Budapest University of Technology and Economics

Bulletin
2018-2019

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BULLETIN

Budapest University of Technology and Economics

2018–2019

An ECTS Guide

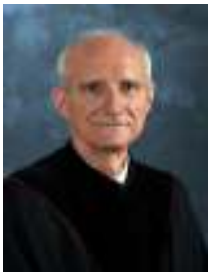
Engineering Programs in English
http://www.kth.bme.hu/en/
admission@kth.bme.hu

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 12 January 2018.

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 236 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 2018/2019 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
Physics	Faculty of Natural Sciences

MSc 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
Mechanical Engineering Modelling	Faculty of Mechanical Engineering
Physics	Faculty of Natural Sciences
Structural Engineering	Faculty of Civil Engineering
Transportation Engineering	Faculty of Transportation Engineering and Vehicle Engineering
Vehicle Engineering	
Logistics Engineering	

PhD programmes	Faculty
Study programmes	Faculty
Architecture Engineering	Faculty of Architecture
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
Mechanical Engineering Science	Faculty of Mechanical Engineering
Transportation Engineering	Faculty of Transportation Engineering and Vehicle Engineering
Vehicle Engineering	
Logistics Engineering	
Physical Sciences	Faculty of Natural Sciences

Tuition Fees for 2018/2019 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	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 Civil Engineering	8	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)		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

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
Central Academic Office:
Building R, ground floor, room No. 001
Mailing Address: Műegyetem rkp. 7-9.
H-1111 Budapest, Hungary
Phone: (+36-1) 463-4609
Fax: (+36-1) 463-2550
E-mail: nagy-margit@mail.bme.hu

Dean of the Faculty: Dr. László Jakab
Vice-Dean of the Faculty: Dr. Gábor Tevesz
Course Director: Dr. Eszter Udvary
International coordinator (Faculty): Ms Nóra Demeter
Study administrator (CAO): Ms Margit Nagy

Curriculum of BSc Subjects in Electrical Engineering

Subject			lectures/practical lectures/laboratory							
Name	Code	Credits	1	2	3	4	5	6	7	Requisities
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)										
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, 3		2	2/0/0/m	2/0/0/m					2/0/0/m	
Mandatory Humanities & Economics 4, 5		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		
Design Laboratory		3					0/0/2/m			
Project Laboratory	general	5						0/0/4/m		
Bsc Theses Work	general	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. At least power engineering will be available. List of subjects are published on the website.

Subject			lectures/practical lectures/laboratory							
Name	Code	Credits	1	2	3	4	5	6	7	Requisities
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	Credits	1	2	3	4	5	6	7	Requisities
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 Examin Calculus 1&2 For Informaticians	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)										
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						2/0/0/m		
Mandatory Humanities & Economics Elective 2		2						2/0/0/m		
Mandatory Humanities & Economics Elective 3		2							2/0/0/m	
Mandatory Humanities & Economics Elective 4, 5		2	2/0/0/m						2/0/0/m	
Core it 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						2/0/1/m		
Restricted electives[1]		3							3/0/0/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	
Design laboratory	general	3					0/0/3/m			
Project laboratory	general	5						0/0/4/m		
BSc theses work	general	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	

Subject			lectures/practical lectures/laboratory							
Name	Code	Credits	1	2	3	4	5	6	7	Requisities
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	
Restricted electives										
Embedded Information Systems	VIMIAD00	3							2/1/0/m	
Voice Information Systems	VITMAD00	3							2/1/0/m	
Declarative Programming	VISZAD00	3							2/1/0/m	
Image Processing	VIIIAD00	3							2/1/0/m	

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]One of the restricted electives (see below) must be finished.

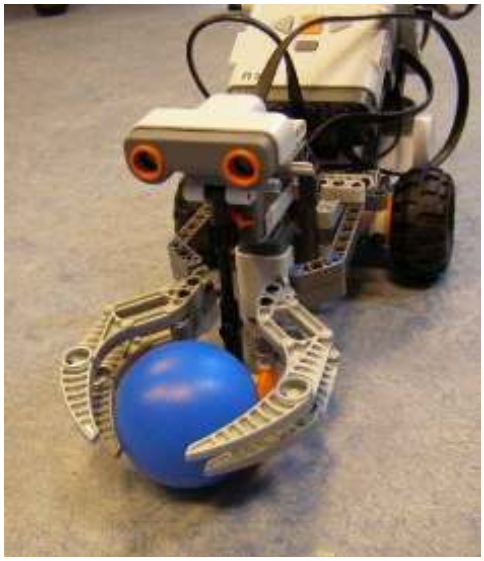
[2]10 credits of free electives could be substituted by any subjects available

[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. At least software engineering will be available. List of subjects are published on the website.

Subject			lectures/practical lectures/laboratory							
Name	Code	Credits	1	2	3	4	5	6	7	Requisities
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	Credits	1	2	3	4	Requisities
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			Credits of Project Laboratory 1
Thesis Project 1	BMEVIxxMT00	10			0/5/0/m		Credits of Project Laboratory 2
Thesis Project 2	BMEVIxxMT01	20				0/10/0/m	Credits of Thesis Project 1, and all credits
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		
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		

Notes:

1. Subjects from Economic and Human Sciences: three subjects are selected by the Faculty from the following list before the actual semester							
Quality Management	BMEGT20M002	2			2/0/0/m		
Argumentation, Negotiation, Persuasion	BMEGT41MS01	2			2/0/0/m		
Investments	BMEGT35M004	2			2/0/0/m		
Management Accounting	BMEGT35M005	2			2/0/0/m		

2. Secondary specializations will be determined before the first semester

3. 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)

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

Subject			lectures/practical lectures/ laboratory				
Name	Code	Credits	1	2	3	4	Requisities
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			Credits of Project Laboratory 1
Thesis Project 1	BMEVIxxMT00	10			0/5/0/m		Credits of Project Laboratory 2
Thesis Project 2	BMEVIxxMT01	20				0/10/0/m	Credits of Thesis Project 1, and all credits
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		
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		

Notes:

1. Subjects from Economic and Human Sciences: three subjects are selected by the Faculty from the following list before the actual semester							
Quality Management	BMEGT20M002	2			2/0/0/m		
Argumentation, Negotiation, Persuasion	BMEGT41MS01	2			2/0/0/m		
Investments	BMEGT35M004	2			2/0/0/m		
Management Accounting	BMEGT35M005	2			2/0/0/m		

2. Secondary specializations will be determined before the first semester.

3. 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	Credits	1	2	3	4	Requisities
Fundamentals in Natural Sciences (22 credits)							
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 Systems Integration)		14					
Project Laboratory 1	BMEVIxxML02	5	0/0/3/m				
Project Laboratory 2	BMEVIxxML03	5		0/0/3/m			Credits of Project Laboratory 1
Thesis Project 1	BMEVIxxMT02	10			0/5/0/m		Credits of Project Laboratory 2
Thesis Project 2	BMEVIxxMT03	20				0/10/0/m	Credits of Thesis Project 1, and all credits
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		

Notes:

1. Subjects from Economic and Human Sciences: three subjects are selected by the Faculty from the following list before the actual semester							
Quality Management	BMEGT20M002	2			2/0/0/m		
Argumentation, Negotiation, Persuasion	BMEGT41MS01	2			2/0/0/m		
Investments	BMEGT35M004	2			2/0/0/m		
Management Accounting	BMEGT35M005	2			2/0/0/m		

2. 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	Credits	1	2	3	4	Requisities
Fundamentals in Natural Sciences (22 credits)							
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 Systems Integration)		14					
Project Laboratory 1	BMEVIxxML02	5	0/0/3/m				
Project Laboratory 2	BMEVIxxML03	5		0/0/3/m			Credits of Project Laboratory 1
Thesis Project 1	BMEVIxxMT02	10			0/5/0/m		Credits of Project Laboratory 2
Thesis Project 2	BMEVIxxMT03	20				0/10/0/m	Credits of Thesis Project 1, and all credits
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		
Notes:							
1. Subjects from Economic and Human Sciences: three subjects are selected by the Faculty from the following list before the actual semester							
Quality Management	BMEGT20M002	2			2/0/0/m		
Argumentation, Negotiation, Persuasion	BMEGT41MS01	2			2/0/0/m		
Investments	BMEGT35M004	2			2/0/0/m		
Management Accounting	BMEGT35M005	2			2/0/0/m		

2. 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	Requisities
Fundamentals in Natural Sciences (22 credits)							
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 Systems Integration)		14					
Project Laboratory 1	BMEVIxxML02	5	0/0/3/m				
Project Laboratory 2	BMEVIxxML03	5		0/0/3/m			Credits of Project Laboratory 1
Thesis Project 1	BMEVIxxMT02	10			0/5/0/m		Credits of Project Laboratory 2
Thesis Project 2	BMEVIxxMT03	20				0/10/0/m	Credits of Thesis Project 1, and all credits
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		

Notes:

1. Subjects from Economic and Human Sciences: three subjects are selected by the Faculty from the following list before the actual semester							
Quality Management	BMEGT20M002	2			2/0/0/m		
Argumentation, Negotiation, Persuasion	BMEGT41MS01	2			2/0/0/m		
Investments	BMEGT35M004	2			2/0/0/m		
Management Accounting	BMEGT35M005	2			2/0/0/m		

2. Secondary specializations will be determined before the first semester.

3. 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, mea-

suring 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 cur-

rent 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: vectoriza-

tion. 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 continue 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 appli-

cations. 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)