processing in human-machine interaction. (3 credits)

Introduction to Experimental Psychology

BMETE47MC25 – 2/0/0/v/3

Dr. Gyula Demeter

Introduction. Understanding psychology as a science. Experimental psycholgy and the scientific method. Research techniques : observation and correlation, experiments. Ethics in psychological research. Attention and reaction time. 1st Written examination paper. Conditioning and learning. Memory and forgetting. Individual differences and development. 2nd Written examination paper. Presentation of research plans. Presentation of research plans. (3 credits)

Mathematics

BMETE92MC15 – 2/2/0/v/5

Dr. János Tóth

The aim of the course is to give a nontechnical introduction into higher mathematics via lectures and via reading texts containing the use of mathematics in the different parts of cognitive science. Instead of calculation methods logical and philosophical connections will be emphasized. Technical and geometrical aspects will not receive emphasis, however, we try to analyse the meaning of notions within and, if possible, outside mathematics. Instead of proofs examples will be shown together with applications and with historical remarks. A shortened introduction to the classical material of calculus will be followed by introductions to areas which cannot be absolutely neglected by someone interested in cognitive science: dynamical systems, graphs and networks, algorithms and the use of computers in mathematics. – Topics: Fundamental notions of set theory and logics. A review of the notion of numbers. Relations and functions. The connection between operations and relations and between functions. Operations on functions. Series and infinite sums. Convergence, limit. Limit and continuity of real variable real valued functions. Differentiability of real variable real valued functions. Tangent. Rules of derivation. Applications of calculus: analysis of functions. Monotonicity, maxima and minima. Integration: antiderivative, definite integral. The fundamental theorem of calculus. Solving simple differential equations. On discrete dynamical systems. Simple models with chaotic behavior. On graphs and networks. Their rules of modelling. Algorithms. Applying mathematical program packages. (5 credits)

Memory and the Psychology of Learning

BMETE47MC29 – 0/3/0/f/3

Dr. Mihály Racsmány

The topics covered in the course are the currently topical areas of memory research. The most controversial results and new theories of the various topics are discussed based on one or two studies. – Sleep and memory. Consolidation and reconsolidation.

Amnesia. Prospective memory. Autobiographica memory. Memory decay. Consultation with students on research proposal. Recall. Inhibition and interference. Learning and transfer. Working memory. Consultation with students on second research proposal. (3 credits)

Neurobiology 1 – Foundations and Neurobiology of Perception

BMETE47MC22 – 2/0/2/v/5

Dr. Gyula Kovács

Basic neural processes, the cell membrane, the action potential. The synapse. Autonomous nervous system, hypothalamus. Perception – intorduction – methods. Integration of sensory and motor functions. From nerve cells to cognition. Somatosensory system: periphery, cortical processing, the perception of pain and temperature. Vision: early vision, higher vision. Hearing. Chemical senses – smell and taste. Practice: a HHSIM simulatory program, summary paper. (5 credits)

Neurobiology 2 – Sensory and Motor Processes

BMETE47MC23 – 2/0/0/v/3

Dr. Gyula Kovács

Multisensory integration. The human eye – anatomy, eye-movements, the retina. Subcortical mechanisms, thalamic nuclei and the superior colliculus. The V1. Visual cortical processes – after the V1. Dorsal and ventral visual pathways. Hearing. The motor system: from the muscle fibre to the spinal chord, brainstem, cortex, the basal ganglia and the cerebellum. (3 credits)

Neurobiology 3 – Higher Cognitive Functions

BMETE47MC24 –2/0/0/v/3

Dr. Szabolcs Kéri

The concept of mental functions. Structure of the association neocortex: Brodmann's areas, columnas, local neuronal circuits. The Mesulam-Fuster model, functional maps, cognits, temporal integration (oscillations, synchronization) Connections between neocortex and limbic system: Broca, the concept of the extended limbic system, Papez circuit + amygdala/OFC/cingulate system. Connections between neocortex and basal ganglia, subregions of the frontal lobe, maps of striatal loops, the Gruber-MacDonald model (S-R-C-O). Cellular bases of cognitive processes (selectivity, associativity, sustained activity, reward prediction, mirroring). The connectome", large-scale neuronal networks. The Bayes model, Friston's free energy principle. Posner's concept of attention: alerting, orienting, executive. The frontoparietal system, thalamus, colliculus. Ventral bottom-up, dorsal top-down and cingulo-opercular systems. Neglect. The biased competition model (Desimone). Frontal eye field [FEF] and intraparietal sulcus, search versus detection. Attention and temporal integration, alpha-gamma interactions. Cellular bases of the biased competition model, interaction of preferred and non-preferred stimuli in the receptive field, attentional weighting. FEF microstimulation, role of dopamine in attention and decision making. Subfields of intraparietal sulcus, attention and body-reference, affordances, interactions with premotor cortex canonic cells. Attention and Gestalt-organization, feature integration (Treisman) pop-out, object file", spatial filters and their attentional modulation. Ultra rapid attentional modulation. The MTL (medial temporal lobe) and its connections with the prefrontal cortex: fornix, thalamus, prefrontal subfields. Gamma-on-theta temporal integration. (3 credits)

Neuropsychology

BMETE47MC06 – 2/0/2/v/5

Dr. Gyula Demeter

In this course students will study the neural foundations of higher cognitive functions such as concept formation, language, planning of action, problem solving, emotions and consciousness, with a focus on recent findings and methodological development. Not only do recent findings and methodological achievements shape scientific theory, they also tend to affect therapy as well. We review these new findings while looking for links between normal and pathological functioning. (5 credits)

Psycholinguistics

BMETE47MC36 – 2/0/0/v/3

Dr. Ágnes Lukács

The course is based on the relationship between problems in linguistics and psychology and the history of the overlap between the two fields of research. In analysing the processes of language comprehension, beside presenting experimental methods in psycholinguistics, the main organizing principle is the contradiction of decompositional and interactive theories in explaining linguistic behavior, together with the problem of the psychological reality of linguistic levels. For speech production, the goal is to present stage models of planning and realization, as well as to demonstrate how production is embedded in conversation. The course also relates models of lexical organization to analyses of conceptual organization. The part on child language mainly focuses on constructivist and innatist explanations of language development, and connects them to our current biological knowledge. (3 credits)

Reading Seminar in Psycholinguistics 1, 2, 3

BMETE47MC31, 32, 33 – 2/0/0/v/3

Dr. Anna Babarczy

The course discusses current issues in psycholinguistics and experimental linguistics through the analyisis of current theoretical and empirical papers in the Hungarian and international literature. Each semester, the most topical issue will be chosen. Topics to choose from include: Theoretical debates in language acquisition. Language learning and implicit learning. Language Specific Impairment. Language and executive functions. The development of pragmatic competence. Scalar implicatures. Empirical findings in Metaphor theory. Clinical pragmatics. Models of language processing. Ambiguity. Corpus analysis of child language. Computer models of language acquisition. Computer models of pragmatic competence. Speech production. Language evolution. (3 credits)

Social Cognition

BMETE47MC28 – 2/0/0/v/3

Dr. Szabolcs Kéri

Infant understanding of others' behavior: intentions, goals, agency and early theory of mind. The foundations of cultural learning: ostensive signals, referencial communication and imitation. The roots of understanding the social world: cooperation, competition, altruism and the moral baby". Intentional stance, processing of social signals, group processes. Haggard's model of intentional actions, whether-what-when" decisions. Internal models and efferent copy. Neuronal mechanisms of intentional, self-generated and reflexive-stimulus-driven actions. Hypoactivity, alienation, delusions of reference, and hallucinations. Pre-SMA and alien hand syndrome. Processing of social signals. Self-representation and the somatosensory/insular cortex. Medial PFC and the default mode network": introspective cognition, mentalisation, mental time travel. Anticorrelative network with the executive system. Evolution of the anterior PFC, von Economo neurons, canonic cells, mirror cells and their network. Higher-level person perception: mentalisation, attribution, early conclusions, self-monitoring. Neuronal correlates of empathy. Neuronal representation of the self (Damasio and Frith): proto-, core- and autobiographic self. Nuclei of the brainstem, colliculi, somatosensory cortex, and the cingulum. The motor self: reconstruction in time. Basic processes in group interactions: competition, cooperation, cultural synchronization, distribution of resources, opportunism, heuristics, fragmentation. Neuronal relevance of the Nash-equilibrium: ultimatum game, dictator game, trust game, and prisoner's dilemma. Neuronal correlates of moral emotions and decisions. Hyperscanning, correlations of brain activity during cooperation, role of oxytocin in trust and attachment. Evolutionary cycles of cooperation and deception, cultural evolution, religion and political Machiavellianism. (3 credits)

Statistics and Methodology

BMETE92MC20 – 2/0/2/v/5

Dr. Márta Lángné Lázi

All the major areas of statistics (such as estimation, hypothesis testing, regression) will be treated with special reference to the assumptions usually assumed in introductory courses (such as normality, linearity, stationarity and scalar valuedness), which, however, are never fulfilled in real applications. How to test these assumptions and what to do if they are violated - these questions will act as guides in the course. – Topics: Random variables. Distributions. Generating random numbers. Sampling. Methods of estimation. Confidence intervals. Testing hypotheses. Independence, normality. Regression and interpolation. Getting and importing data. Cluster analysis. Experimental designs. Applications. Writing a report. Depending on the circumstances the calculations will either be done using Mathematica, or EXCEL, or SPSS. (5 credits)

FACULTY OF ECONOMIC AND SOCIAL SCIENCES

General Information

The Faculty of Economic and Social Sciences (GTK) of the Budapest University of Technology and Economics (BME) is one of the prime institutions of higher education in Hungary specialised in the fields of business, economics and social sciences.

As the youngest faculty of BME, it provides a dynamic and accommodating environment to all of its students and academic staff in the middle of Budapest, the historic capital of Hungary.

Programs offered by the Faculty provide solid theoretical foundations along with up-to-date practical skills at the bachelor, master and doctorate levels. The Faculty offers the largest MBA program in the country, as well as a high-ranking Ph.D. program in management science. Apart from its full programs, the Faculty is very active in providing courses to students of the engineering and natural science faculties of the University.

From 2019 September, the Faculty of Economic and Social Sciences launches three full time master programmes and a doctoral programme in English for both Hungarian and international students. Our programmes focus on innovation, both technical and social in nature, to equip our students with the most relevant and up-to-date knowledge and skills to tackle the fast changing business and social environment of the coming decades. Being in a STEM (Science Technology Engineering Mathematics) environment we build on our unique capabilities for familiarizing our students with data analytics, the new models of data economy and technological innovations in finance.

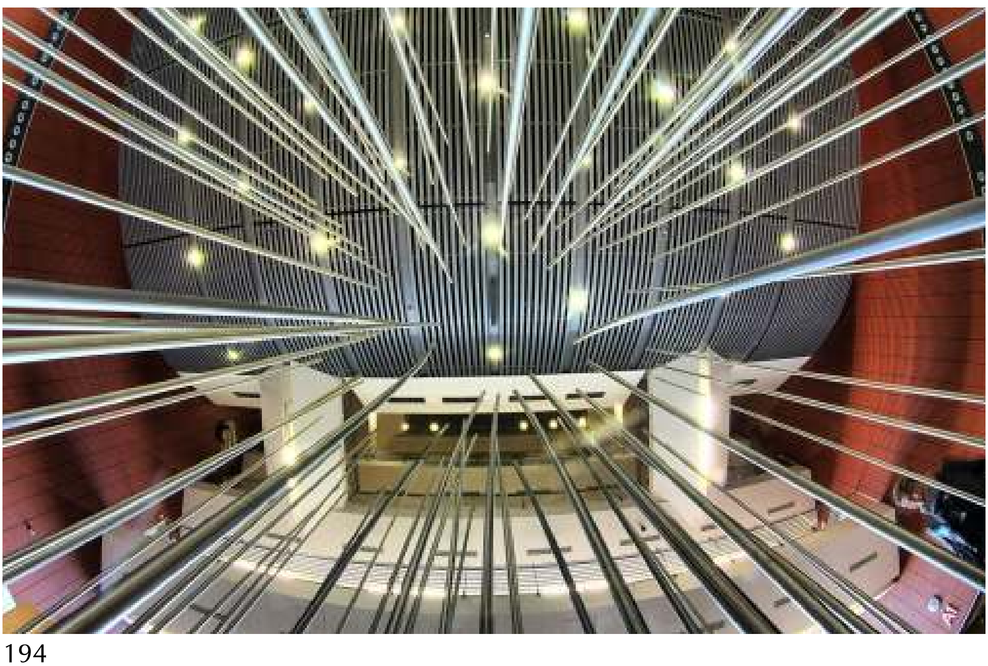
GTK plays an extensive role in the scientific scene, both domestic and international, by conducting research projects within the field of expertise of the 11 departments and centres operating at the Faculty. Research and high quality publication has a high priority in order to facilitate up-to-date teaching and practical training activities. The Faculty publishes 'Periodica Polytechnica – Social and Management Sciences', a peer-reviewed international scientific journal founded in 1993, publishing both research and application oriented papers in the area of management and social sciences.

Adult education and training, as well as specialised life-long training programs tailored to the requirements of various enterprises, companies and other clients also play a significant role in the life of the Faculty.

The Faculty hosts the Centre of Modern Languages, which provides language courses, exams and a translator and interpreter training program to students and staff of the University, and is also active in research activities.

The Faculty also offers a wide range of curricular and extra-curricular forms of physical education within the framework of the Centre of Physical Education.

The following pages introduce the three master and one doctoral programme of the Faculty for the academic year 2019/20.



Departments

Department of Business Law
Department of Economics
Department of Environmental Economics
Department of Ergonomics and Psychology
Department of Finance
Department of Management and Business Economics
Department of Philosophy and History of Science
Department of Sociology and Communication
Department of Technical Education
Centre of Modern Languages
Centre of Physical Education

Budapest University of Technology and Economics
Faculty of Economic and Social Sciences
Faculty Office: Building "Q" wing A, 203.
Address:
2 Magyar Tudósok krt. H-1111 Budapest, Hungary
E-mail: gtk-dekani@gtdh.bme.hu
Phone: (+36-1) 463-2152
International Study Office: Ms. Noémi Girst
E-mail: iso@gtdh.bme.hu

Dean of the Faculty: Prof. Dr. Tamás Koltai
Vice-Deans of the Faculty:
Dr. András Bethlendi (finance)
Dr. Anikó Grad-Gyenge (innovation)
Dr. Emma Lógó (education)
Prof. Dr. Gyula Zilahy (scientific and international affairs)

Description of master programmes

Master in Finance

Length of study: 4 semesters

Programme objectives: The goal of the program is to equip our students with a global competitive edge in finance, in particular financial analysis and risk management. Our graduates will be capable to solve complex financial tasks independently and to manage and analyse financial processes present in the economy both at macro and micro levels. The main focus of our program is to provide high level of professional standards in investment analysis, portfolio management, corporate and bank treasury and risk management.

To this end, we designed our course structure and curricula to meet the requirements of the international Chartered Financial Analyst (CFA) Program and Financial Risk Manager (FRM) accreditation. As a consequence, our students, upon graduation, will also have gained the knowledge to successfully pass CFA/FRM exams. This feature of our programme is unique in the Hungarian higher education market, and is also rare in an international setting.

General conditions of admission into the master programme:

- BSc in Finance and Accounting or Business Administration and Management (ISDEC level 6 or higher)
- Any other BA/BSC with the proof of minimum 60 ECTS equivalent required in the following disciplines:
    - 15 ECTS from Quantitative foundations (mathematics, statistics, informatics)
    - 10 ECTS of Economics (micro and macroeconomics, international economics, environmental economics, economics theory, economics statistics, economics theory, economic modelling, economic policy, sectoral and functional economics, international economy, European economy, public policy);
    - 10 ECTS of Business Basics (corporate economics, accounting, controlling human resources, business law, marketing, management and organization, value creation processes, decision theory and methodology, business ethics, strategic planning, business communication);
    - 10 ECTS from the basics of Social Sciences (European Union, general and business law, economic history, sociology, psychology, philosophy);
    - 15 ECTS of Financial Knowledge (finance, money and capital market, banking, financial policy, taxation, corporate finance, corporate valuation).
- Applicants can be admitted with 30 ECTS from the above listed disciplines on the condition that they collect the remaining 30 ECTS during the first year of their studies
- Minimum GPA of accepted credits is on the middle of the scale
- B2 level command of English: a TOEFL iBT score of 88 or above, IELTS overall band 6.5 or above.

Master in Management and Leadership

Length of study: 4 semesters

Programme objectives: The key objective of the program is to develop future business leaders by putting strategy and leadership into the center of the curriculum for enabling our students to make decisions in non-standard situations in an autonomous way. Graduates will be able to demonstrate relevant knowledge of, and critical engagement with, the key issues in strategy and leadership alongside more broadly the types and networks of organizations, the external environment in which they operate and how they are managed.

The program aims to equip students with knowledge, skills, and competencies required for a successful carrier in the age of digital transformation, cultural and global change. The basic essentials of the program cover knowledge areas in quantitative decision making, operations management, organizing services, financial management, marketing, law, human resources and international strategy. In these fields students develop competencies of effective communication, working in teams, adopting international benchmarks, appreciating cultural differences and acting upon ethical principles of social and environmental sustainability.

The programme's unique features include a focus on digital transformation and its consequences and the integration of such contemporary skills as understanding cultural diversity and the importance of balancing economic interests with the interest of society (corporate social responsibility).

General conditions of admission into the master programme:

- BA/BSc in Finance and accounting or Business Administration or Management (ISDEC level 6 or higher)
- Any other BA/BSc with the proof of minimum 60 ECTS equivalent in the following disciplines:
    - 15 ECTS in Quantitative Studies (mathematics, statistics, computer science/programming);
    - 10 ECTS in Economics (micro and macroeconomics, international economics, environmental economics, economics theory, economics statistics, economic modelling, economic policy, regional economics, European economy, public policy);
    - 15 ECTS in Business and Management (business economics, accounting, controlling, human resources, business law, marketing, management and organization, production management, decision theory and methodology, business ethics, strategic planning, business communication);
    - 10 ECTS in Social Sciences (International or European studies, general and business law, sociology, psychology, philosophy);
    - 10 ECTS credits of financial knowledge (finance, money and capital market, banking, financial policy, taxation, corporate finance, corporate valuation)
- Applicants can be admitted with 30 ECTS from the above listed disciplines on the condition that they collect the remaining 30 ECTS during the first year of their studies
- B2 level command of English: a TOEFL iBT score of 88 and above, IELTS overall band 6.5 or above.

Master in Regional and Environmental Economic Studies

Length of study: 4 semesters

Programme objectives: The programme aims to train experts of environmental and regional economics, capable of analysing regional and sustainability-related problems, and propose novel solutions by putting their theoretical knowledge and acquired expertise to practice. Regional economics and business aspects of sustainability are important parts of the programme as well. Courses are highly workshop-oriented, where students may work together to focus local and regional aspects of actual global sustainability challenges.

Our graduates will be capable of creatively and innovatively contribute to the solution of sustainability challenges and to regional policy-making, strategic planning and project programming, both in governments and in private enterprises.

General conditions of admission into the master programme:

- BSc/BA in economics, management or engineering/natural sciences (ISDEC level 6 or higher)
- In case of BA/BSc in engineering/natural sciences it is necessary to prove a minimum of 60 ECTS equivalent in the following disciplines:
  - 20 ECTS in Quantitative Studies (mathematics, statistics, computer science/programming, etc.);
  - 20 ECTS in Economics and Management Studies (micro and macroeconomics, international economics, environmental economics, economics theory, economics statistics, economic modelling, economic policy, regional economics, European economy, public policy, business economics, accounting, controlling, human resources, business law, marketing, management and organization, production management, decision theory and methodology, etc.);
  - 20 ECTS in Natural or Social Sciences (International or European studies, general and business law, sociology, psychology, philosophy, biology, physics, chemistry, geography, earth sciences, etc.).
- Applicants can be admitted with 40 ECTS from the above listed disciplines on the condition that they collect the remaining 20 ECTS during the first year of their studies
- ECTS-proof is compulsory for all applicants regardless of their preliminary studies and the discipline of BA/BSc diploma
- B2 level command of English: a TOEFL iBT score of 88 and above, IELTS overall band 6.5 or above.

Ph.D. Programme in Business and Management

Length of study: 8 semesters

Programme objectives: The aim of the Doctoral School of Business and Management is to provide PhD studies for students specializing in engineering management, management sciences and business economics. In their studies they concentrate on recognizing, formulating, modelling the economic, technical and social aspects of different production, service and public activities.

PhD students will be able to acquire the basic knowledge and skills needed for research beyond general economics knowledge. The programme will allow students to master analytical and methodological skills required to conduct research in their area of specialization, design and carry out original research and demonstrate the ability to communicate research findings in a clear and effective manner.

Admission requirements:

The Business and Management PhD program accepts students with a master degree from all domains of business and management master programs, such as marketing, management and leadership, finance, accounting, regional and environmental economics, international economy and business and master of business administration (MBA).

Applications with a master's degree from other disciplines may also be acceptable on the basis of an assessment of the doctoral school management.

Curriculum of MA in Regional and Environmental Economics

Subject	Contact hours / Exam type / Credit				
Name	**1**	**2**	**3**	**4**	**Preliminary requirements**
Economics	2/t/3				
Quantitative Methods	4/t/5				
Environmental Economics*	3/e/5				
Regional Economics*	4/e/5				
Geoinformatics	3/t/4				
Economic and Social Geography	2/t/3				
Elective Course Unit 1	2/t/3				
Methods of Regional and Environmental Analysis		2/t/3			
Data Analytics		2/e/3			
Sustainable Environmental and Natural Res. Econ.*		4/e/5			
Environmental and Regional Policy of the EU		4/t/5			
Environmental and Urban Sociology		4/t/5			
Municipal Management and Local Governance		4/e/5			
Elective Course Unit 2		2/t/3			
Regional Economic Development*			4/e/5		Regional Economics, Environmental Economics
Project Management			4/e/5		
Environmental Management Systems*			4/e/5		Environmental Economics
Regional and Municipal Marketing			4/t/5		Regional Economics, Regional Policy
Diploma Project 1 (Compulsory Elective)			11/t/12		A total of 45 ECTS credits (from Compulsory and Elective course units) shall have been obtained before taking this course unit.
Local Development and Social Policy				2/t/3	
Urban Development and Urbanism				4/e/5	
Sectoral Sustainability Studies				4/t/5	
Competitiveness Evaluations				4/e/5	
Diploma Project 2 (Compulsory Elective)				12/t/13	Diploma Project 1
Total	**21/2e/28**	**22/3e/29**	**27/3e/32**	**26/2e/31**	
Elective units					
Language courses (refer to separate documentation)	4/t/0	4/t/0			
Physical Education and Sports (refer to separate documentation)	2/s/0	2/s/0			

For curriculum updates please visit our website http://www.gtk.bme.hu/en/

Course Unit Type
Compulsory (Core) Unit
Compulsory Elective Unit (students may choose course units from a pre-selected list)
Elective Unit (students may choose course units from the entire university portfolio)
Criterion Requirement

****Final Examination Course Units***
final examination course unit (a course unit whose topics constitute some of the topic questions on the final examination)

Weekly Hours
Weekly Hours = Lectures + Practicals/Seminars + Laboratory work

Assessment Type
e: examination t: term grade s: signature (proof of completion only, no evaluation of performance required)

Example of Notation
E.g.: Quantitative Methods 4/e/5
Meaning: Compulsory (Core) Unit, 4 contact hours a week, performance assessed by means of examination, totalling 5 ECTS credits.

Curriculum in MA of Finance

Subject	Contact hours / Exam type / Credit				
Name	**1**	**2**	**3**	**4**	**Preliminary requirements**
Economics	2/e/3				
Quantitative Methods	4/t/5				
Principles of Accounting	4/t/5				
Investments*	2/t/3				
Introduction to Financial Mathematics	4/t/5				
Foundations of Risk Management*	4/e/5				
Business Law	2/e/3				
Intensive Seminar	2/t/4				
Data Analytics		2/t/3			
Management controlling		4/e/5			
Economic History		2/e/3			
Corporate Finance*		4/t/5			
Macro Finance*		2/e/3			
Pricing and Price Forecasting		4/t/5			Introduction to Financial Mathematics
Innovation and Green Finance		2/e/3			
Valuation of Enterprises*			4/t/5		Corporate Finance
Environmental Management Systems			4/e/5		
Organisational Behavior			4/e/5		
Fixed income and Management of Market Risk*			4/t/5		Foundations of Risk Management
Credit and Operational Risk Management*			4/t/5		Foundations of Risk Management
Management Information Systems			2/t/3		
Elective Course Unit 1. (Compulsory Elective)			2/t/3		
Analysis of production and operation decisions				4/t/5	
Elective Course Unit 2. (Compulsory Elective)				2/t/3	
Thesis				12/t/15	
Compulsory Electives					
Specialisation in risk management (2 courses should be selected from the list)					
Investment management risk measurement				2/e/3	
Banking				2/e/3	
Insurance				2/e/3	
Specialisation in financial analysis (2 courses should be selected from the list)					
Portfolio Management and Alternative Investments				2/e/3	
International Finance				2/e/3	
Derivatives and Real Options				2/e/3	
Total	**24/33**	**20/27**	**22/31**	**22/29**	
Electives (refer to separate documentation)					
Language courses	4/t/0	4/t/0			
Physical Education and Sports	2/s/0	2/s/0			

For curriculum updates please visit our website http://www.gtk.bme.hu/en/

Course Unit Type
Compulsory (Core) Unit
Compulsory Elective Unit (students may choose course units from a pre-selected list)
Elective Unit (students may choose course units from the entire university portfolio)
Criterion Requirement

****Final Examination Course Units***
final examination course unit (a course unit whose topics constitute some of the topic questions on the final examination)

Weekly Hours
Weekly Hours = Lectures + Practicals/Seminars + Laboratory work

Assessment Type
e: examination t: term grade s: signature (proof of completion only, no evaluation of performance required)

Example of Notation
E.g.: Quantitative Methods 4/e/5
Meaning: Compulsory (Core) Unit, 4 contact hours a week, performance assessed by means of examination, totalling 5 ECTS credits.

Curriculum in MA of Management and Leadership

Subject	Contact hours / Exam type / Credit				
Name	**1**	**2**	**3**	**4**	**Preliminary requirements**
Economics	2/e/3				
Quantitative Methods*	4/t/5				
Marketing*	4/e/5				
Business Law	2/t/3				
Production and Operations Management*	4/e/5				
Accounting*	4/e/5				
Organisational Behaviour*	4/e/5				
Data Analytics*		2/e/3			
Corporate Finance I.*		4/e/5			Accounting
Production Organisation*		4/e/5			Production and Operations Management
Quality Management*		4/e/5			
Management Elective Block 1. (Compulsory Elective)		2/t/3			
Finance Elective Block 1.		2/t/3			
Elective Course Unit 1.		2/t/3			
Investments			2/t/3		Production Organisation
Environmental Management Systems*			4/e/5		
Management Information Systems (MIS)*			2/e/3		
Project Management*			4/e/5		
Intensive Seminar			2/t/4		
Management Elective Block 2.			2/t/3		
Finance Elective Block 2.			2/t/3		
Business Law Elective Block			2/t/3		
Elective Course Unit 2.			2/t/3		
Logistics and supply chain management				4/t/5	Production and Operations Management
Analysis of production and operation decisions				4/e/5	
Technology Management				4/e/5	
Thesis				12/t/15	A total of 80 ECTS credits shall have been obtained before taking this course unit.
Total	**24/4v/31**	**22/4v/27**	**22/5v/32**	**24/2v/30**	
Electives (refer to separate documentation)					
Language courses	4/t/0	4/t/0			
Physical Education and Sports	2/s/0	2/s/0			

For curriculum updates please visit our website http://www.gtk.bme.hu/en/

Course Unit Type
Compulsory (Core) Unit
Compulsory Elective Unit (students may choose course units from a pre-selected list)
Elective Unit (students may choose course units from the entire university portfolio)
Criterion Requirement

****Final Examination Course Units***
final examination course unit (a course unit whose topics constitute some of the topic questions on the final examination)

Weekly Hours
Weekly Hours = Lectures + Practicals/Seminars + Laboratory work

Assessment Type
e: examination t: term grade s: signature (proof of completion only, no evaluation of performance required)

Example of Notation
E.g.: Quantitative Methods 4/e/5
Meaning: Compulsory (Core) Unit, 4 contact hours a week, performance assessed by means of examination, totalling 5 ECTS credits.

Faculty of Transportation Engineering and Vehicle Engineering

The Faculty of Transportation Engineering and Vehicle Engineering is an accredited source of engineering studies since 1951, transferring knowledge in the fields of transportation processes, modeling and optimization, vehicle operation, automation, planning and control, manufacturing and services. The Faculty's mission defines the undertaking of high level professional training and high quality scientific activity, research and development, offering expertise and consultation to transport operators, vehicle industry companies and logistics providers.

BSc programmes in Hungarian:

- **Transportation Engineering BSc** – we focus on transportation and shipping related processes and their control.
- **Vehicle Engineering BSc** – students will acquire knowledge on the transportation vehicles, machinery, material handling and building machinery.
- **Logistics Engineering BSc** – the programme offers complex insight and knowledge in corporate logistics systems and supply chains and also helps with building up an analytical point of view.

MSc programmes in Hungarian:

- **Vehicle Engineering MSc**
- **Transportation Engineering MSc**
- **Logistics Engineering MSc**

MSc programmes in English:

- **Vehicle Engineering MSc**
- **Transportation Engineering MSc**
- **Logistics Engineering MSc**
- **Autonomous Vehicle Control Engineer MSc**

PhD studies:

The highest level of the faculty's education is represented by the Kandó Kálmán Doctoral School, where the PhD students are being prepared for scientific research and a possible career as a professor and researcher. The 4 year program lets the students take part in professional subjects and courses, teaching activities and individual scientific research tasks. Research activity is being lead by a professional supervisor, and the PhD students will show their results through their publications and later in their dissertation.

Departments:

Department of Material Handling and Logistics Systems
Department of Automotive Technologies
Department of Vehicle Elements and Vehicle Structure Analysis
Department of Control for Transportation and Vehicle Systems
Department of Transport Technology and Economics
Department of Aeronautics, Naval Architecture and Railway Vehicles

Budapest University of Technology and Economics
Faculty of Transportation Engineering and
Vehicle Engineering
Faculty Office: Building K I. 27
Address: H-1111 Budapest, Műegyetem rkp. 3.
E-mail: kjk@mail.bme.hu
Phone: +36- 1-463-3551

Dean of the Faculty: Dr. István Varga
Vice-dean of the Faculty: Dr. Ádám Török
Program co-ordinator: Ms. Barbara Mag

Description of BSc training

BSc in Vehicle Engineering
Length of study: 7 semesters

Program objectives: T: The aim of the bachelor education programme is to train vehicle engineers, who will be able to maintain and operate road, railway, water, air, construction and material handling vehicles with appropriate knowledge in the fields of transportation and logistics. They will be able to fulfill roles of vehicle engineering tasks, like improvement, manufacturing and operation. The listed tasks are accomplished by taking into account safety, environment and energy management aspects. The gained knowledge provides the basics to continue their education in the MSc programmes of the Faculty.

Specializations: Automotive vehicle, Aerospace vehicle, Naval vehicle, Railway vehicle, Construction equipment, Automated material handling equipment and robotics, Vehicle manufacturing, Vehicle mechatronics, Vehicle structure

Competencies and skills: Possessing the basic certificate, the vehicle engineers - taking into consideration also the prospective specialisations - become able:

- to determine the necessary equipment for the realisation of transportation and logistic processes,
- to organize, arrange, control the safe, the powerful and environmental-protective operation of vehicles, vehicle systems, mobile machines, materials-handling machines and machine systems,
- to perform the basic engineering tasks related to the designing, manufacturing, repair, as well as organisation of vehicles and mobile-machinery,
- to provide and organize the official work related to installation and operation of vehicles and mobile-machinery.

BSc in Transportation Engineering
Length of study: 7 semesters

Program objectives: The aim of the bachelor engineering programme is to train transportation engineers, who will be able to organize and operate processes of passenger and goods transportation. They will learn how to choose proper measures for these tasks, how to operate and maintain such transportation systems, including elements of infrastructure, control and IT systems. The gained knowledge is sufficient to continue their education in the MSc programmes of the Faculty.

Specializations: Road transportation, Railway transportation, Air transportation, Waterborne transportation

Competencies and skills: The transportation engineers received a basic certificate (BSc) - taking into consideration also the specialisations - become able:

- to recognise the demands for transportation and transportation-logistics, to determine the relationships to be applied,
- to exert active detailed cognition of transportation-and transportation logistics processes, to manage the processes mentioned together with their technical realisation,
- to design processes in accordance with the function of transportation and transportation-logistics systems, to select the technical components and to manage the operation of the system,
- to keep in operation vehicles and mobile machines serving the transportation process, to make the control systems operated, to take into consideration the environmental factors,
- to perform designing, organising and keeping in operation duties,
- to carry out public service and marketing activities.

BSc in Logistics Engineering

Length of study: 7 semesters

Program objectives: The aim of the study is to train logistics engineers, who will be able to maintain and operate corporate logistics and good transportation systems. They will know modern supply chains and networks, their management and organizational basics, and transport control processes and workflows. Related logistics control and IT systems basics are also acquired. The gained knowledge is sufficient to continue their education in the MSc programmes of the Faculty.

Specializations: From the 5th semester every student will participate in one logistics engineer specialization, which covers all specific areas of logistics, and prepares the further MSc integration and specializations, and/or the specific logistics operating engineer work.

Competences and skills: Possessing the basic certificate, the logistics engineers - taking into consideration also the prospective specialisations - become able:

- to define the equipment necessary to realize logistics systems and processes,
- to organize, arrange, control logistics systems in a safe and environmentally-friendly way,
- to perform the basic engineering tasks related to the design, manufacture and repair, as well as the organization of material handling machines,
- to provide and organize the official work related to the installation and operation of logistics machinery.

Actually, due to changes in basic training (BSc) our Faculty can ensure training in English with tuition fee for the time being only part-time (attending term at other faculties, training exchange students). The list of optional subjects in the given term is on website: http://transportation.bme.hu/for-students/courses/

Description of MSc training

MSc in Autonomous Vehicle Control Engineer

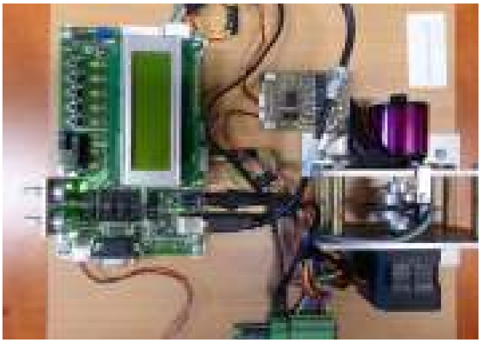
Length of study: 4 semesters

Program objectives: : The Autonomous Vehicle Control Engineer Master programme focuses on transferring high level knowledge regarding vehicle technology, engineering, computer science and economics. The application of new technologies and methodologies will ensure that engineers are able to plan, develop, operate and conduct practical and research oriented tasks in the field of autonomous vehicles.

The aim of the programme is to educate the next generation of engineers, who are capable of developing new technologies and handling problems of autonomous vehicles transport systems taking into account environmental and energy management requirements. Furthermore they will be prepared to continuously deepen their knowledge, thus providing up-to-date solutions for new challenges.

Competences and skills: The students will be prepared to take part in designing, developing and manufacturing autonomous vehicles, simulate networks, test and validate processes and work in a complex environment with various sensor data. The students will also be able to facilitate the creation of safe and energy-saving operation of autonomous transportation systems considering environmental and sustainable parameters.

The cooperation with our industrial partners guarantees that students will be able to participate in the latest research and development projects. The integration of the requirements of the industrial partners and project results to the curriculum leads to a unique education programme, that helps to achieve a specific knowledge transfer between the university and the vehicle industry.



MSc in Vehicle Engineering

Length of study: 4 semesters

Program objectives: The master education programme is a continuation of the bachelor vehicle engineering studies. Our aim is to provide the required knowledge to graduates, required to manage development, design, dimensioning, manufacturing and analyzing internal processes of different vehicles. The students will also be prepared to management tasks and to creatively participate in Research & Development related tasks. These studies prepare students for our PhD programmes.

Specializations: Automotive vehicle engineer, aerospace vehicle engineer, naval vehicle engineer, railway vehicle engineer, Mobile machinery and construction equipment engineer, automated material handling system, Vehicle manufacturing and repairing engineer, Vehicle system engineer, Road and traffic safety engineer, Vehicle automation engineer, Vehicle structure engineer.

Competencies and skills: Possessing the MSc degree, vehicle engineers are able:

- to integrate a system oriented and process analysing way of thinking directed on vehicles and mobile-machinery, having a role in transportation processes,
- connected with the specialization selected, to carry out assessments, to develop, design, organise and control complex systems of vehicle technology.

Accepted to the input without any conditions:

- Transportation engineering

Accepted to the input under given conditions:

- mechanical engineering;
- mechatronics engineering;
- military staff, and safety technology engineering;
- agricultural and food industrial engineering;
- engineering informatics.

MSc in Transportation Engineering

Length of study: 4 semesters

Program objectives: The master education programme is a continuation of the bachelor studies. Our aim is to train graduates, who will be able to analyze, plan, organize and control transport related processes in an integrated way considering economic, safety, environmental and human resource aspects. Graduates will be able to deal with tasks of transport administration and transport authorities, choice and operation of vehicles and facilities of passenger and good transportation systems and related infrastructural, control and IT system elements. The students will also be prepared to higher management tasks, to creatively participate in research & development tasks. These studies prepare students for our PhD programme.

Specializations: Transportation systems, Transportation automatization, Transportation engineer manager, Freight forwarding management, Air Traffic Management.

Competencies and skills: Possessing the MSc degree, transportation engineers are able:

to recognise connections between systems and processes of transportation, to evaluate and to handle them in the framework of system theory, as well as to apply the related principles and methods,

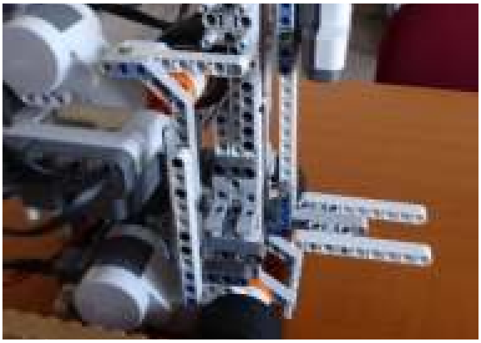
connected with the specialization selected, to carry out state assessments, to develop, design, organise and control complex transportation systems.

Accepted to the input without any conditions:

- Transportation engineering

Accepted to the input under given conditions:

- mechanical engineering;
- mechatronics engineering;
- military staff and safety technology engineering;
- civil engineering;
- engineering informatics;
- light industry engineering.



MSc in Logistics Engineering

Length of study: 4 semesters

Program objectives: The MSc study is a continuation of the BSc studies. Our aim is to train graduates, who will be able to plan, organize and control corporate logistics systems, good transport systems and supply and distribution networks. Furthermore they will be able to join to developing logistics systems related machines and tools. The students will also be able to deal with complex logistics system modeling and optimization, they understand operation and planning principles of corporate logistics systems, distribution networks and supply chains. The students will also be prepared to manage leading tasks, to creatively participate in R&D related problem, and continue their studies later on our PhD programme.

Specializations: Corporate logistics and operations planning, Technical logistics, Freight forwarding management.

Competencies and skills: Possessing the MSc degree, logistic engineers are able to interconnect the component-processes of logistic systems and the component-units performing the physical realisation of the former relationships.

Accepted to the input without any conditions:

- Transportation engineering

Accepted to the input under given conditions:

- mechanical engineering;
- mechatronics engineering;
- military staff, and safety technology engineering;
- agricultural and food industrial engineering;
- engineering informatics;
- light industry engineering.

Admittance to master courses (MSc) ensured by the announced training, partly in English language, is possible in case of meeting the input conditions, passing entrance examination and in case of at least 5 students' participation.

PhD studies

The highest level of the faculty's education is represented by the Kandó Kálmán Doctoral School, where the PhD students are being prepared for scientific research and a possible career as a professor and researcher. The programme's tasks deal with transportation, vehicle industry and logistics related questions, which actual topics are frequently updated.

The 4 year program lets the students take part in professional subjects and courses, teaching activities and individual scientific research tasks. The programme will deepen the students' knowledge in 3 main fields: high level natural science, foundation of profession and specialist subjects in vehicles and mobile machines, transportation and logistics sciences. Furthermore they will gather knowledge through specific optional subjects.

The high quality of the education is guaranteed by the well recognized core members of the programme. Research activity is being lead by a professional supervisor, and the PhD students will show their results through their publications and later in their dissertation.

Curriculum of MSc in Autonomous Vehicle Control Engineering

Subject		Lecture / Practice / Laboratory / Exam type / Credit				Prerequisites	
Name	Code	1	2	3	4	Com-pulsory	Recom-mended
Control theory and system dynamics	BMEKOKAM701	2/0/2/v/4				-	-
Automotive environment sensors	BMEKOKAM708	2/0/2/v/5				-	-
Automotive vehicle systems	BMEKOGGM712	2/0/1/f/4				-	-
Vehicle testing and validation	BMEKOGGM406	0/0/3/f/3				-	-
High Performance Microcontrollers and Interfaces	BMEVIAUMA07	2/1/0/v/4				-	-
Numerical methods	BMEKOVRM121	2/0/1/f/4				-	-
Programming in C and Matlab	BMEKOKAM603	2/0/2/f/4				-	-
Computer Vision Systems	BMEVIIIMA07	2/1/0/v/4				-	-
Automated driving systems	BMEKOGGM707		2/0/2/v/5			-	-
Autonomous Robots and Vehicles	BMEVIIIMA12		2/1/0/v/4			-	-
Embedded Opertating Systems and Client Applications	BMEVIAUAC07		2/1/0/v/4			-	-
Vehicle operation	BMEKOGGM174		2/0/1/v/4			-	-
Localization and mapping	BMEEOFTMKO1		2/2//f/4			-	-
Vehicle dynamics	BMEKOGGM705		2/0/1/v/3			-	-
Vehicle mechanics fundamentals	BMEKOGGM713		2/0/1/v/4			-	-
Artificial Intelligence	BMEVIMIAC10		3/0/0/f/3			-	-
Design and Integration of Embedded Systems	BMEVIMIMA11		2/1/0/v/4			-	-
Software Development Methods and Paradigms	BMEVIAUMA00		2/1/0/v/4			-	-
Signal Processing Fundamentals	BMEVIHIM009		4/0/0/f/4			-	-
Automotive network and communication systems	BMEKOGGM709			2/0/2/f/4		-	-
Automated vehicle design project	BMEKOKAM710			2/0/2/v/6		-	-
Safety and reliability in vehicle industry	BMEKOKAM703			2/0/0/f/3		-	-
MSc Diploma Thesis I.	BMEKOKAM553/ BMEKOGGM553			0/5/0/f/10		-	-
Traffic modelling, simulation and control	BMEKOKAM704			2/0/2/f/4		-	-
Project Management	BMEGT20M420			2/0/0/f/2		-	-
Automotive R&D processes and quality systems	BMEKOGGM711				3/0/0/f/4	-	-
Legal Framework of Autonomous Vehicles	BMEGT55M420				2/0/0/f/2	-	-
MSc Diploma Thesis II.	BMEKOKAM554/ BMEKOGGM554				0/10/0/f/20	-	-
Human Factors in Traffic Environment	BMETE47M000				2/0/0/f/2	-	-
Machine vision	BMEKOALM702				2/0/2/f/4	-	-

Curriculum of MSc in Vehicle Engineering

Subject		Lecture / Practice / Laboratory / Exam type / Credit				Prerequisites	
Name	Code	1	2	3	4	Com-pulsory	Recom-mended
Advanced Driver Assistance Systems	BMEKOGGM657	2/0/2/v/4				-	-
Advanced Flight Theory	BMEKORHM620	2/1/0/v/4				-	-
Advanced materials and technologies	BMEKOGGM601	3/2/0/f/5				-	-
Aircraft design and production I.	BMEKOVRM629	2/0/2/v/4				-	-
Computer aided design	BMEKOJSM605	2/0/2/v/4				-	-
Control theory	BMEKOKAM142	2/1/0/v/3				-	-
Environment Sensing in the Vehicle Industry	BMEKOKAM656	2/0/2/v/4				-	-
Instrumental tests for motor vehicles, measurement technology	BMEKOGGM668	0/0/4/f/4				-	-
Machine Intelligence	BMEKOALM644	2/2/0/v/4				-	-
Measurement techniques and signal processing in vehicles	BMEKOKAM635	4/0/2/v/8				-	-
Mechanics of superstructure materials	BMEKOJSM663	2/0/2/v/4				-	-
Numerical methods	BMEKOVRM121	2/0/1/f/4				-	-
Operation of railway vehicles	BMEKOVJM409	2/0/0/v/3				VJM402	VJM109
Practice in technology of manufacturing and materials in vehicle industry	BMEKOGGM648	0/2/2/v/4				-	-
Programming in C and Matlab	BMEKOKAM603	2/0/2/f/4				-	-
Railway vehicle system dynamics	BMEKOVRM608	3/1/0/v/5				-	-
Requirements for superstructure designers	BMEKOJSM662	0/2/2/v/4				-	-
Road safety, legislative environment, human factors	BMEKOGGM653	2/0/2/v/4				-	-
Ship design	BMEKOVRM615	2/2/0/v/5				-	-
Simulation of technical systems	BMEKOALM645	2/1/1/v/4				-	-
Surface Engineering	BMEKOGGM647	2/0/2/v/4				-	-
Suspension design	BMEKOGJM613	2/0/2/v/4				-	-
Theory of Ships III.	BMEKOVRM616	2/1/0/v/3				-	-
Vehicle operation, reliability and diagnostics	BMEKOVRM602	2/0/0/f/2				-	-
Accident analysis I., forensic processes	BMEKOGGM654		2/0/2/v/4			-	-
Aircraft analysis I.	BMEKOVRM631		2/0/2/v/4			-	-
Aircraft design and production II.	BMEKOVRM630		2/0/2/v/4			-	-
Computational fluid- and thermodynamics	BMEKOVRM606		2/0/2/v/4			-	-
Construction of vehicle manufacturing systems I.	BMEKOGGM649		2/0/2/v/4			-	-
Design methods of drive systems	BMEKOALM646		2/0/1/v/3			-	-
Design of material handling machine design	BMEKOKAM627		2/2/1/v/5			-	-
Design of pleasure craft	BMEKOVRM625		2/1/0/v/4			-	-
Diesel and electric traction	BMEKOVRM610		3/1/0/v/5			-	-
Discrete Control Design	BMEKOKAM658		2/0/2/v/4			-	-
Dynamics of vehicle, active- and passive safety	BMEKOGJM641		2/0/2/v/4			-	-
Electronics – electronic measurement systems	BMEKOKAM103		2/1/0/f/4			-	-
Engine design I.	BMEKOGGM670		2/0/2/v/4			-	-
Fixing and sealing	BMEKOGGM650		2/0/2/v/4			-	-
Machines of construction material production	BMEKOALM672		2/2/1/v/5			-	-
Mechatronics, microcomputers	BMEKOKAM604		2/0/2/f/4			-	-
Ship motions	BMEKOVRM624		2/1/1/v/4			-	-
Structural vibrations	BMEKOJSM665		2/0/2/v/4			-	-
Structure analysis	BMEKOJSM609		2/0/2/v/4			-	-
Superstructure preliminary design	BMEKOJSM664		2/0/2/v/4			-	-
System technique and analysis	BMEKOVRM129		2/2/0/f/4			-	-
Traction mechanics	BMEKOVRM619		2/1/0/v/3			-	-
Transmission system design	BMEKOGJM612		2/0/2/v/4			-	-
Vehicle automation systems	BMEKOGGM659		2/0/2/v/4			-	-
Vehicle system dynamics and control	BMEKOVRM636		3/2/1/v/8			-	-

Curriculum of MSc in Vehicle Engineering (Contd.)

Subject		Lecture / Practice / Laboratory / Exam type / Credit				Prerequisites	
Name	Code	1	2	3	4	Com-pulsory	Recom-mended
Accident analysis II., simulation methods	BMEKOGGM655			2/0/2/v/5		GGM654	-
Analysis of Aircraft II.	BMEKOVRM632			3/0/2/v/7		-	-
Computer aided manufacturing	BMEKOGGM618			2/0/2/v/4		JSM605	-
Construction machinery design - project	BMEKOALM674			2/2/0/v/5		-	-
Construction mechanization project planning methods	BMEKOALM673			1/2/1/v/5		-	-
Construction of vehicle manufacturing systems II.	BMEKOGGM651			2/0/2/v/5		-	-
Design and testing of railway vehicle systems	BMEKOVRM607			4/0/2/v/10		-	-
Design methods of material handling systems	BMEKOALM642			1/2/1/v/5		-	-
Design of material handling machines - project	BMEKOALM643			2/2/0/v/5		-	-
Design of Vehicle Automation Systems	BMEKOKAM661			2/0/4/v/7		KAM658	-
Engine design II.	BMEKOGGM671			2/0/2/v/5		GGM670	-
Measurement systems in vehicle manufactur-ing	BMEKOGGM652			2/0/2/v/5		-	-
Mechatronic design of vehicle systems	BMEKOGGM622			2/0/2/v/5		-	-
Production process quality assurance in the vehicle industry	BMEKOGGM611			2/0/0/f/2		-	-
Project	BMEKOVRM633			0/1/2/f/3		-	-
Project work	BMEKOVRM628			0/1/1/f/2		-	-
Projectmanagement in automotive industry	BMEKOKKM617			2/0/0/f/2		-	-
Reliability, Safety and Security in the Vehicle Industry	BMEKOKAM660			2/0/0/v/3		-	-
Research and devlopment process in the vehicle industry	BMEKOGGM614			2/0/0/f/2		-	-
Ship hydrodynamics	BMEKOVRM626			1/1/1/v/4		-	-
Ship strength	BMEKOVRM621			1/1/1/v/4		-	-
Superstructure control technics	BMEKOJSM666			2/0/2/v/5		-	-
Vehicle evaluation, traffic environment	BMEKOGJM640			2/0/2/v/5		-	-
Vehicle simulation and optimisation	BMEKOVRM638			2/2/0/v/5		-	-
Vehicle superstructure design	BMEKOJSM667			2/0/2/v/5		JSM664	-
Vehicle system informatics	BMEKOVJM437			2/0/2/v/5		-	-
Thesis work					0/30/0/f/30	-	-

Curriculum of MSc in Transportation Engineering

Subject		Lecture / Practice / Laboratory / Exam type / Credit				Prerequisites	
Name	Code	1	2	3	4	Compulsory	Recommended
Control theory	BMEKOKAM142	2/1/0/v/3				-	-
Decision making methods	BMEKOKKM221	3/1/0/f/5				-	-
Intelligent transport systems	BMEKOKUM205	2/0/2/v/5				-	KUM203
Mathematics MK	BMETE90MX59	2/2/0/f/4				-	-
Road Safety	BMEKOKKM222	2/1/0/f/3				-	-
Transport automation	BMEKOKAM202	2/1/0/v/4				-	-
Transport Economics	BMEKOKGM201	2/1/0/v/4				-	-
Air Traffic Management (ATM)	BMEKOVRM224		1/0/1/f/3			-	-
Communications, Navigation and Surveillance (CNS) I.	BMEKOKAM226		2/1/0/f/3			-	-
Controlling systems in transportation	BMEKOKGM215		4/0/0/v/6			KGM201	KGM201
Electronics – electronic measurement systems	BMEKOKAM103		2/1/0/f/4			-	-
Forwarding Management 1	BMEKOKKM132		2/2/0/v/5			-	-
I+C technologies	BMEKOKAM104		2/1/0/f/3			-	-
Information connection of the vehicle and the track	BMEKOKAM232		2/0/0/f/3			-	-
"Material handling and warehousing processes "	BMEKOALM225		2/1/0/f/4			-	-
Meteorology	BMEKOVRM231		2/0/0/v/3			-	-
Modelling and control of vehicles and traffic systems	BMEKOKAM233		2/3/0/v/6			-	-
Numerical methods	BMEKOVRM121		2/0/1/f/4			-	-
Smart City	BMEKOKKM227		2/0/0/f/3			-	-
Transport informatics	BMEKOKKM223		2/0/2/v/5			-	-
Transport Infrastructure Management	BMEKOKKM228		2/0/0/f/3			-	KGM201
Transport modelling	BMEKOKKM229		1/0/3/v/6			-	-
Transport operation	BMEKOKUM206		2/2/0/v/5			-	KUM203, KAM202
Air Traffic Control	BMEKOVRM235			2/0/1/v/4		-	-
Case study	BMEKOVRM237			0/2/0/f/3		-	-
City logistics	BMEKOALM244			2/2/0/v/5		KKM227	-
Communications, Navigation and Surveillance (CNS) II.	BMEKOKKM239			3/0/0/v/4		-	-
Engineering of transport automation systems	BMEKOKAM234			2/0/3/v/6		KAM233	-
Environmental effects of transport	BMEKOKKM230			2/1/0/f/4		-	-
Financing techniques in transportation	BMEKOKKM236			1/0/3/v/5		KGM201	-
Forwarding Management 2	BMEKOKKM133			3/1/1/v/5		KKM132	-
Forwarding marketing	BMEKOKKM135			1/0/2/f/4		-	-
Human resource management in transportation	BMEKOKKM238			1/0/2/f/3		KGM201	-
Management of transport and logistic services	BMEKOKGM217			2/2/0/v/6		KGM201	-
Passanger transportation	BMEKOKUM208			2/0/2/v/5		-	KUM204
Project	BMEKOKAM242			0/2/0/f/3		KAM233	-
Projectmanagement in transportation	BMEKOKKM241			2/0/0/f/2		-	-
Safety in air traffic control	BMEKOKAM243			2/0/0/f/3		-	-
Signal processing in transport	BMEKOKAM211			2/2/0/v/5		KAM104	-
Supply and distribution processes	BMEKOALM240			1/1/0/f/2		-	-
Trade, Financial, Accounting Techniques	BMEKOKKM138			1/1/1/v/3		-	-
Traffic flow	BMEKOKUM204			2/1/0/v/4		-	-
Thesis work					0/30/0/f/30	-	-

Curriculum of MSc in Logistics Engineering

Subject		Lecture / Practice / Laboratory / Exam type / Credit				Prerequisites	
Name	Code	1	2	3	4	Compul-sory	Recom-mended
Control theory	BMEKOKAM122	2/1/1/v/5				-	-
Lean management	BMEKOALM322	2/1/0/f/4				-	-
Logistics controlling	BMEKOKKM330	2/0/0/f/3				-	-
Logistics information system planning	BMEKOALM321	2/0/2/f/5				-	-
Mathematics ML	BMETE90MX60	2/2/0/v/5				-	-
Planning of extra-logistics networks	BMEKOALM337	2/1/0/v/4				-	-
Algorithm Design	BMEKOKAM326		2/0/2/f/5			-	-
Automation of logistics systems	BMEKOALM325		2/0/2/v/5			-	-
Demand planning and inventory management	BMEKOALM328		2/1/1/v/5			-	-
Enterprise logistics project 1.	BMEKOALM339		0/4/0/f/4			-	-
Forwarding Management 1	BMEKOKKM132		2/2/0/v/5			-	-
Forwarding project 1.	BMEKOKKM338		0/4/0/f/4			-	-
Logistics planning softwares	BMEKOALM336		0/0/2/f/3			-	-
Numerical optimization	BMEKOVRM334		3/0/1/v/5			-	-
Process planning	BMEKOALM331		2/1/0/v/3			-	-
Simulations planning	BMEKOALM335		1/1/1/f/3			-	-
Technical logistics project 1.	BMEKOALM333		0/4/0/f/4			-	-
Construction of logistics machinery	BMEKOALM324			2/1/0/v/3		-	-
Control of transport logistics	BMEKOALM341			2/0/1/v/3		-	-
Enterprise logistics project 2.	BMEKOALM343			0/7/0/f/7		ALM339	-
Forwarding Management 2	BMEKOKKM133			3/1/1/v/5		KKM132	-
Forwarding marketing	BMEKOKKM135			1/0/2/f/4		-	-
Forwarding project 2.	BMEKOKKM342			0/2/0/f/2		KKM338	-
Integrated material flow systems	BMEKOALM332			2/1/0/v/4		-	-
Planning of plant logistics systems	BMEKOALM327			2/2/0/v/5		ALM331	ALM335
Planning of warehousing systems	BMEKOALM323			2/2/0/v/5		ALM331	ALM335
Production planning & scheduling	BMEKOALM329			2/0/1/v/4		ALM328	-
Technical logistics project 2.	BMEKOALM340			0/7/0/f/7		ALM333	-
Trade, Financial, Accounting Techniques	BMEKOKKM138			1/1/1/v/3		-	-
Thesis work					0/30/0/f/30	-	-

Description of M.Sc. Subjects
Master Section in Autonomous Vehicle Control Engineering

Control theory and system dynamics

BMEKOKAM701

Dr. József Bokor

The course aims the study of the analytical and control design methods of electromechanical systems. First, the modeling paradigms and state space representations are outlined. After this, system analysis is presented, such as controllability, observability and stability, Through the control design problem, the course examines the different qualitative properties, and the consideration techniques of system uncertainties and disturbances. From the classical methods, the pole allocation and the quadratic linear control is presented. The course focuses on the interpretation of the observer design and the separation principle.

Automotive environment sensors

BMEKOKAM708

Dr. Tamás Bécsi

The course aims the studying of the technologies developed for the tasks of environment sensing of an automated vehicle, the currently available technologies and the corresponding signal processing techniques. First, the course introduces the inner sensors of the vehicles, such as position, velocity, translation or rotation, basics of their physical operation and their limitations. After this, the main principles of environment sensing, such as ultrasonic, radar, lidar and machine vision systems are introduced through application examples. To strengthen the robustness of the collected data, several typical sensor fusion techniques are also studied.

Automotive vehicle systems

BMEKOGGM712

Dr. Bálint Szabó

The target of the subject is to present the vehicle systems and structures. Within the framework of the subject the vehicle engines, transmissions, suspension systems, brake systems and frame structures are teached. In the Autonomous Vehicle Control Enginees MSc tematics, the target of the subject is to caught up the students, who do not have vehicle engineer BSc. By the end of the subject the students are able to recognise the important parts and systems of road vehicles, they know their function and operatation.

Vehicle testing and validation

BMEKOGGM406

Dr. Bálint Szabó

Introduction into the modern instrumental vehicle measurements. Acquirement of the usage of instruments, testing methods, and application of vehicle testing processes. In the Autonomous Vehicle Control Enginees MSc tematics, the target of the subject is to present to the students the testing procedures and possibilities of vehicle and software testing. By the subject the students are able to coordinate tests in simulation, laboratory and open road environment.
Introduction of the basic measurement methods and instruments. Demonstration of different vehicle testing instruments. The subject goes through on the testing methods and tools different vehicle subsystem. Engine and driveline testing on modern engine test rigs demonstrates the dynamics, efficiency and emission of the powertrain. Brake system testing will be performed on both test benches and on a test track using a real vehicle according to the ECE directives. Suspension testing introduces both the passanger car suspension measurement methods, and the air spring system testing for heavy duty vehicles. Steering system testing is demontrated as well. This course also shows different levels of testing: like laboratory tests on a subsystem of a vehicle, laboratory tests in simulation environment (HIL), laboratory tests on a real vehicle, and testing on test track. In addition the testing as a part of the V-model based development is also explained during this course.

High Performance Microcontrollers and Interfaces

BMEVIAUMA07

Dr. Gábor Tevesz

Insight is given of the computer system architectures, high performance microcontroller architectures and their building blocks. Convectional architectures are analyzed then special architectures (ARM, DSP, network and graphic processors, GPGPU) are dealt with and compared with the SoC devices with soft and hard processors. Methods increasing the performance, security and reliability, decreasing power consumption are treated. Mechanical, electrical and logical aspects of bus systems connecting parts of control systems are treated in detail. Diagnostic methods of WEB, mobile, etc. based control systems are also introduced.

Numerical methods

BMEKOVRM121

Dr. József Rohács

System modeling. General model, assumptions, errors. Solving the non-linear equation, Newton iteration. Polynomial equations, Horner, Newton methods. Systems of linear equations: Gauss elimination, Matrices, enginvalues. Linear programming. Simplex Method. non-.linear optimization, gradient method. Interpolation. Newton's, Lagrange Hermite methods, spline. Approximation: Chebyshev, Padé. Fast Fourier transformation. Numerical differentiation, integration. Solving the differential equations. Euler, Runge-Kutta, predictor-corrector methods. Systems of partial differential equations. finite differences, finite volumes methods. Stochastic modeling.

Programming in C and Matlab

BMEKOKAM603

Dr. Tamás Bécsi

The subject aims the learning of the C and Matlab programming languages and environments. These tools aim the students in the implementation tasks required by other courses.
The goal on one hand is the introduction of the syntax of the two languages: Types, variables, data structures. Flow control, if-then, loops, functions, complex types and data structures. On the other hand, through the learning of syntax, the design and application of basic algorithm design paradigms is also studied.

Computer Vision Systems

BMEVIIIMA07

Dr. László Vajta

Along with the development of computer technologies, automatic evaluation of visual content became a daily practice on areas of quality control, process control, navigation, security systems, medical diagnostics, and many more.

The aim of the course is to provide an introduction of the principles and applications of advanced computer image processing and visualisation, covering virtual technologies which are playing a key role in the management of supervised autonomous industrial processes.

Automated driving systems

BMEKOGGM707

Dr. Zsolt Szalay

The goal is to present driver assistant systems and automated driving functions. The levels of automation according to SAE. Brief overview about vehicle dynamics. Driver assistance system overview on the stabilization level. Typical DAS systems, like AEBS, LDW, LKA available at present vehicles. Outlook on future advanced driver assistance systems at higher automation levels.

Topics included: SAE automation levels, Basic vehilce dynamic model, lateral and longitudinal, ABS, ASR, ESP, Automated emergency braking, Lane departure warning, Lane keep assist, Lane change assist, Turning assist, Tempomat, adaptive cruise control, Park assist, Traffic jam assist, Highway Assist Pilot, Platooning.

Autonomous Robots and Vehicles

BMEVIIIMA12

Dr. Bálint Kiss

The course presents the theoretical and practical fundamentals of the modeling, control and realization of robotic and autonomous systems. The construction and programming of robotic devices are studied together with the principles of mechanical modeling and navigation of mobile platforms. Advanced methods for path planning and control are explained in details including the real-time aspects of their realization. Special emphasis is put on the principles of cooperation of legged and wheeled autonomous robots and UAVs.

Embedded Opertating Systems and Client Applications

BMEVIAUAC07

Dr. Gábor Tevesz

Basic concepts of embedded operating systems. The objective of the course is to present platforms, techniques and tools which are required to create and run both application and system level software for embedded systems. After creating the hardware unit and embedded programs for it, the next natural step is the implementation of a desktop or web application that enables monitoring and parameterizing the hardware unit from a standard PC. Mobile applications are becoming more widely used as well. The course presents the programming of desktop and web based client applications, focusing on user interfaces, graphics drawing tools, multithreaded and network programming. Most modern development platforms follow object-oriented concepts. Consequently, the course provides introduction to object-oriented design, basic UML and a few architectural and design patterns.

Students will be able to develop desktop and thin client applications to access hardware units from PCs, and to create user friendly user interfaces for different client types. Network programming also gets an important role. The topics covered are illustrated by case studies and demo applications.

Vehicle operation

BMEKOGGM174

Dr. Tamás Szirányi

Time frame, maintenance, energy-, material and information technological environment of the vehicle operation. Characteristic uncertainties in the vehicle operation and vehicle dimensioning. Basics of probability analysis. Practical methods of reliability analysis: block -diagram method and fault-tree analysis. Random faults and defects in vehicle operation. Methods of determining reliabilty and availability. Availability definitions. Renewal processes. Modelling of operation processes by semi-Markovian approach. Application of the theory of mass service systems. Queueing problem. Optimum storing processes. Elements of material damages, leading to component failures. General approach to system diagnosis. Vehicle diagnosis based on dynamical simulation for ensureing the criteria presribed by transportation safety rules. Identification of the weak-spots using diagnostic tests.

Localization and mapping

BMEEOFTMKO1

Dr. Árpád Barsi

Goal of the subject is to present the basics of positioning and localization, the map making procedure, the requirements against the maps, as well as the use of maps. During the semester the surveying methods, the basics of geoinformatics (GIS) and the modern map making is demonstrated. The students get knowledge about positioning and its accuracy measures by own conducted measurements. The latest map standards, the newest research results and the future trends are also presented.

Vehicle dynamics

BMEKOGGM705

Dr. Zsolt Szalay

Analysis of dynamical models apt for examining the main motion of vehicles and vehicle-strings, as well as traffic flows. The non-linear dynamic model of the force transfer in rolling contact with regard to stochasticity coming from tribological properties. Motion equations of lumped parameter models capable for vibrations describing vehicle system. The forces and motion excitation, as well as parametric excitations. The stochastic ordinary differential equation system of the discrete dynamical system. Constraction of motion equation systems of distributed parameter vehicle systems. The stochastic partial differential equation system of the distributed parameter dynamical system. The vehicle dynamical systems as a controlled or regulated section. Formulation of some typical vehicle dynamical task for control, with operation-technical explanation of the control signals. The vehicle control problem formulated by model based methods. Methods apt for designing vehicle control. Failure detecting in the vehicle control system. Design of vehicle control of reconfigurating and fault-toleranting character. Design of integrated control and inspection control. Case studies concerning controlled vehicle dynamical systems.

Vehicle mechanics fundamentals

BMEKOGGM713

Dr. Bálint Szabó

Introduction into the basics of vehicle dynamics. Description of motion equation of vehicles. Longitudinal, lateral and vertical dynamics of road vehicles. In the Autonomous Vehicle Control Enginees MSc tematics, the target of the subject is to caught up the students, who do not have ve-

hicle engineer BSc. By the subject the students are able to analyse and modelling the dynamics of a vehicle.
The course starts with the basic definitions of vehicle dynamics, coordinate systems, simple vehicle motions. Starting with tyre dynamics the longitudinal and lateral slip conditions will be presented. The vehicle dynamics are separated to longitudnial, lateral and vertical behaviour. The longitudinal motion consists the acceleration performance and the brake dynamics. In lateral direction the low speed turning, the steady state cornering. As the vertical motion of the vehicle the ride behaviour is demonstrated as well. Motion equation are set up to describe the vehicle behaviour under different circumstances. Vehicle stability aspects.

Artificial Intelligence

BMEVIMIAC10

Dr. Béla József Pataki
The aim of the subject is a short, yet substantial presentation of the field of artificial intelligence. The principal presented topics are: expressing intelligent behavior with computational models; analysis and application of the formal and heuristic methods of artificial intelligence; methods and problems of practical implementations.

Design and Integration of Embedded Systems

BMEVIMIMA11

Dr. István Majzik
This subject first presents the following topics: development life cycle models (e.g., V-model, iterative models), quality assurance, project planning, requirements traceability, version control and configuration control methods. Among system development methods, the subject presents the hardware-software co-design and component integration techniques. The subject also covers the specific design methods for safety-critical embedded systems in which the malfunctions may lead to hazards, or in case of given environmental conditions even to accidents or damages. The students will be familiar with the architectural concepts (that are often referred in related standards), the techniques of safety and dependability analysis (that are needed to assess the design decisions), as well as the techniques of systematic verification.

Software Development Methods and Paradigms

BMEVIAUMA00

Dr. László Lengyel
The goal of this course is to teach the software development methodologies, their application possibilities and conditions, practices and tools required and preferred for the design and development of methods. Students become practiced in treating issues of common software architectures and software systems, furthermore, they will have a good knowledge related to software development methods.
The course discusses the software development methodologies, the methods and techniques supporting methodologies and development processes, furthermore, practices, architectural requirements and solutions related to software systems.

Signal Processing Fundamentals

BMEVIHIM009

Dr. János Levendovszky
The course is concerned with laying down the foundations of signal processing with special emphasis of the representation of signals in different domains. The adaptive part help the students solve adaptive identification and equalization tasks. In this way, after successfully completing the course the students are capable of solving various signal processing tasks arising in different applications.

Automotive network and communication systems

BMEKOGGM709

Dr. Zsolt Szalay
The goal is to present the communication systems of vehicles with advanced driver assitance systems. ECU level communications, communication types between ECU-s like CAN, LIN, MOST, FlexRay, Ethernet. Communication between vehicles, V2x. ADAS related localization and mapping systems and their communication protocolls. Cyber security aspects. Electromagnetic compatibility. Diagnosis and testing and validation of communication systems.

Automated vehicle design project

BMEKOKAM710

Dr. Péter Gáspár
The aim of the course is to apply the knowledge gained by the previous courses through the elaboration of an individual or group project. The students choose from an well described problem group of the automated vehicles, and after studying the problem, they design a solution for it. The elaboration of the task goes through the stages of specification, state of the art study, algorithm design, implementation, documentation and end-semester presentation. The classes of the projects aim the elaboration of the project, the supervision of the progress, and consultation.

Safety and reliability in vehicle industry

BMEKOKAM703

The aim of the course is to provide the students with theoretical and practical knowledge about the approach and methods for designing reliable, safe and secure vehicle systems. The task is to review the safety and reliability analysis methods used in the vehicle industry and to describe the safety standards for the automotive industry. The curriculum includes the introduction of the concepts of risk and risk analysis, basic concepts of safety and reliability, as well as an overview of reliability modeling techniques used in the vehicle industry, as well as a set of best practices for reliability and safety analysis. During the processing of the subject we pay attention to ISO 26262 for vehicle safety.

MSc Diploma Thesis I.

BMEKOKAM553/BMEKOGGM553

Dr. Péter Gáspár / Dr. Zsolt Szalay

Traffic modelling, simulation and control

BMEKOKAM704

Dr. István Varga
This subject gives an introduction to road traffic automation and control. Students become familiar with the basic notions and theories, and get acquainted with the hardware architectures of road traffic control systems. Traffic detection technologies, signal automation, road traffic controllers, as well as traffic control centers and monitoring systems are introduced. An introduction to the traffic control theories is also provided. The students practice the basics of the traffic modeling through Matlab/Simulink and SUMO traffic simulator.

Project Management

BMEGT20M420

Dr. Zoltán Sebestyén

The subject introduces students with the terminology, basic tools and techniques related to project management. The curriculum briefly summarizes the basic knowledge needed to manage a project, in a structured way, to the extent of the subject.

Automotive R&D processes and quality systems

BMEKOGGM711

Dr. Zsolt Szalay

The aim of the course is to get students acquainted with the processes in the automotive industry, the research and development, and the relevant regulations. Students will gain insight into the standards and process models required by the automotive industry related to development processes. Within the subject, students can get acquainted with the flow elements, their structure and their relationships. In addition, within the framework of the subject, students can get acquainted with the quality management methods that support the development.

Legal Framework of Autonomous Vehicles

BMEGT55M420

Dr. Anikó Grad-Gyenge

The objective of the course is to introduce the students into the legal environment of the autonomous vehicles, including especially the basic principles and guidelines and the present and possible future framework of these laws. Autonomous vehicles in the recent legal environment, esp. a) public law and private law questions. Autonomous vehicles in the private and public laws, legal frameworks of administrative laws, registrations, torts and product liability, warranty, software-law issues, risk-management, contract-management, insurance issues, b) Data protection (privacy) and data safety issues c) relevant criminal law issues. Autonomous vehicles in the recent legal environment. Criminal issues, and criminal liability; Autonomous vehicles in the Future. a) Types and definitions of autonomous and automated cars. Minimum requirements, technical compliance standards. b) Future use of autonomous cars and its possible effects on law - use in controlled environments, ride services, etc. c) Human - machine interface and its legal problems; new requirements - e.g. driving licence standards for the human “”element”” of the system.

MSc Diploma Thesis II.

BMEKOKAM554/BMEKOGGM554

Dr. Péter Gáspár / Dr. Zsolt Szalay

Human Factors in Traffic Environment

BMETE47M000

Kornél Németh

The purpose of the subject is to present the human factors involved in transport. The following topics are of the utmost importance: Overview of human risk factors, basic concepts of transport, presentation of the test methodology of vehicle driving behavior and description of its models.

Overview of human visibility, visual attention and search processes, in particular the overhead resulting from parallel processing. Human-specific aspects of spatial navigation.

Machine vision

BMEKOALM702

Dr. Tamás Szirányi

Machine vision is the one of the most important measure of intelligent road transport. It allows you to track the movement of complex movement and complex traffic participants, continuously analyze situations and locations. The processing and semantic evaluation of the video stream extracted through the camera gives basic information to the autonomous leadership. The subject is about capturing, analyzing and interpreting visual information: extracting high-level image descriptors from lower-level visual characteristics.

Description of M.Sc. Subjects
Master Section in Vehicle Engineering

Advanced Driver Assistance Systems

BMEKOGGM657

Dr. Zsolt Szalay
(4 credits)

Advanced Flight Theory

BMEKORHM620

Dr. József Rohács
Basic summary of aerodynamics, flight performance, stability, flight dynamics and control. Modeling the aerodynamic coefficients and derivatives, non-steady aerodynamics. Non-linear and statistical flight dynamics and control. Critical flight regimes. New control methods. Use of biological principles. Aircraft active, endogenous subjective control. Less-skilled pilots and safety philosophy of the small and personal aircraft. Use of MEMS (micro-electro-mechanical systems) in flow and flight control. Rendezvous control. Hypersonic flights. (4 credits)

Advanced materials and technologies

BMEKOGGM601

Dr. Krisztián Bán

(5 credits)

Aircraft design and production I.

BMEKOVRM629

Dr. Dániel Rohács
Aircraft development philosophies.: the role of aviation in economy, major problems of aviation and aeronautical industry, goodness factors and their changes during development processes, general development process, technology transfer, development and design methods, control of the development processes.
Computer aided design processes. Specific aspects of using the CATIA. Surface modeling.
Development and design of the aircraft gas turbines. and their parts. (4 credits)

Computer aided design

BMEKOJSM605

Dr. László Lovas
Advanced computer aided design (CAD) methods. Kinematic and kinectic analysis. Surface modelling. Modelling and measuring of stochastic loads. Numerical lifetime expecation using probalistic methods. Load collective. Fatigue of parts. Linear elasctic fracture theory, remaining lifetime. (4 credits)
Control theory

BMEKOKAM142

Dr. József Bokor
The course provides deepening of knowledge in control theory. Provides theoretical knowledge, and discusses modern tools, which are necessery in later eingineering practice. This is introduced through different examples, taken from vehicle and transportation systems. (3 credits)

Environment Sensing in the Vehicle Industry

BMEKOKAM656

Dr. Tamás Bécsi
The course aims the introduction of the main sensor technologies of the vehicle industry. Amng these, Ultrasonic, radar, Lidar, and camera based methods are discussed. (4 credits)

Instrumental tests for motor vehicles, measurement technology

BMEKOGGM668

Dr. Bálint Szabó
Based on the requirements of the current vehicle engineer education this subject gives a deep knowledge on methods of vehicle tests and measurement systems. Methods and tools of vehicle dynamical tests are introduced. It focuses on the dynamical measrements of the vehicle subsystems like brake system, steering system and the suspension. According to the present requirements of vehicle developments the demonstration of the testbench based HIL tests are part of the education. Besides the vehicle dynamical measrements, it is essential to get familiar with the fuel consumption measurements and with the emission tests performed on roller test bench. To intoduce the modern engine testing methods, engine test bench mearements will be carried out during the course. Alongside the development related test, the latest diagnostic measurement methods will be introduced as well. (4 credits)

Machine Intelligence

BMEKOALM644

Dr. Tamás Szirányi
This subject teaches the students basics of machine intelligence in order to understand and be capable to apply them. (4 credits)

Measurement techniques and signal processing in vehicles

BMEKOKAM635

Dr. Alexandros Soumelidis
Provides knowledge about the instrumental measurment and evaluation of the vehicle paramaters. Furthermore introducing sensing and measurement principles, signal processing, traffic measurment. Theory of sensorfusion, sensor networks of the vehicle dynamics measurment. State estimation, parameter estimation, Kalman-filter. Applications in vehcile control systems. (8 credits)

Mechanics of superstructure materials

BMEKOJSM663

Dr. Péter Béda
Modeling of materials. Role of the constitutive equation, principles of its building. Types of material laws, typical behavior issue from experiments. Presentation and study of elastic and plastic bodies. Rheological models. Application examples. (4 credits)

Numerical methods

BMEKOVRM121

Dr. Rohács József
Introduction. System modeling. General model, assumptions, errors. Solving the non-linear equation, Newton iteration. Polynomial equations, Horner, Newton methods. Systems of linear equations: Gauss elimination, Matrices, enginvalues. Linear programming. Simplex Method. non-. linear optimization, gradient method. Interpolation. New-

ton's, Lagrange Hermite methods, spline. Approximation: Chebyshev, Padé. Fast Fourier transformation. Numerical differentiation, integration. Solving the differential equations. Euler, Runge-Kutta, predictor-corrector methods. Systems of partial differential equations. finite differences, finite volumes methods. Stochastic modeling. (4 credits)

Operation of railway vehicles

BMEKOVJM409

Dr. József Csiba

Service processes for railway vehicles. Vehicle input, the actual service timing and vehicle output as componenets of a random service process. Inventory problems in the operation of railway vehicles, the theory of minimum cost-storing and purchase. Statistical theory of the operating system of railway vehicles based on the technical state. Analysis of the operation reliability of railway vehicles, reliability-based operation/maintenance (RCM system). Railway vehicle diagnostics, vehicle diagnostics and stationary equipments, stations. Systems for identifying of vehicles and their operational modes. Operational properties of braked trains, braking-difficulties, dynamical- and thermal processes. (3 credits)

Practice in technology of manufacturing and materials in vehicle industry

BMEKOGGM648

Dr. Krisztián Bán

(4 credits)

Programming in C and Matlab

BMEKOKAM603

Dr. Tamás Bécsi

The course aims the introduction to programming in C and Matlab languages. (4 credits)

Railway vehicle system dynamics

BMEKOVRM608

Dr. Zoltán Zábori

The railway vehicle as a dynamical system. Main motion and parasitic motions. Railway vehicle vibration analysis. The spring and damper elements. The wheel-rail rolling contact. Eigen-frequencies and stability reserves, limit cycles and chaotic motions. The non-linear models. The wheel-rail wear process. The track-vehicle system dynamics. Definition and measurement of track irregularities. Spectral characteristics of the track irregularities. Parameter sensitivity of the track-vehicle system. Parameter optimization. Measurement procedures for examining the vehicle-track system processes. (5 credits)

Requirements for superstructure designers

BMEKOJSM662

Dr. Péter Béda

Manufacturer's requests for vehicle superstructure designers. Manufacturer's rules for superstructures and assembling. National and international laws. Preparation for manufacturing. (4 credits)

Road safety, legislative environment, human factors

BMEKOGGM653

Dr. Gábor Melegh

Legal studies: an extract from the constitutional law, substantive and procedural civil law, criminal law, criminal procedural law, driving offences, issues of damages claims. Human factors in road traffic: personality characteristics, behaviours, human health protection, generational problems, effects of weather and seasons, special related questions of vegetation and fauna, damages caused by wild animals.
Personal injuries: the human body, physiological particularities, classification of injuries, examination of accidents in the light of injuries, examination of blood alcohol concentration, examples of medical investigation of accidents. (4 credits)

Ship design

BMEKOVRM615

Dr. Győző Simongáti

The course aims at introduction of the process of ship design, the design spiral, determination of main particulars, lines planning, optimisation techniques, conceptual design, preliminary design methods, tonnage calculation, etc. (5 credits)

Simulation of technical systems

BMEKOALM645

Dr. Gábor Bohács

The subject intruduces to the students software background which can be used as a virtual reality to support engineering decisions. (4 credits)

Surface Engineering

BMEKOGGM647

Dr. Tamás Markovits

Interpretation of surface properties and function. Tribology. Surface preparation and modification technologies. Creation of thin surface layers (CVD, PVD, ion implantation). Plasma processes, laser technology (laser sources, laser material interaction, laser cutting, welding, drilling, surface treatment, rapid prototyping). (4 credits)

Suspension design

BMEKOGJM613

Dr. Bálint Szabó

Analysis of forces acting on wheel using modern tyre-models, knowing objective functions of static and dynamic geometrical parameters of tyres, necessary for design. Geometrical design of tyre suspension, structural design of each parts of suspension (rods, arms, ball joints, rubber mountings). Vibration analysis of vehicle, geometrical and structural design of elements of suspension (coils, springs, shock absorbers, stabilizers, motion boundary elements) in regard to requirement systems of suspensions. Dynamical analysis of braking vehicle in order to determine design requirements; methods for proportioning brake force between axles; design of conceptual schema of brake system; geometrical, structural, thermo- and fluid dynamical design of each parts. Determination of initial data needed to design the steering system using dynamical analysis of steering; design of steering mechanism; geometrical and structural design of elements of steering systems (tie rod, track rod, steering-gear, steering wheel and axle, ball joints). (4 credits)

Theory of Ships III.

BMEKOVRM616

Dr. Győző Simongáti

The aim of the course is to introduce the special cases of stability to the students. Topics are: deterministic and probabilistic damaged stability methods, grounding, docking, stability of floating cranes, split barges. (3 credits)

Vehicle operation, reliability and diagnostics

BMEKOVRM602

Dr. József Csiba
Time frame, maintenance, energy-, material and information technological environment of the vehicle operation. Characteristic uncertainties in the vehicle operation and vehicle dimensioning. Basics of probability analysis. Practical methods of reliability analysis: block -diagram method and fault-tree analysis. Random faults and defects in vehicle operation. Methods of determining reliabilty and availability. Availability definitions. Renewal processes. Modelling of operation processes by semi-Markovian approach. Application of the theory of mass service systems. Queueing problem. Optimum storing processes. Elements of material damages, leading to component failures. General approach to system diagnosis. Vehicle diagnosis based on dynamical simulation for ensureing the criteria presribed by transportation safety rules. Identification of the weak-spots using diagnostic tests. (2 credits)

Accident analysis I., forensic processes

BMEKOGGM654

Dr. Gábor Melegh
Technical causes of road traffic accidents, malfunctions of vehicles and engines: the most occurring malfunctions of vehicles and its engines, causing great damages. Identifying the root causes of accident from incurred damages. ascertainment of the technical responsibility, conclusions, options of accident avoidances. Role of vehicles, explanation of technical malfunctions,
analysis of road traffic accidents occurred for technical reasons, contribution of subjective causes.
Evaluation of accident forms: Main forms of accident and conclusions deductible from conditions after accident. Accidents attendant on hitting pedestrians, fundamental calculation methods, evaluation of hitting pedestrian overstepping form covering,
accidents occurred in reduced visibility, experimental reconstruction of traffic accidents.
Vehicle collision: substantial formulas of crashes, crash-calculation by analytical and graphical methods; deformations of vehicles and pictures of damages, energy grid. (4 credits)

Aircraft analysis I.

BMEKOVRM631

Dr. Károly Beneda
The aim of the course is to introduce the analysis techniques of aircraft and powerplants. (4 credits)

Aircraft design and production II.

BMEKOVRM630

Dr. Balázs Gáti
Aircraft Design II. (4 credits)

Computational fluid- and thermodynamics

BMEKOVRM606

Dr. Árpád Veress
The goal of the present subject is to prepare students for the state of the art application of CFD calculation methods in the vehicle engineering with including thermodynamics and heat transfer. (4 credits)

Construction of vehicle manufacturing systems I.

BMEKOGGM649

Dr. Tamás Markovits
(4 credits)

Design methods of drive systems

BMEKOALM646

Dr. Gábor Bohács
This subject aims to introduce the construction and materials handling machines' specific drive systems, construction and examination methodology. (3 credits)

Design of material handling machine design

BMEKOKAM627

Dr. Gábor Bohács
Design and norming of material handling machines. Capacity and power requirement calculation for machines of bulk materials. Design of material handling machines for unit loads, especially forklifts and cranes. (5 credits)

Design of pleasure craft

BMEKOVRM625

Dr. Győző Simongáti
The course aims at introduction of the specialities pleasure craft design. (4 credits)

Diesel and electric traction

BMEKOVRM610

Dr. András Szabó
Design properties of railway Diesel engines, dynamical processes of injection and control systems. Turbocharging systems of railway diesel engines. Design properties of Diesel-hydraulic and Diesel-electric powertrain system design, machine-group optimization, transient operation processes. Drive dinamics of electric traction units, electromechanical, controlled systems. Analysis of the work done and energy-consumption, hydraulic/electro-dynamic braking of trains of Diesel and electric traction units, and their optimization. (5 credits)

Discrete Control Design

BMEKOKAM658

Dr. Péter Gáspár
The course aims the presentation of discrete control theory. Besides the theoretical and mathematical design aspects, implementation issues are also discussed. (4 credits)

Dynamics of vehicle, active- and passive safety

BMEKOGJM641

Dr. Gábor Melegh
Analysis of the forces acting on the wheels, state of the art tyre-models, static and dynamic geometric characteristics of tyre from the point of view of traffic safety. Analysis of force and moment conditions of transmission systems, examination of dynamic parameters of mechanical and hydrodynamical torque converter.
Geometry of tyre suspension, load of each elements of suspension.Vibration theory of vehicle, parts of suspension. Dynamic analysis of vehicle braking; methods for proportioning brake force
between axles of vehicle; conceptual schema of different types of brake systems; geometrical-, mechanical-, heat-

and hydrodynamics loads of single part.
Dynamical analysis of steering, geometrical and mechanical design of parts os steering systems (tie rod, track rod, steering gear, steering wheel and axle, ball joints).
Rreview of software solutions applicable for making vehicle dynamic models; examination of longitudinal and transverse vehicle dynamics, methods for controlling vehicle dynamics. Dynamical examination and modelling of vehicle's roll over process.
Active and passive components of vehicle safety: control systems of vehicle dynamics, introducing systems which are suitable to mitigating consequences of accidents. Detailed review of sensors and actuators which are parts of these systems. Uses of data stored in these systems' ECUs for reconstruction
of an accident. (4 credits)

Electronics – electronic measurement systems

BMEKOKAM103

Dr. Géza Szabó
The subject gives basic knowledge of electronics and electronic measurements and their application in different areas of transportation. It summarizes the operational modes of basic components and basic circuits and describe how one can design and apply them. It gives an overview of electric and mechanical measurements and how the results of measurements can be processed
(4 credits)

Engine design I.

BMEKOGGM670

Dr. Huba Németh
Grouping of engine simulation methods. Wave action engine models and its equations. Flow filed, pressure drop and heat transfer in the intake and exhaust systems. Flow splits. Flow on intake and exhaust valves. Constructional and geometrical design of combustion chambers. Set up of bore-stroke ratio, valve diameters, and compression ration values. Modelling of combustion processes, and its main parameters. Wall heat transfer models. Mechanic losses and friction models. Determination of charger pressure and fuel rate for given performance targets. Set up of the charger and its cooperation with the engine. Reduced charger maps. Control of charging systems.
Mechanical and thermal loads of the reciprocating engine pistons. Geometric and construction design of pistons. Wrist pin design. Dimensioning methods. (4 credits)

Fixing and sealing

BMEKOGGM650

Dr. Krisztián Bán
(4 credits)

Machines of construction material production

BMEKOALM672

Dr. Gábor Bohács
Computer aided construction of crushing machines. Motion equations of vibrating sieves. Construction of concrete mixers. Reinforcing steel processing equipment sizing and system control features. (5 credits)

Mechatronics, microcomputers

BMEKOKAM604

Dr. Péter Gáspár
Introducing the modern computer systems and the operating principles of robots. Numeral systems CPU arithmetics, operations and algorithms with binary numbers. CPU architectures, tasks and operation. Computer networks: protocols, devices for wired and wireless communication. (4 credits)

Ship motions

BMEKOVRM624

Dr. Győző Simongáti
The course aims to introduce students to the dynamics and transient phenomena of ship motions, and to the dynamics of equipments which may effect on ship motions. (4 credits)

Structural vibrations

BMEKOJSM665

Dr. Péter Béda
The second order Lagrange equation equation for holonomic and scleronomic conservative systems. The existence of stable equilibrium. Small oscillations, frequencies approximate definition. Vibrations of rods, axes, strings and membranes. Basics of modal analysis. Methods for nonlinear oscillation problems. (4 credits)

Structure analysis

BMEKOJSM609

Dr. Péter Béda
Theory and practice of the finite element method. Linear, elastic and plastic material modeling. Mechanical and thermal analysis. Eigenfequencies and vibrations. Topological structure optimisation. Study and verification of the optmized model. (4 credits)

Superstructure preliminary design

BMEKOJSM664

Dr. László Lovas
Construction, special links. Connections among square tubes, sheet metal and elastic covers. Connection between vehicle frame and rigid superstructure with given function. (4 credits)

System technique and analysis

BMEKOVRM129

Dr. István Zobory
Vehicle and machine analysis using system theoretical approach. System characterisation by means of graphs. Hierarchy of system structures: emements, element-groups, machine, machine group. Characterisation of complex engineering systems by block-diagrams, structure graps and sigjnal-flow graphs. Desciption of the system connections. Construction of the input-output system equations by using the system operator. Application of Lagrangean and Hamiltonean procedure. The general theoryh of linear dynamic systems. Weighting function, transition function in the time domain. Convolution theorem. Complex frequency function in the frequency domain. Periodic, aperiodic and stationary stochastic excitations, widht SISO and MIMO systems. Determination of the system response. Analysis of the coherency conditions. (4 credits)

Traction mechanics

BMEKOVRM619

Dr. István Zobory

Factors of train motion. Tractive effort, braking force, track force. The tractive and braking forces applied in the control system influencing the torque conditions of the rotating components. Determining the train-weight that can be started, the construction Koreff-figure. Detreming the speed-timing diagrams by means of simulation using dynamical models. Taking into account the limit force that can be transferred through the rolling contact, without macroscopic sliding. The longitinal dynamics of trains. Dynamics of train-tearing. Dynamics of special train motions: shunting, marshalling, hump. Energy demand of train motion, simulation of energy consumption with Diesel- and electric traction. Outlook to the sphere of problems of energy optimum train control, basic principle for the application of traction and braking forces, the numerical layuot of the optimum train control. (3 credits)

Transmission system design

BMEKOGJM612

Dr. Huba Németh

Main parameters of vehicle mechanics. Construction of an arbitrary selected transmission component (clutch, gearbox or final drive), set-up of functional dimension based on vehicle dynamic calculations, geometrical construction of all components, structural dimensioning of gears, shafts and bearings for load and lifetime, construction and dimensioning of actuation mechanisms, design of housings and fixation points. (4 credits)

Vehicle automation systems

BMEKOGGM659

Dr. Zsolt Szalay

(4 credits)

Vehicle system dynamics and control

BMEKOVRM636

Dr. István Zobory

Analysis of dynamical models apt for examining the main motion of vehicles and vehicle-strings, as well as traffic flows. The non-linear dynamic model of the force transfer in rolling contact with regard to stochasticity coming from tribological properties. Motion equations of lumped parameter models capable for vibrations describing vehicle system. The forces and motion excitation, as well as parametric excitations. The stochastic ordinary differential equation system of the discrete dynamical system. Constraction of motion equation systems of distributed parameter vehicle systems. The stochastic partial differential equation system of the distributed parameter dynamical system. The vehicle dynamical systems as a controlled or regulated section. Formulation of some typical vehicle dynamical task for control, with operation-technical explanation of the control signals. The vehicle control problem formulated by model based methods. Methods apt for designing vehicle control. Failure detecting in the vehicle control system. Design of vehicle control of reconfigurating and fault-toleranting character. Design of integrated control and inspection control. Case studies concerning controlled vehicle dynamical systems. (8 credits)

Accident analysis II., simulation methods

BMEKOGGM655

Dr. Gábor Melegh

Description of crash-models used in software solutions for accident reconstruction. Examination and analysis of complete regular and irregular vehicle motion process with simulation methods.
Specifying the parameters which are necessary for simulation; confinement the circle of questions
answerable by available parameters and data in a concrete case. Interpretation of probabilistic ascertainments. Parameter sensitivity analysis of simulation results.
Evaluation, analysis and explanation of results provided by simulation software; plausibility of results. (5 credits)

Analysis of Aircraft II.

BMEKOVRM632

Dr. Balázs Gáti

(7 credits)

Computer aided manufacturing

BMEKOGGM618

Dr. Zoltán Pál

(4 credits)

Construction machinery design - project

BMEKOALM674

Dr. Gábor Bohács

Theory of mechanical construction of the building machines. Handling special load cases of the building industry’s tasks. Preparation of a complex task relating construction machines. (5 credits)

Construction mechanization project planning methods

BMEKOALM673

Dr. Gábor Bohács

Management of construction projects from mechanization aspects. Compilation of machine chains and systems. Capacity planning and scheduling. Determining operational parameters of earthwork machines and other construction machinery. (5 credits)

Construction of vehicle manufacturing systems II.

BMEKOGGM651

Dr. János Takács

(5 credits)

Design and testing of railway vehicle systems

BMEKOVRM607

Dr. András Szabó

Rail vehicle construction and design of mechanical equipment. Systemtechnical analysis of railway vehicles. Optimization of the components in the vehicle system. On board condition monitoring and data collection systems. Design of systems with prescribed reliability. Computer-assisted vehicle tests. Strainth analysis of railway vehicles by usind finite elemet methods. Dynamical simulation to predict the loading conditions of structural elements. Computer based measurement evaluation methods. Numerical methods for parameter optimization. Real-time simulation methods. Railway vehicle design project. (10 credits)

Design methods of material handling systems

BMEKOALM642

Dr. Gábor Bohács
Characteristics of structure and operation of material handling systems. Mechanical connections and communicational issues among the systems' components. Identification methods for bottlenecks. Planning operational strategy of material handling system. Safety in material handling systems. (5 credits)

Design of material handling machines - project

BMEKOALM643

Dr. Gábor Bohács
During the classes students learn most relevant issues of materials handling equipments' mechanical construction. Construction of a selected materials handling machine is also carried out by students. (5 credits)

Design of Vehicle Automation Systems

BMEKOKAM661

Dr. Tamás Bécsi
The course aims the strengthening of project design skills through a large indivudal student project. (7 credits)

Engine design II.

BMEKOGGM671

Dr. Huba Németh
Theoretical aspects of internal combustion engine design for road vehicles. Crankcase material selection, design and dimensioning. Setup of the cranktrain mechanism. Applied cranktrain solutions. Dimensioning process of crankshafts and fly wheels. Mass balance calculations. Dimensioning, material selection and design of bearings, bearing covers, bed plates. Conrod wrist pin, piston and piston ring design. Cylinder head design and material selection. Design of charge exchange control components. Intake, exhaust valve, camshaft, rocker and roller finger follower design and calculations. Engine cooling and lubrication system calculation and design. Main ingredients of the technical design documentation: calculations and drawings. (5 credits)

Measurement systems in vehicle manufacturing

BMEKOGGM652

Dr. Pál Bánlaki
Basic concepts of measurement methods, measurement errors, systematic errors, random errors. Measuring tools and measurement systems. Typical measurement tasks and assets: shape meas-urement error, position error measurements, surface-based characteristics, coordinate measurements. Automatic size control. Surface digitization. Process measurement technology. Measuring in-struments calibration, validation. Statistical process control (SPC). Measuring device management. (5 credits)

Mechatronic design of vehicle systems

BMEKOGGM622

Dr. Zsolt Szalay
System design methods. SIL and HIL simulation methods in system design and testing. Printed circuit board design introduction. Main loads on meachtronic components. Vibration loads and its design methods. Thermal loads and its design methods. Electronic loads and its design methods. Sesons types, selction and design. Actuator types, selection and design. Pnaumatic, hydraulic and electro-mechanic actuations. Selection and design of actuators. (5 credits)

Production process quality assurance in the vehicle industry

BMEKOGGM611

Dr. Zsolt Stukovszky
(2 credits)

Project

BMEKOVRM633

Dr. Árpád Veress
In this subject the students have the possibility either to work as a trainee at an aircraft design office or get involved in a project running at our department. (3 credits)

Project work

BMEKOVRM628

Dr. Győző Simongáti
In this subject the students have the possibility either to work as a trainee at a ship design office or get involved in a project running at our department. (2 credits)

Projectmanagement in automotive industry

BMEKOKKM617

Zoltán Nagy
Project management can play an important role in the current wave of product development reengineering taking place in the automotive industry. In this course those special project management processes and tools can be studied which are necessary during automotive product development. (2 credits)

Reliability, Safety and Security in the Vehicle Industry

BMEKOKAM660

Dr. Balázs Sághi
The aim of the course is to provide the students with theoretical and practical knowledge about the approach and methods for designing reliable, safe and secure vehicle systems. (3 credits)

Research and devlopment process in the vehicle industry

BMEKOGGM614

Dr. Zsolt Stukovszky
(2 credits)

Ship hydrodynamics

BMEKOVRM626

Dr. Győző Simongáti
The subject aims to introduce the basic analytical and numerical methods for calculation of ship resistance, water velocity and pressure distribution around hull. International and practical recommendations for numerical calculations of ship hydrodynamics. (4 credits)

Ship strength

BMEKOVRM621

Dr. Győző Simongáti
The course aims to explain numerical methods for calculating ship strength, and to introduce the verification calcula-

tion methods of ship strength according to the legal regulations, international standards and classification societies. (4 credits)

Superstructure control technics

BMEKOJSM666

Dr. Ferenc Pápai

Traditional hydraulic drives. Electrohydraulic drives, sensors, actuators. Presentation of the onboard electronic devices. Definition of stability and overload criteria. Accident prevention. (5 credits)

Vehicle evaluation, traffic environment

BMEKOGJM640

Dr. Gábor Melegh

Students know the basics tasks and expectations connected to making damage survey, determination of the repair costs and depreciation after repairs (or betterment). They are informed of the related disciplines, which directly or indirectly connected to these questions. Knowledge about different types of vehicle insurances.

Detailed review of catalogue systems used for vehicle evaluation and calculating repair coast.

Examination of special questions of maintainability and deterioration of vehicles.

Solving specific vehicle evaluation problems with statistical methods.

Human factors of driving road vehicles, reaction time, perception and perceivability. (5 credits)

Vehicle simulation and optimisation

BMEKOVRM638

Dr. Vilmos Zoller

The real vehicle system and its investigation model. The discrete and distributed parameter models, hybrids. Formulation of the system model giving the basis of the simulation procedura. Typical techniques: linearization, considering the non-linearities. Parameter space, state space, and excitation space. The stair-like simulation technology. Possibilities for the solution of the system equations: time-domain and frequency-domain analyses. Numerical solutions by using digital simulation. Special solvers for differential equations and their subroutines. Real-time simulations. Prediction of the motion and loading conditions of vehicles. Statistical analysis of the simulation results. Stochastic simulation. The problem of system optimization. Selection of the optimization objective function, action-parameters and constraint conditions. Analytical and numerical optimization techniques. Problems leading linear programming (LP). Algorithm and suroutine of the generalized gradient method . Procedure in case of a random variable valued objective function (stochastic field). (5 credits)

Vehicle superstructure design

BMEKOJSM667

Dr. László Lovas

Superstructure construction regarding the needs of manufacturable design and tooling. Optimization of duperstructures (weight, rigidity, manufacturing). (5 credits)

Vehicle system informatics

BMEKOVJM437

Dr. Ferenc Kolonits

Vehicle Computing System as info. storage, transmission, grouping, sorting, processing: data representation, data input, storage, retrieval, transmission, distribution. Determining document structure. Document description of the main tools: SGML, HTML, XML and DTD. XSL. DTD: name structure, syntax, terminal descriptors. Standard and generic items. Attribute syntax. Namespace applications. Application type descriptor (entity). Vehicle-document hierarchical structure and structural levels battery unit, structure, group, division, sub vehicle. Enlargement of the structure. The event codes ordering parts. XML editors: XML mind morph, Xerlin, Web download software use. Clarity. Document Processing: XSL various tools: Finding the XML document elements, navigating structural axes. Implementation mechanism of the template. Targeted info. Extraction. Processing Software: COOKTOP (free downloadable software) review of the principal lines. Using XSL-generator program. The Xtract software. Vehicle Document Management: performing elementary operations XSLT routines scenarios and bills of withdrawal of the document specified. Description of vehicle structural links: contact and containment relations. The functional areas and roads setting - the possibilities and the processing pathes. Graph theoretical analysis of the failure groups. Production data structures for vehicle system reliability analysis. The statistical processing programs to connect preparation. (5 credits)

Description of M.Sc. Subjects
Master Section in Transportation Engineering

Control theory

BMEKOKAM142

Dr. József Bokor
The course provides deepening of knowledge in control theory. Provides theoretical knowledge, and discusses modern tools, which are necessery in later eingineering practice. This is introduced through different examples, taken from vehicle and transportation systems. (3 credits)

Decision making methods

BMEKOKKM221

Dr. Zoltán Békefi
Introduction of the most important methods of operations research and their applications in the transport sector. (5 credits)

Intelligent transport systems

BMEKOKUM205

Dr. János Tóth
The components of intelligent transport systems. The application of ITS on higways and in urban transport. Supporting private and public transport by road and passenger information systems. Traffic management systems. Geographical Information Systems (GIS) in transport. The features and planning pinciples of GIS databases in transport. The methods of positioning, tracking systems. The vehicle detection and identification systems. Route planning methods. Fleet management. (5 credits)

Mathematics MK

BMETE90MX59

Dr. Sági Gábor
(4 credits)

Road Safety

BMEKOKKM222

Dr. János Juhász
Indicators of Traffic Safety. Evaluation of PIN in EU and in Hungary. Attributes of the traffic elements (human, infrastructure, vehicles), their influences to traffic safety. Pedestrians and cyclists behaviours. Driver's training. Self explaining roads. Passive and active vehicle safety systems. (3 credits)

Transport automation

BMEKOKAM202

Dr. Balázs Sághi
Main topics of the subject include: Basic principles of safety.
Development of safety-critical systems
System life cycle models
Safety requirement specification, safety criterion
Hazard and risk analysis techniques
Safety integrity of systems
Safety analysis
Failure management of safety critical systems
Introduction to formal techniques, Petri nets
(4 credits)

Transport Economics

BMEKOKGM201

Dr. Ferenc Mészáros
Analysis of EU transport strategies in different modes. Monetarising and internalising of transport externalities. (4 credits)

Air Traffic Management (ATM)

BMEKOVRM224

Dr. Dániel Rohács
The course aims at introduction to the basic principles of air traffic control, the categories of airspaces and the main methods and support systems of ATC. The course examine the most important human factors and the main researches. (3 credits)

Communications, Navigation and Surveillance (CNS) I.

BMEKOKAM226

Dr. Dóra Meyer
The aim of the subject is to provede deeper knowlegde on planning and operating of air transportation related navigation systems, facilities or devices that have been operationally released to be used either by airspace users (e.g. ground navigation facilities) directly, or are used in the provision of operational air traffic management services. (3 credits)

Controlling systems in transportation

BMEKOKGM215

Dr. Ferenc Mészáros
Intorduce the technical, legal, economic, financial, social and institutional frameworks and directives that control operation and improve integration, development of transportation system in European Union. Promoting their domestic adaptation and application. (6 credits)

Electronics – electronic measurement systems

BMEKOKAM103

Dr. Géza Szabó
The subject gives basic knowledge of electronics and electronic measurements and their application in different areas of transportation. It summarizes the operational modes of basic components and basic circuits and describe how one can design and apply them. It gives an overview of electric and mechanical measurements and how the results of measurements can be processed
(4 credits)

Forwarding Management 1

BMEKOKKM132

Dr. Ferenc Mészáros
History and attibutes of freight forwarding, international agreements, different contract types, rules of extra ordinary freight forwarding, legal framework of customs, tasks of national and international forwarding services. (5 credits)

I+C technologies

BMEKOKAM104

Dr. Tamás Bécsi

The course aims at introduction to the basic principles of modern computer architectures, and especially computer systems and communication techniques which are of high importance in transportation. (3 credits)

Information connection of the vehicle and the track

BMEKOKAM232

Dr. Géza Szabó

The subject gives an overview of information transmission between infractructure and vehicles, both logically and phicically. Examples are given for railway, road and air transportation sectors. (3 credits)

Material handling and warehousing processes

BMEKOALM225

Dr. Gábor Bohács

The specific properties and main groups of the materials in the logistics systems. The functions of the packaging, packaging nation's economic role. The classification of packaging, packaging materials - different materials, packaging materials, packaging accessories. Cargo unit creation. Characteristics of the material handling systems, the main groups, material handling tasks, material flow characteristics. The main groups of material handling machines and techniques. Performance and reliability of the material handling systems. Calculation of the material handling time. Material handling process examination. Secondary analysis, layout planning. Conventional storage systems, high bay warehouse systems. Order picking. Statistical sampling procedures. Tenders. (4 credits)

Meteorology

BMEKOVRM231

Dr. Rohács Dániel

The course aims at introduction to meteorological phenomenas and conditions, the structure of the atmosphere and other important aviation weather informations. (3 credits)

Modelling and control of vehicles and traffic systems

BMEKOKAM233

Dr. István Varga

Design of road traffic systems and traffic modeling practice with state-of-the-art design software:
- microscopic modeling with VISSIM,
- advanced use of VISSIM via COM programming with MATLAB,
- macroscopic traffic planning (classical four-step approach) with VISUM
- application of MATLAB for freeway traffic modeling and control,
- introduction to the application of QGIS. (6 credits)

Numerical methods

BMEKOVRM121

Dr. Rohács József

Introduction. System modeling. General model, assumptions, errors. Solving the non-linear equation, Newton iteration. Polynomial equations, Horner, Newton methods. Systems of linear equations: Gauss elimination, Matrices, enginvalues. Linear programming. Simplex Method. non-. linear optimization, gradient method. Interpolation. Newton's, Lagrange Hermite methods, spline. Approximation: Chebyshev, Padé. Fast Fourier transformation. Numerical differentiation, integration. Solving the differential equations. Euler, Runge-Kutta, predictor-corrector methods. Systems of partial differential equations. finite differences, finite volumes methods. Stochastic modeling. (4 credits)

Smart City

BMEKOKKM227

Dr. János Tóth

Smart city introduction, land use functions and models, city planning, utilization of social media, Internet of Things, wireless sensor networks, Smart Grids, lighting, best practices. (3 credits)

Transport informatics

BMEKOKKM223

Dr. Csaba Csiszár

The subject is based on Transport information systems I. and II. Main topics: modelling of con-cepts, relations and regularities in information systems and applying of these models in trans-portation. The structure and operation of the transportation organizations and operational con-trol processes (preparation, execution and accounting) are also lectured. (5 credits)

Transport Infrastructure Management

BMEKOKKM228

Dr. Ferenc Mészáros

Role of transportation networks and regulatory policies. Asset valuation, asset management techniques and systems. Operation contracts, risk sharing and management. Tasks in adaption to climate change and sustainability principles. (3 credits)

Transport modelling

BMEKOKKM229

Dr. János Tóth

Basic theory of transport modelling. Transport network planning by software VISUM. The fundamentals of the program. Network model, Demand model, Impact model. Traffic assignment methods on private transport and on public transport. Microscopic modells, fundamentas of VISSIM software. Modelling the traffic in a junction. (6 credits)

Transport operation

BMEKOKUM206

Dr. Péter Mándoki

Plannig of intermodal node. Infrastructure and vehicles of different transport modes. (5 credits)

Air Traffic Control

BMEKOVRM235

Dr. Dániel Rohács

The course aims at introduction to the basic principles of air traffic management, the history and the main methods of ATM. The course examine the most important elements of the management sytsem, the advanteges and disdvanteges and the researching of ATM. (4 credits)

Case study

BMEKOVRM237

Dr. Dániel Rohács
The students have to participate in one of the R+D projects of the faculty. (3 credits)

City logistics

BMEKOALM244

Dr. Bóna Krisztián
The main types of transport goods in the city supply networks. The rule of city logistics in the global logistics networks, the definition of last mile problem. The application of transporting systems in the city logistics. Loading technology in the city logistics. The rule of logistics providers in the city supply, the integration of city logistics in the gateway conception. The urban consolitation centres ans x-docks. The control and organisation of city logistics in big cities. Best practises in worldwide. Application of modelling techniques is the organisation and operation of city logistics systems. Informatics in city logistics. (5 credits)

Communications, Navigation and Surveillance (CNS) II.

BMEKOKKM239

Dr. Rita Markovits-Somogyi
The course aims at introduction to the systems of navigation, surveillanceand data process. The course examine the basic principles of voice communication, the data technologies of air traffic control and complement of the knowledge of course CNS I. (4 credits)

Engineering of transport automation systems

BMEKOKAM234

Dr. Balázs Sághi
The aim of the subject is to provede deeper knowlegde on planning of transportation systems. Rules, legislation basics, guidelines for different domains are introduced, planning phases are touched and project work is expected from students. (6 credits)

Environmental effects of transport

BMEKOKKM230

Dr. János Tóth
Transport- environment, factors of environmental impact, the problem of sustainability. Mitigation of environmental impacts of transport, regulations, policies, tendencies, practices. Local and international case studies. EIA, decision making, preparation of decisions on the field of transport infrastructure development. Integration of transport and land use. Environmental conflicts of freight transport, intermodality and transit policies. Environmental costs of transport, the case of externalities, prices and charges. Urban transport, opportunities of sustainable urban environmental management, integration of environmentally sound mobility forms. Demand management, parking and road charges. Requirements of fuel efficiency, alternative fuels, energy efficient and environmentally enhanced vehicles. (4 credits)

Financing techniques in transportation

BMEKOKKM236

Dr. Zoltán Békefi
Concepts of financing: financing goals (development, operation); financing options: budget, private or public-private partnerships (PPP); loan, bond, lease and their characteristics. Project analysis and evaluation methods. Project identification, technical preparation, traffic forecast and modeling. Risk assessment needs. Feasibility studies, cost-benefit analysis, financial, social, legal, regulatory and technical compliance criterias. The identification of project risks. Definition of government, regional and local priorities. The role of the partners in the project financing. Communication tasks. The media's role for accepting the project financing methods by the society. Optimizing fees and tariffs. Financial structures and models. Contracts. (5 credits)

Forwarding Management 2

BMEKOKKM133

Dr. Ferenc Mészáros
Mode specific knowledge of freight forwarding management (road, rail, aviaton, inland waterway and maritime, combined and LTL transport). (5 credits)

Forwarding marketing

BMEKOKKM135

Dr. Botond Kővári
Marketing concepts, overview of resources. Market analysis methods. Product mix reviews. Advertising strategies. (4 credits)

Human resource management in transportation

BMEKOKKM238

Dr. Botond Kővári
Applied human resource challenges, especially in transportation. Motivation, team working, carrier planning
(3 credits)

Management of transport and logistic services

BMEKOKGM217

Dr. Botond Kővári
The main aim of this course is to develop and implement performance measurement in a transport or logistic organization with the help of a balanced KPI (key performance indicator) system. (6 credits)

Passanger transportation

BMEKOKUM208

Dr. Csaba Csiszár
Characterization of passenger transportation systems, properties, planning process. Evaluation of system. Modelling of motion process in regional area. Qualitative system of passenger transport, service levels. Planning of system elements of passengers transport (local and inter-town), in individual and public transport. Overview and summary of properties of the advanced, so called "transitional" passenger transportation modes (e.g. car-sharing, bike-sharing, car-pooling, chauffeur service, demand responsive transport) in system and process-oriented approach. (5 credits)

Project

BMEKOKAM242

Dr. Balázs Sághi
Project work
(3 credits)

Projectmanagement in transportation

BMEKOKKM241

Zoltán Nagy

This course is an introduction to project management in the transportation sector and basic concepts and tools for developing the student's skills. During this course are presented the most relevant concepts on the formulation and preparation of different transport developing projects and their scheduling and control techniques. Students work with different models and tools for setting professional goals, time management, teamwork and communication techniques. (2 credits)

Safety in air traffic control

BMEKOKAM243

Dr. Dóra Meyer

The aim of the subject is to provide deeper knowlegde on planning of safety certficication in air traffic control. Rules, legislation basics, guidelines for different domains are introduced, planning phases are touched. (3 credits)

Signal processing in transport

BMEKOKAM211

Dr. József Bokor

Introducing the microcontroller architectures used extensively in transportation systems. Embedded system design, and software development. Digital signal processing: A/D and D/A conversion, filtering and DSPs. Safety critical hardware and software design and implmentation. (5 credits)

Supply and distribution processes

BMEKOALM240

Dr. Gábor Kovács

The basics of organizing supply chains (SCM), enterprise logistics system. The organization of the material supplies, material analysis methods (ABC, XYZ), supply strategies (synchronized, by stocking, on request), material planning methods (Gozinto graph, BOM). The inventory systems and processes (rotation indicators), inventory valuation (FIFO), inventory model (EOQ). Distribution systems, demand forecasts (simple methods). Production logistics (MRP, APS, Kanban, Lean). The definition and main tasks of the reverse logistics. (2 credits)

Trade, Financial, Accounting Techniques

BMEKOKKM138

Dr. Ferenc Mészáros

General principles of international trade, stakeholders and their relationships, trade transactions. Set and elements of the banking system, frequent financial transactions of freight forwarders. Accounting obligations and techniques of freight forwarding companies, balance sheet and profit and loss statement. (3 credits)

Traffic flow

BMEKOKUM204

Miklós Kózel

Analysing, modelling and planning of traffic flow on road transportation network, in consideration of passenger and goods transport. Probability distributions, vehicle in winding way, phasing of traffic lights, road markings, traffic signs, pedestrian flow, traffic calming zones
(4 credits)

Description of M.Sc. Subjects
Master Section in Logistic Engineering

Control theory

BMEKOKAM122

Dr. Péter Gáspár

The course provides deepening of knowledge in control theory. Provides theoretical knowledge, and discusses modern tools, which are necessery in later eingineering practice. This is introduced through different examples, taken from vehicle, transportation and logistics systems. (5 credits)

Lean management

BMEKOALM322

János Kosztolányi

Methods of continuous improvement. The teamwork, establishment of suggestion systems, the role of motivation. Main brainstorming methods, the advantages and disadvantages of each method. Introduction and application of problem finding tools, methods for failure analysis, applicability of the main methods. Data request for failure analysis methods. The basics of standardization, the steps of making standard processes, the zeri failure concept (Jidoka, Poka-Yoke), production equalization in lean menedzsment: mathematical methods for Heijunka. Process development methods, and techniques. The importance of changeover time, methods for the reduction os changeover time in the companies. The basics of ergonomics, types of workplaces from the aspect of ergonomics, the steps of REBA analysis. Lean office methods and tools. The basics of Six Sigma method, mathematical background, the levels of quality. Description of six sigma analysis, evaulation of the results. The relationship between six sigma and lean. (4 credits)

Logistics controlling

BMEKOKKM330

Dr. Szabolcs Duleba

The primary task of logistics controlling is managing all logistics activities using comprehensive measures on all levels of a company with the provision of information processing systems based on the management's information needs. After the completion of this module, the graduate will have the knowledge and an understanding of the fundamentals and characteristics of reporting systems for logistics, logistics accounting and cost accounting, activity-based costing, strategic logistics controlling and logistics benchmarking. (3 credits)

Logistics information system planning

BMEKOALM321

Dr. Jenő Tokodi

Logistics information system (LIS) databases. LIS planning. IT representation of system elements, purchase orders, sales, production, quality assurance. System and software planning methods. IT representation of data formats, schemes, process description. Service oriented architecture, webservices, interfaces, Enterprise Service Bus, Orchestrating. ERP webservices, workbench, dictionary, business warehouse, reporting. BI systems. Transactional database. (5 credits)

Mathematics ML

BMETE90MX60

Dr. Gábor Sági

(5 credits)

Planning of extra-logistics networks

BMEKOALM337

Dr. Krisztián Bóna

Architecture and mathematical representation of extra-logistics networks. Key preformance indicators of extra-logistics networks, methodology of network-performance measurement. Criteria set of network optimization. Optimization methods of network topology, one or more region centre searching techniques. Logistics performance based optimization methods. The rule of inventories in the topology optimization of extra-logistics network. Multi-echelon inventory networks. (4 credits)

Algorithm Design

BMEKOKAM326

Dr.Tamás Bécsi

The course aims the introduction of algorithm theory and numerical complexity.
(5 credits)

Automation of logistics systems

BMEKOALM325

Dr. Gábor Kovács

This subject introduces integration of logistics automation into the higher levels of corporate governance. Communication possibilities in PLC networks are also addressed. Introduction of industrial communication protocols and interfaces. Effects of humans, identification and quality checking on automation. (5 credits)

Demand planning and inventory management

BMEKOALM328

Dr. Krisztián Bóna

Specific resource planning areas in the enterprise logistics. Mathematical modeling in the demand planning process, model identification and parameter optimisation. Mathematical modeling in the inventory planning process, select inventory models, optimisation of control parametrers, inventory control systems. Measurement of demand and inventory planning efficiency. Specific planning tools of ERP systems. The rule of inventory and demand planning in the S&OP process. (5 credits)

Enterprise logistics project 1.

BMEKOALM339

Norbert Antal

Within the framework of the course, project groups are formed from the students, which are led by mentors. The project topics may include: operations management, complex project tasks, R&D tasks, based on the interests of student's. During the contact hours, the students consult with their mentors, moreover, each week brief report is held. The students present the problems and the suggested solutions, they practice the techniques of discussion, argumentation, and persuasion. (4 credits)

Forwarding Management 1

BMEKOKKM132

Dr. Ferenc Mészáros

History and attibutes of freight forwarding, international agreements, different contract types, rules of extra ordinary freight forwarding, legal framework of customs, tasks of national and international forwarding services. (5 credits)

Forwarding project 1.

BMEKOKKM338

Dr. Ádám Török
Executive knowledge in managing freight forwarding companies. (4 credits)

Logistics planning softwares

BMEKOALM336

Dr. Jenő Tokodi
Classification of softwares in logistics planning. Introduction of software tools in corporate process planning, including designing flow chart (EPC, BPMN), Gannt chart, Fishbone diagram. The functions of computer aided design softwares, basic components, transformations, dinamic blocks, scaling, managing layers. Standard symbols of logistics components. Basic of spatial designing. Project management softwares. (3 credits)

Numerical optimization

BMEKOVRM334

Dr. József Rohács
Introduction. System modeling. General model, assumptions, errors. Solving the non-linear equation, Newton iteration. Polynomial equations, Horner, Newton methods. Systems of linear equations: Gauss elimination, Matrices, enginvalues. optimization. Linear programming. Transformation to standard forms. Simplex Method. Sensitivity analysis. Transport logistics. Supply chain and production processes, distributing systems. Genetic algoritm. Non-linear optimization, gradient method. Specific cases. Theory of play. Stockpiling. Interpolation. Newton's, Lagrange Hermite methods, spline. Approximation: Chebyshev, Padé. Fast Fourier transformation. Numerical differentiation, integration. Solving the differential equations. Euler, Runge-Kutta, predictor-corrector methods. Systems of partial differential equations. Finite differences, finite volumes methods. Stochastic modeling. Markov models.
(5 credits)

Process planning

BMEKOALM331

Dr. Gábor Kovács
Interpretation the process, parts, contacts, activities, events and processes. Standard methods for the description of the processes. Process Charting Techniques. Process Description levels. Top-down modeling. Standard process description languages. Standard Operating Procedure. Cross-Functional Flowchart. Petri net. Event Driven Process Chain (EPC). Business Process Modeling Notation (BPMN). Integrated Definition Methods (IDEF). Logistics processes modelled by using the standard languages: goal-oriented application. (3 credits)

Simulations planning

BMEKOALM335

Dr. Krisztián Bóna
The types of modells, the basics and mathematical rudiments of modelling. Stochastic and deterministic processes, and the main process properties. The definition of computer based simulation modelling and the application in the logistics system planning. Simulation algorithms and programming. Simulation and optimization, simulation based optimization methods. The simulation softwares and simulators. Application of simulation based optimization methods in logistics. Application of artificial intelligence in specific logistics optimization problems. Development of simulation systems and models in intra- and extra logistics systems. (3 credits)

Technical logistics project 1.

BMEKOALM333

Dr. Gábor Bohács
During the classes students of the technical logistics specialization learn advanced engineering planning systems, and their relation to the expert field of logisticians. (4 credits)

Construction of logistics machinery

BMEKOALM324

Dr. Gábor Bohács
Introduction of main constructional issues of continuous and discontinuous operating materials handling machines.
(3 credits)

Control of transport logistics

BMEKOALM341

Dr. Gábor Bohács
The components of the transport logistics control systems. Summary of GIS funds. Operational control problems and tasks of the transport logistics systems. Mathematical modelling techniques, decision supporting of transport logistics control systems. The mathematical model of transportation network. The shortest path search methods. The exact and the provisional planning. Modelling of routes: direct routes, collecting and distributing routes. The traveling salesman problem (TSP) and the vehicle routing problem (VRP). Soft computing methods. The IT architecture of the freight control systems. The mobile devices. The connection between the freight exchanges and the transport logistics control systems. (3 credits)

Enterprise logistics project 2.

BMEKOALM343

Norbert Antal
As the continuation of the Enterprise logistics project 1., the project groups get operations management tasks, complex project tasks or R&D tasks, based on the interests of student's. The task can be the continuation of what are launched in Enterprise logistics project 1., however, a new task also can be started. During the contact hours, the students consult with their mentors, moreover, each week brief report is held. The students present the problems and the suggested solutions, they practice the techniques of discussion, argumentation, and persuasion. (7 credits)

Forwarding Management 2

BMEKOKKM133

Dr. Ferenc Mészáros
Mode specific knowledge of freight forwarding management (road, rail, aviaton, inland waterway and maritime, combined and LTL transport). (5 credits)

Forwarding marketing

BMEKOKKM135

Dr. Botond Kővári
Marketing concepts, overview of resources. Market analysis methods. Product mix reviews. Advertising strategies.
(4 credits)

Forwarding project 2.

BMEKOKKM342

Dr. Ferenc Mészáros
Executive knowledge in managing freight forwarding companies. (2 credits)

Integrated material flow systems

BMEKOALM332

Dr. Gábor Bohács
Traditionally materials handling systems are separated from technology. There are however special applications, such as assembly lines in the electronic industry where the material handling systems are in strong integration with the technological equipment. During the classes these special machines are addressed. (4 credits)

Planning of plant logistics systems

BMEKOALM327

Dr. Krisztián Bóna
The specific properties and planning process of plant logistics systems. The main steps and tasks of logistics planning. The plant layout planning techniques and methods. The specific plant layout topologies. Optimization and heuristic methods in plant layout design. How to create a logistics system plan in case of a plant logistics system? The material flow system architecture in a plant. The planning steps of the material flow systems in a plant. The methodology of material flow system planning, the main heuristic an optimization modells. Analitical queueing theory and simulations methods in the planning of plant logistics systems. Integration of the basic arguments of lean in the planning process. (5 credits)

Planning of warehousing systems

BMEKOALM323

Dr. Krisztián Bóna
The main material flows and processes in a warehouse. Specific logistics system planning methodology of warehousing systems. The typical logistics technology variations of storing. Planning of transporting connections and loading technology. Planning the dimensions of loading bays, and preparation areas of warehouses. Order picking methods and systems. The technology of order picking. Planning of order picking process. Planning the topology and layout of storage systems. How to create a logistics system plan of a warehousing technology? (5 credits)

Production planning & scheduling

BMEKOALM329

Dr. Krisztián Bóna
Theory of production planning and scheduling. Main topics, goals and constraints in the production systems, the system arichetecture of production control. Modelling of products and production technology. Connection points to the customer orders and forecasts. Then main production strategies. Production and capacity planning. The time view of production scheduling, the long, middle and short term planning. The informatics of the production planning and scheduling. Production planning and scheduling algorithms. The rule of production planning in the S&OP process. (4 credits)

Technical logistics project 2.

BMEKOALM340

Dr. Gábor Bohács
During this subject students perform and complete a technical logistics project in groups. These can originate from either the industry or from defined research and innovation tasks. (7 credits)

Trade, Financial, Accounting Techniques

BMEKOKKM138

Dr. Ferenc Mészáros
General principles of international trade, stakeholders and their relationships, trade transactions. Set and elements of the banking system, frequent financial transactions of freight forwarders. Accounting obligations and techniques of freight forwarding companies, balance sheet and profit and loss statement. (3 credits)

Pre-Engineering Course

Pre-Engineering Course

The Budapest University of Technology and Economics (BME) is one of the leading universities in Europe and a member of CESAER (Conference of European Schools for Advanced Engineering Education and Research), with a high admission standard.

The Hungarian secondary schools have very high level final exam in mathematics and physics, one of the highest in the world, as it has been proved through international competitions. Very often, there is a gap between the Hungarian and foreign students' secondary school's education program as far as the preparation for engineering studies are concerned. Many students are not trained enough to solve complex problems.

Therefore the Pre-Engineering Course is designed to help students develop the basic skills necessary to successfully pursue engineering studies at the Budapest University of Technology and Economics or any other engineering or science-oriented university with high academic standards.

The program lasts one academic year and offers intensive instruction in mathematics, physics, and English language. In addition, students are introduced to conceptual approaches in engineering.

New students at the Budapest University of Technology and Economics take a required Placement Test on the week before the academic year starts (see the Academic Calendar). Based on the results of this test, students will either be accepted into the first semester of the undergraduate program (BSc), or will be instructed to the Pre-Engineering Course prior to the undergraduate program.

Students who think they would benefit from the profound preparation of the Pre-Engineering Course may simply register for the Pre-Engineering Course (without taking the Placement Test).

Exams are given at the end of each semester of the Pre-Engineering Course. Students who achieve at least good results at the end of the second semester can begin their first year engineering studies at the Budapest University of Technology and Economics without taking the Placement Test.

Students who will not continue their studies at the Budapest University of Technology and Economics can take any of the individual subjects on a credit basis. Acceptance of the credits depends on the student's home institution.

Budapest University of Technology and Economics
Central Study Office
Building R, ground floor, room 001.
Mailing Address: H-1111 Budapest,
Műegyetem rkp. 3-9. bldg. R, Hungary
Phone: (+36-1) 463-4609
Fax: (+36-1) 463-2550

Course Director: Dr. Zsolt Papp
Office: Building F. room 10, tel.: +36-1-463-3827
Program Co-ordinator: Ms. Margit Nagy

Description of Subjects

Description of 1st Semester Subjects (Fall)

Introductory Physics I

Mechanics

Principles and concepts of classical physics. Vector and scalar quantities. Motion in one and two dimensions. Projectiles. Newton's laws. Conservative and dissipative forces. Equilibrium of rigid bodies. Levers, pulleys. Torque, circular motion, angular acceleration, moment of inertia. Linear and angular momentum. Work and energy. Energy of rotational motion, work of spring. Laws of conservation. 2 hours of lectures with demonstrational experiments and problem solving practice 4 hours/week.

Electricity

Fundamental phenomena of electrostatics. Electric charge, field strength. Electric potential and voltage. Electric polarization. Capacitors. Energy of the electric field. Electric current. Electric power. Electric circuits. Magnetic field produced by current. Electromagnetic induction. Self induction. Transformers. Alternating current. Electrical oscillations. Electromagnetic waves. 2 hours of lectures with demonstrational experiments and problem solving practice 4 hours /week.

Introductory Mathematics I

Algebra

Real numbers and algebraic expressions. Fundamental laws, identities. Equations in one variable: linear and quadratic equations. Applications to word problems. Quadratic formula, relationship between roots and coefficients, the discriminant. Radical equations, extraneous roots. System of equations in two or more variables. Word problems. Exponents, integer and fractional. Laws of exponents. 4 hours /week.

Geometry

Elements of geometry: circumference and area of geometric figures, surface area and volume of geometrical solids. Right triangle trigonometry. Law of cosines and sines. To solve a triangle. Trigonometric identities, equations. 4 hours/week.
Compulsory English for Pre-Eng. Students I.

(0 credit)

Description of 2nd Semester Subjects (Spring)

Introductory Physics II

Vibration, Waves, and Thermodynamics

Elastic properties of materials, vibrational motion. Simple and physical pendulum. Wave motion. Transverse and longitudional waves. Interference. Standing waves. Polarization of transverse waves. Sound waves. Thermodynamics: temperature and the behavior of gases, the ideal gas law, specific and molar heat capacity, first and second laws of thermodynamics, entropy, Carnot theorem and conservation of energy, refrigerators and heat pumps. 2 hours of lectures with demonstrational experiments and problem solving practice 4 hours /week.

Optics and Atomic Physics

Optics: fundamental concepts of optics; reflexion, refraction, dispersion of light; coherence of light; light as electromagnetic wave; interference, diffraction, polarization; holograms. Atomic physics: photoelectric effect; wave particle dualism; hydrogen atom model. 2 hours of lectures with demonstrational experiments and problem solving practice 4 hours/week.

Introductory Mathematics II

Algebra

Factoring. Sets: definition, notations, subset. Operations with sets. Wenn diagrams. The set of real numbers, intervals. Linear and quadratic inequalities. Functions: definition, domain and range of a function. Properties of functions. Inverse of a function. Exponential and logarithmic functions and equations. Absolute value, equations and inequalities involving absolute values. Sequences. Arithmetic and geometric progressions. Geometric progression with an infinite number of terms. 4 hours/week.

Geometry

Coordinate system. Distance and midpoint formula. To sketch a graph. Equations of a line. The circle. Quadratic functions and parabolas. Ellipse and Hyperbola. Trigonometric functions. Complex numbers. Complex algebra. 4 hours/week.

Computer Algebra

Introduction. What is Maple? The Command window. The Maple Syntax. Mathematical functions. The Maple Packages. Data types and operations. Expression sequences, arrays, sets. Plot structures. Basic plotting. Solving equations exactly and approximately. Preparing report with Graphs, comments. Applications. 2 hours/ week.

Compulsory English for Pre-Eng. Students

(0 credit)

Elective subjects (2nd Semester)

Computing

General informations about computers and peripheral devices. Algorithms and programs. PASCAL Programming Language. 2 hours/week.

Engineering Drawing

Rules and conventions of engineering drawing. Descriptive geometry. 2 hours/week.

Advanced Algebra

Functions (definition, domain, range, graph, zeros). Operations on functions. Power functions, polynomials. Graph of polynomials and rational functions using zeros and asymptotic behaviour at infinity. Limit of functions. Calculating limits. Convergent, divergent sequences. Calculating limits of sequences. Monotonic, bounded sequences. 2 hours/week.

Workshop


www.bme.hu


Budapest University of
Technology and Economics
www.bme.hu

Excursions - Solt

Graduation Speech

"Do not go where the path may lead, go instead where there is no path and leave a trail"

I am most honored to be called amongst many to give this speech on this special occasion. I stand here today to reinforce character and vision.

I started by grace and have finished by grace, and I thank God, my parents, my lecturers, my fellow graduating students, and of course you sited here as well as my friends, for this rare opportunity to stand before you. Have you ever sat in your mums chair at her office, and in her absence you had to sign the collection of a letter (your admission letter) which was delivered to her, and yet you did not know it was your admission letter to school abroad, I guess not, but that was me signing the collection of that letter more than four years ago.

Leaving your mother land to a foreign land to be educated should not be done without vision/dream. Four and half years ago I could have fallen prey to the lack of vision, stepping my feet into Hungary and listening to those who at the time had no vision telling me to be comfortable with the poorest of academic grades, and I thought to myself if the reason for being educated in this institution is to fall short of my expectations then I could have as well been home schooled, I decided not to speak with poor minds on serious issues for I had vision.

This group of graduates has been strong, tough and thriving, having clearer vision by the day, walking with any of them would leave a lesson of hard work and the ability to bend due to tough academic work and yet not be bent. Budapest University of Technology and Economics in my short experience is not a place for poor minds so I urge you to be visionaries if you must take the world by storm.

We are here today to celebrate the end of a very significant phase in life and the beginning of the next most important phase of a new life outside school. The world has been waiting for us and we are now ready for them. I believe that the lessons learnt here at BME, from the accomplishments/successes, failures and studies, means we now posses the skills to learn, aptitude to succeed, ability and creativity to make a difference, to work to meet world needs and to assist in solving the problems facing the society at large. Knowledge as we know is power and it is gotten from education, although it might seem expensive buy it, for ignorance is more expensive. This school has taught us the elements of character and vision, on this note I want to encourage all students to show character, have vision and pursue it, and if an opportunity of success has not knocked on your door build a door and keep in mind that neither success nor failure is final keep succeeding.

To accomplish great things today and in the future, we must not only dream, but also act, and not just act but plan and believe in our dreams and vision, for "the future belongs to those who believe in the beauty of their dream", and "I hope your dreams take you to the corners of your smile, to the highest of your hopes, to the windows of your opportunities and to the most special places your heart has ever known".

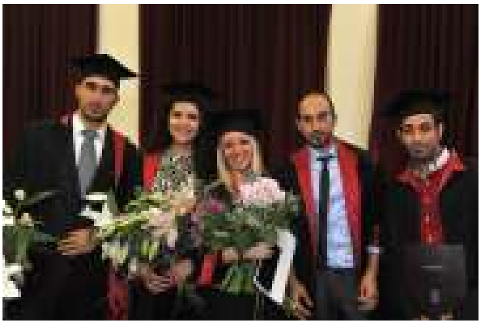
Courses and Doctorate schools at BME

We offer undergraduate & PhD courses in:

- Architecture
- Architectural Engineering
- Civil Engineering
- Chemical Technology
- Electrical Engineering
- Information Technology
- Mechanical Engineering
- Mathematics
- Physics
- Cognitive Science

Doctorate Schools

- Géza Pattantyús-Ábrahám PhD School in Mechanical Engineering
- PhD School in Computer Science and Information Technology
- PhD School in Electrical Engineering
- Kálmán Kandó PhD School in Mechanical Engineering



Contents

2019/2020 ACADEMIC CALENDAR

Fall Semester: All accepted Preparatory Beginners

Preparatory Classes (Math, Physics) **for Placement Test**	**21 – 23 August**
Placement Tests: Math (26.08.), Physics (27.08.) and English Language (28.08.)	**26 – 28 August**
Placement Test Results Posted Outside Student's Office	**30 Aug at 12 am**
Presentation of Schedules for Freshmen in Bldg. R 1. Student's Office	30 Aug at 12 am -1 pm
Registration in Students' Office, Bldg. R 1. **(after payment of tuition fees)**	**26 Aug – 6 Sept 2019**
Appointments for Obligatory Medical Check-up (Necessary for Health Insurance).	2 Sept – 6 Sept 2019
Orientation Program Newly enrolled regular and Exchange Students	2 – 6 September
First day of classes	**9 Sept at 8:15 am (Monday)**
Opening ceremony	**19 Sept (Thursday)**
Last Day of Classes	**13 Dec (Friday)**
Examinations in fall semester of 2018/2019	2 Jan 2020 - 29 Jan 2020
Work days (instead of 24 and 27 Dec.)	7, 14 Dec 2019 (Saturdays)
Winter Holidays	**24 Dec 2019 - 1 Jan 2020**

Fall Semester: BSc/MSc Students

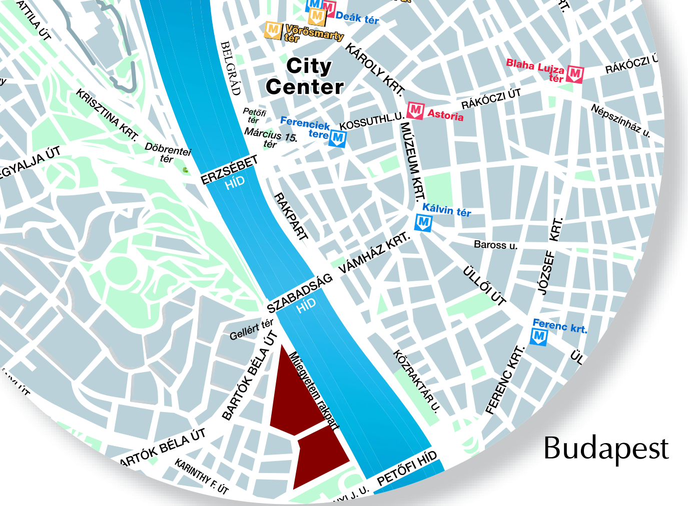
Registration in Student's Office	**26 Aug – 6 Sept 2019**
First Day of Classes	9 Sept 2019 (Monday)
Last Day of Classes	13 Dec 2019 (Friday)
Delayed submission	14 Dec 2019 – 20 Dec 2019
Winter Holidays for All Students	**24 Dec 2019 – 1 Jan 2020**
Examination Period (Check with your Faculty!)	**2 Jan 2020 – 29 Jan 2020**
Work days (instead of 24 and 27 Dec.)	7, 14 Dec 2019 (Saturdays)
Last Day of Final Exams	**29 Jan 2020**

Spring Semester: All Students

Orientation Program Newly enrolled regular and Exchange Students	**30 Jan - 1 Feb 2020**
Registration in Students' Office, Bldg. R 1.	5 Feb – 7 Feb 2020
First Day of Classes	**10 Feb 2020 (Monday)**
Last Day of Classes	**22 May 2020 (Friday)**
Delayed submission	25 May – 29 May 2020
Examination Period (Check with your Faculty!)	**2 June – 29 June 2020**
Last Day of Final Exams	**3 July 2020**

Days off for All Students

Sports day	12 Sept 2019 (Thursday)	Free day	27 Dec. 2019 (Friday)
National Day 1956	23 Oct 2019 (Wednesday)	Good Friday	10 April 2020 (Friday)
All Saints' Day	1 Nov 2019 (Friday)	Easter Monday	13 April 2020 (Monday)
Students' Scientific Conference	12 Nov 2019 (Tuesday)	Spring Holiday	14 – 17 April 2020
Open day	29 Nov 2019 (Friday)	Labour Day	1 May 2020 (Friday)
Free day	24 Dec. 2019 (Tuesday)	Whit Monday	1 June 2020 (Monday)



Budapest

Administration Block A
Fluid Mechanics Building Ae
Chemistry Building Ch
Mechanical Engineering Building D
Building Construction Laboratory El
Physics Building F
Production Engineering Building G
Informatics Buildings I, Q
Vehicle Engineering Building J
Central Building K
Central Library Kö
Hydraulic Machinery Laboratory L
Mechanics Building Mm/Mg
Mechanical Technology Building Mt
Classrooms R, T, H, E
Electrical Engineering and Informatics Buildings St, V1, V2
Nuclear Training Reactor TR

Office of International Education, Central Academic Office: R

Lágymányosi Bridge

MŰEGYETEM 1782

Budapest University of Technology and Economics

BME