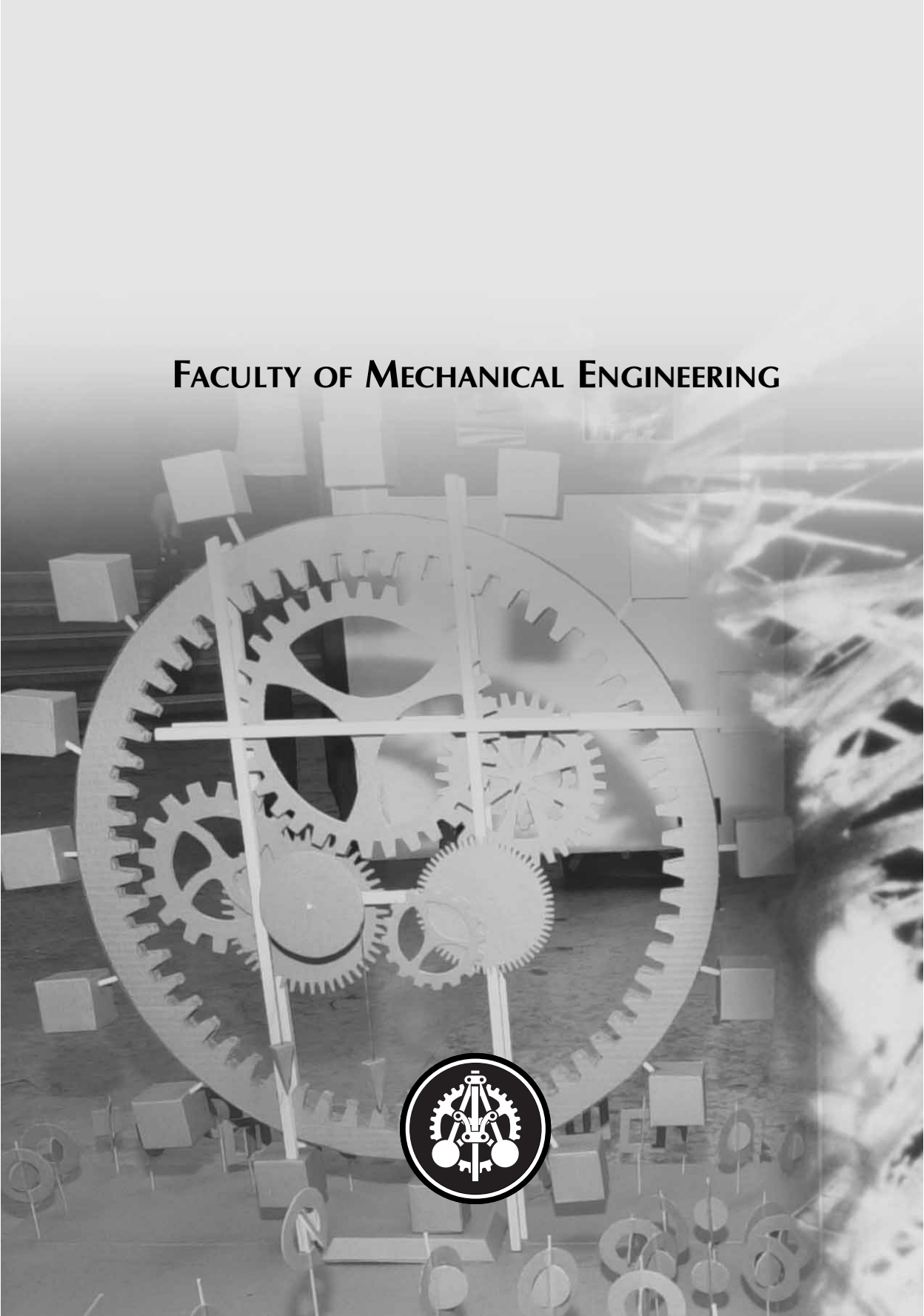
Faculty of Mechanical Engineering

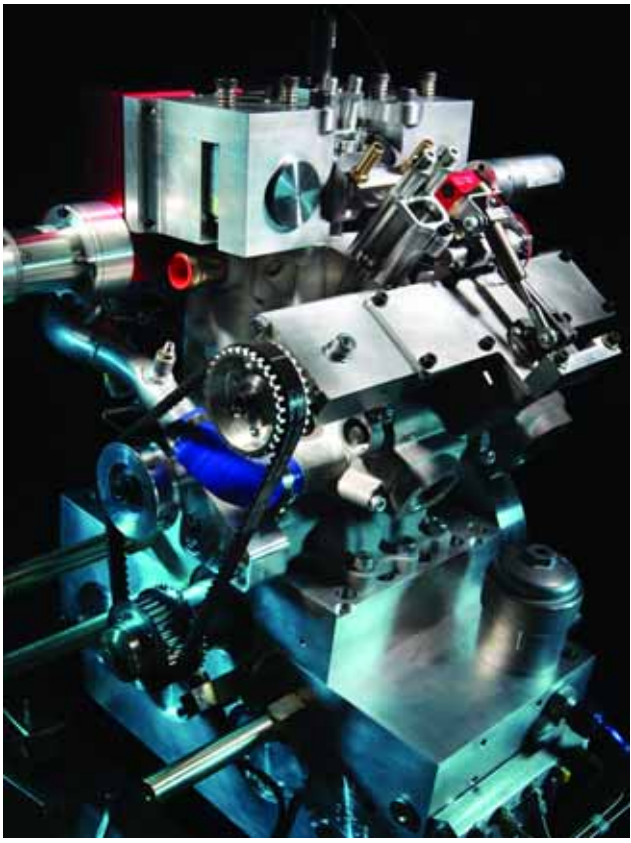


The Mechanical Engineering Program at the Budapest University of Technology and Economics began in 1863, and the Faculty of Mechanical Engineering was established soon afterward, beginning official operations in the 1871/72 academic year. The Faculty is justly proud of its continuous and progressive 150-year history and now offers undergraduate and graduate programs in both Hungarian and English.

Since the 2006/07 academic year, the Faculty of Mechanical Engineering has offered a 3.5-year undergraduate B.Sc. degree program in English. The new two-year graduate program in English, leading to an M.Sc. degree started in February 2009, students can start the study either in fall and in spring semester. Individual postgraduate academic and research programs, which are usually completed in two to three years, are available for those who already have an M.Sc. degree and wish to pursue a Ph.D. degree.

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

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



The goals of the Faculty's graduate M.Sc. and Ph.D. programs are:

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

Brief Description on the MSc in Mechanical Engineering Modeling started in 2009:

'One designed by a civil engineer starts moving that is bad; one designed by a mechanical engineer does not move that is bad, too. Mechanical engineers should design machines that move.'

This course deals with those time-dependent problems of mechanical engineering, which typically require the efficient modeling of these tasks in order to access the continuously developing methods of computational engineering. Modern computational methods are very popular since they show their easy-to-use interface for engineers. This often causes misunderstanding and disappointment during the naive applications of engineering software. Computational methods are reliable if they are properly tested and the principles of their applied algorithms and procedures are understood. This is analogous to the modern cartoon industry: the 25 pictures of one second of a cartoon can be drawn by computers if the first and the last picture of that second are designed for them by the artist but the computers will totally fail if they have to draw the cartoon without any reference picture, or based on the first (or last) picture only.

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

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

1. Solid Mechanics *2. Fluid Mechanics* *3. Thermal Engineering*
4. Design and Technology *5. Industrial Electronics (minor only)* *6. Robotics*

The possible combinations provide a large flexibility starting with the more research oriented knowledge (combinations of the first 3 modules), through the development oriented one (major form modules 1-3 and minor from 4-6 or vice versa), till the practice and applied oriented innovation (major and minor from the modules 4-6).

This new course is in English only. It is based on the foundations provided by the long-standing positive traditions of some former successful courses of the Faculty of Mechanical Engineering at BME, like Engineering Mathematics, Integrated Engineering (mechanical and electrical), Robotics (formerly also in Russian), Mechanical Engineering (BSc and MSc courses in English). This course is also compatible to many master courses in mechanical engineering in the European Union (see, for example, U Bristol, U Bath, ENS Cachan, TU Karlsruhe, U Hannover, TU Munich): Engineering Fluid Dynamics; Mechanics and Technical Design; Mechanics and Technology; Research in Mechanics and Systems of Engineering; Advanced Dynamics Engineering; Geometric Modeling and Design; Manufacturing Modeling; Power Transmission and Motion Control Systems; Thermal Engineering; Components of Electrical Engineering; Motion Engineering and Robotics; Dynamics and Control in Robotics; Computational Mechanics, etc.

Departments

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

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Vice-Dean of the Faculty: Dr. Tibor Szalay
Course Director: Prof. Dr. Gábor Stépán
Program Co-ordinator: Ms. Margit Nagy

Curriculum of B.Sc. Subjects

Subject			working hours / week								Requsities
Name	**Code**	**Credits**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
1st semester, Fall											
Compulsory English I.	BMEGT63A301	2	0/4/0								p
Descriptive Geometry	BMETE90AX06	3	1/2/0								e
Introduction to Mechanical Engineering	BMEGEVGAG01	4	2/1/1								e
Information Systems	BMEGERIA31I	4	2/0/2								p
Macro- and Microeconomics	BMEGT30A001	4	4/0/0								e
Mathematics A1a - Calculus	BMETE90AX00	6	4/2/0								e
Technical Chemistry	BMEVEKTAGE1	3	2/0/1								p
Statics	BMEGEMMAGM1	3	1/1/0								p
	Total credits:	**29**									
2nd Semester, Spring											
Compulsory English II.	BMEGT63A302	2		0/4/0							p
Materials Science and Testing	BMEGEMTAGA1	6		3/1/1							e
Fundamentals of CAD	BMEGEGEA3CD	4		1/0/2							p
Physics A2	BMETE15AX02	2		2/0/0							e
Fundamentals of Machine Design	BMEGEGEAGM1	4		2/2/0							p
Mathematics A2a - Vector Functions	BMETE90AX02	6		4/2/0							e
Software Engineering	BMEGERIA32P	2		0/2/0							p
Strength of Materials	BMEGEMMAGM2	5		2/2/0							e
	Total credits:	**31**									
3rd Semester, Fall											
Dynamics	BMEGEMMAGM3	5			2/2/0						e
Materials Engineering	BMEGEMTAGA2	4			2/1/1						e
Physics A3	BMETE15AX03	2			2/0/0						p
Machine Elements 1.	BMEGEGEAGG1	5			2/1/1						e
Environmental Management Systems	BMEGT42A003	3			3/0/0						p
Mathematics A3 for Mechanical Engineers	BMETE90AX10	4			2/2/0						p
Mathematics Global Exam	BMETE90AX23										ge
Analysis of Technical and Economical Data	BMEGEVGAG14	3			2/1/0						p
Measurement Technology	BMEGEMIAMG1	3			2/0/1						p
	Total credits:	**29**									
4th Semester, Spring											
Basics of Electrical Engineering	BMEVIAUA007	3				2/0/1					p
Machine Elements 2.	BMEGEGEAGG2	6				3/1/1					e
Manufacturing	BMEGEGTAG01	5				2/0/3					e
Fluid Mechanics	BMEGEÁTAG11	5				3/1/1					p
Engineering Thermodynamics	BMEGEENAETD	3				2/1/0					p
Polymer Materials Science and Engineering	BMEGEPTAG0P	6				3/0/2					e
Vibrations	BMEGEMMAGM4	3				2/1/0					p
Mechanics Global Exam	BMEGEMMAGM0										ge
	Total credits:	**31**									
5th Semester, Fall											
Electromechanics	BMEVIAUA008	4					2/1/1				e
Control Engineering	BMEGEMIAGEI	4					2/2/0				e
Heat Transfer	BMEGEENAEHK	4					2/2/0				e
Diffusion Processes	BMEGEVÉAG02	2					1/1/0				e
Measurement at Energy and Env. Protection	BMEGEENAG51	3					0/1/2				p
Measurement Technique of Processes	BMEGEVGAG03	2					1/0/1				p
Fundamentals of FEM	BMEGEMMAGM5	3					1/1/1				p
Management and Business Economics	BMEGT20A001	4					4/0/0				p
Business Law	BMEGT55A001	2					2/0/0				p
Optional subject:		2									
Marketing (2 credits) OR	BMEGT20A002						2/0/0				e
Communication Skills - English (2 credits)	BMEGT63A061						0/2/0				e
	Total credits:	**30**									
6th Semester, Spring											
Technical Acoustics and Noise Control	BMEGEÁTAG15	3						2/0/1			e
Fluid Machinery	BMEGEVGAG02	4						2/1/1			e
Heat Engines	BMEGEENAEGK	4						2/1/1			e
Numerical Simulation of Fluid Flows	BMEGEÁTAG06	2						1/0/1			p
Processes and Equipments of Chemical Industry	BMEGEVÉAG03	5						3/2/0			e
Air Pollution, Wastewater and Solid Waste Man.	BMEGEÁTAG04	3						3/0/0			p
Independent Study 1	BMEGEVGAG06	4						0/0/4			p
Optional subject:		4									
Heating (4 credits) OR	BMEGEÉPAG61							3/1/0			e
Manager Communication (2 credits) AND	BMEGT63A081							0/2/0			e
Crosscultural Communication (2 credits)	BMEGT63A091							0/2/0			e
	Total credits:	**29**									

Notations: lecture/practice/laboratory, e - exam, p - practical mark, ge - global exam

Curriculum of B.Sc. Subjects (contd.)

Subject			working hours / week								Requsities
Name	**Code**	**Credits**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
7th Semester, Fall											
Fluid Flow Systems	BMEGEVGAG07	3							2/1/0		p
Energy Processes and Equipments	BMEGEENAG71	5							3/0/2		p
Volumetric Pumps and Compressors	BMEGEVGAG04	2							1/1/0		p
Measurement for Chemical and Env. Proc.	BMEGEVÉAG04	3							0/1/2		p
Final Project	BMEGEXXA4SD	15							0/10/0		p
Optional subject:		4									
Air-conditioning (4 credits)	BMEGEÉPAG62								2/2/0		p
	Total credits:	**32**									
The Faculty of Mechanical Engineering offers additional and optional courses (30 credits - upgrade 240) on BSc level to its students to take.											
Optional subjects											
Modeling of Processes and Equipment	BMEGEÉEAG01	3							1/1/0		p
Laboratory	BMEGEÉEAG00	5							0/0/4		p
Independent Study 2	BMEGEVGAIP2	8							0/0/8		p
Heating	BMEGEÉPAG61	4							3/1/0		e
Manager Communication	BMEGT63A081	2							0/2/0		e
Crosscultural Communication	BMEGT63A091	2							0/2/0		e
English for Engineers	BMEGT63A051	2							0/4/0		e
Analytical Mechanics	BMEGEMMMW01	4							3/0/0		e
Advanced Fluid Mechanics	BMEGEÁTMW01	4							3/0/0		e
Advanced Thermodynamics	BMEGEENMWAT	4							2/1/0		e

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Curriculum of M.Sc. Subjects

Subject	Beginning: spring				Beginning: fall			
Name	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Mechanical Engineering Modeling								
Basic Subjects								
Differential Equations and Numerical Methods	4/2/0/8/e					4/2/0/8/e		
Laser Physics		3/1/0/4/e			3/1/0/4/e			
Analytical Mechanics	3/0/0/4/e					3/0/0/4/e		
Advanced Fluid Mechanics	3/0/0/4/e					3/0/0/4/e		
Advanced Thermodynamics	2/1/0/4/e					2/1/0/4/e		
Electronics		2/0/1/4/e			2/0/1/4/e			
Advanced Control and Informatics		2/1/0/4/e			2/1/0/4/e			
Special Compulsory Subjects								
Machine Design and Production Technology		2/1/0/4/e			2/1/0/4/e			
Major Compulsory Subject I		3/0/1/5/p			3/0/1/5/p			
Major Compulsory Subject II	2/1/0/5/p					2/1/0/5/p		
Major Project			0/0/11/14/p				0/0/11/14/s	
Special Subjects								
Major Elective Subject I			1/0/2/3/e					1/0/2/3/e
Major Elective Subject II				1/0/1/3/e			1/0/1/3/e	
Major Elective Subject III				1/1/0/3/p			1/1/0/3/p	
Minor Compulsory Subject I	3/0/1/5/p					3/0/1/5/p		
Minor Compulsory Subject II		2/1/0/5/p			2/1/0/5/p			
Minor Elective Subject I			1/0/1/3/e					1/0/1/3/e
Minor Elective Subject II			2/0/0/3/p					2/0/0/3/p
Final Project				0/0/15/19/s			0/0/15/19/s	
Subjects in Economics								
Management		3/0/0/5/p			3/0/0/5/p			
Marketing			3/0/0/5/p					3/0/0/5/p
Elective Subjects								
Further Elective Subjects			1/1/0/3/p	1/0/1/3/p			1/0/1/3/p	1/1/0/3/p
Criterion								
Industrial Practice								
Total								
Total credit points	30	31	31	28	31	30	28	31
Total contact hours	17/4/1/22	17/4/2/23	8/0/15/23	3/2/16/21	17/4/2/23	17/4/1/22	3/2/16/21	8/0/15/23
Number of Exams	4	4	2	1	4	4	1	2
Fluid Mechanics								
Basic Subjects								
Advanced Fluid Mechanics	3/0/0/4/e					3/0/0/4/e		
Special subjects / Major or Minor Compulsory Subjects								
Computational Fluid Dynamics		2/2/0/5/p			2/2/0/5/p			
Flow Measurements	2/1/1/5/p					2/1/1/5/p		
Major Project			0/0/11/14/p				0/0/11/14/s	
Special subjects / Major or Minor Elective Subjects								
Large-Eddy Simulation in Mechanical Engineering			1/1/0/3/ p					1/1/0/3/p
Fluid Technical Process Modeling			2/0/0/3/p					2/0/0/3/p
Multiphase and Reactive Flow Modeling			1/1/0/3/p					1/1/0/3/p
Unsteady Flows in Pipe Networks			2/0/0/3/p					2/0/0/3/p
Measurement Techniques and Signal Processing			2/0/0/3/p					2/0/0/3/p
Building Aerodynamics				2/0/1/3/p			2/0/1/3/p	
Aerodynamics and its Application for Vehicles				2/0/0/3/p			2/0/0/3/p	
Advanced Technical Acoustics and Measurement Techniques				2/0/0/3/p			2/0/0/3/p	
Hemodynamics				2/0/0/3/p			2/0/0/3/p	
Flow Stability				2/0/0/3/p			2/0/0/3/p	
Theoretical Acoustics				2/0/0/3/p			2/0/0/3/p	
Final Project				0/0/15/19/s			0/0/15/19/s	
Solid Mechanics								
Basic Subjects								
Analytical Mechanics	3/0/0/4/e					3/0/0/4/e		
Special subjects / Major or Minor Compulsory Subjects								
Finite Element Analysis	2/0/2/5/p					2/0/2/5/p		
Continuum Mechanics		2/1/0/5/p			2/1/0/5/p			
Major Project			0/0/11/14/p				0/0/11/14/s	
Special subjects / Major or Minor Elective Subjects								
Elasticity and Plasticity			1/1/0/3/p					1/1/0/3/p
Nonlinear Vibrations			1/1/0/3/e					1/1/0/3/e
Coupled Problems in Mechanics			1/0/1/3/p					1/0/1/3/p
Mechanisms				1/1/0/3/p			1/1/0/3/p	
Beam Structures				1/1/0/3/e			1/1/0/3/e	
Experimental Methods in Solid Mechanics				1/0/1/3/p			1/0/1/3/p	
Final Project				0/0/15/19/s			0/0/15/19/s	

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

Curriculum of M.Sc. Subjects

Subject	Beginning: spring				Beginning: fall			
Name	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Themal Engineering								
Basic Subjects								
Advanced Thermodynamics	2/1/0/4/e					2/1/0/4/e		
Special subjects / Major or Minor Compulsory Subjects								
Combustion Technology		2/1/1/5/p			2/1/1/5/p			
Measurements in Thermal Engineering	1/0/3/5/p					1/0/3/5/p		
Major Project			0/0/11/14/p					0/0/11/14/s
Special subjects / Major or Minor Elective Subjects								
Energy Conversion Processes and its Equipment			2/1/0/3/e					2/1/0/3/e
Simulation of Energy Engineering Systems			1/0/2/3/p					1/0/2/3/p
Thermal Physics			2/0/1/3/p					2/0/1/3/p
Thermo-Mechanics				2/0/1/3/p			2/0/1/3/p	
Steam and Gas Turbines				2/1/0/3/p			2/1/0/3/p	
Thermo-Hydraulics				2/1/0/3/e			2/1/0/3/e	
Final Project				0/0/15/19/s			0/0/15/19/s	
Design and Technology								
Special subjects / Major or Minor Compulsory Subjects								
Machine Design and Production Technology		2/1/0/4/e			2/1/0/4/e			
Product Modeling		2/0/1/5/p			2/0/1/5/p			
Advanced Manufacturing	1/0/3/5/p					1/0/3/5/p		
Major Project			0/0/11/14/p					0/0/11/14/s
Special subjects / Major or Minor Elective Subjects								
CAD Technology			1/0/2/4/p					1/0/2/4/p
Materials Science			2/0/0/3/e					2/0/0/3/e
Structural Analysis			1/0/2/4/p					1/0/2/4/p
Process Planning				1/1/0/3/p			1/1/0/3/p	
NC Machine Tools				1/1/0/3/p			1/1/0/3/p	
Fatigue and Fracture				2/0/0/3/e			2/0/0/3/e	
Final Project				0/0/15/19/s			0/0/15/19/s	
Industrial Electronics								
Basic Subjects								
Electronics		2/0/1/4/e			2/0/1/4/e			
Special subjects / Major or Minor Compulsory Subjects								
Power Electronics		2/0/1/5/p			2/0/1/5/p			
Motion Control	2/0/1/5/p					2/0/1/5/p		
Special subjects / Major or Minor Elective Subjects								
Analog Electronics			1/0/2/3/p					1/0/2/3/p
Digital Electronics			1/0/2/3/p					1/0/2/3/p
Real Time Systems			1/0/2/3/p					1/0/2/3/p
Programmable Digital Devices				1/0/1/3/p			1/0/1/3/p	
Industrial Vision Systems				1/0/1/3/p			1/0/1/3/p	
Web Based Laboratory				1/0/1/3/p			1/0/1/3/p	
Industrial Embedded Systems				1/0/1/3/p			1/0/1/3/p	
Robotics								
Basic subjects								
Advanced Control and Informatics		2/1/0/4/e			2/1/0/4/e			
Special subjects / Major or Minor Compulsory Subjects								
Robot Constructions		2/0/1/5/p			2/0/1/5/p			
Robot Control	2/1/0/5/p					2/1/0/5/p		
Major Project			0/0/11/14/p					0/0/11/14/s
Special subjects / Major or Minor Elective Subjects								
Production Planning and Control			3/0/0/3/e					3/0/0/3/e
Software Technologies			2/0/1/3/p					2/0/1/3/p
Artificial Neural Networks and Hybrid Systems			1/1/0/3/e					1/1/0/3/e
Robot Programming			1/0/2/3/p					1/0/2/3/p
Simulation of CNC Machines and Robots				2/0/0/3/p			2/0/0/3/p	
Assembly				1/1/1/3/p			1/1/1/3/p	
Special Robots and Robot Applications				1/1/0/3/p			1/1/0/3/p	
Microelectronics in Control				1/1/0/3/p			1/1/0/3/p	
Final Project				0/0/15/19/s			0/0/15/19/s	

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Description of B.Sc. Subjects

Compulsory English I and II.

BMEGT63A301, BMEGT63A302

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

Descriptive Geometry

BMETE90AX06

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

Introduction to Mechanical Engineering

BMEGEVGAG01

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

Information Systems

BMEGERIA31I

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

Macro- and Microeconomics

BMEGT30A001

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

Mathematics A1a - Calculus

BMETE90AX00

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

Technical Chemistry

BMEVEKTAGE1

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

Statics

BMEGEMMAGM1

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

Materials Science and Testing

BMEGEMTAGA1

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

Fundamentals of CAD

BMEGEGEA3CD

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

Physics A2

BMETE15AX02

Properties of electric charges. Insulators and conductors. Coulomb's law. The electric field. Superposition. Electric field lines of forces. The electric flux. Gauss's law. Examples: the electric field of some specific charge distributions. The elec-

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

Fundamentals of Machine Design

BMEGEGEAGM1

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

Mathematics A2a -Vector Functions

BMETE90AX02

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

Software Engineering

BMEGERIA32P

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

Strength of Materials

BMEGEMMAGM2

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

Dynamics

BMEGEMMAGM3

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

Materials Engineering

BMEGEMTAGA2

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

Physics A3

BMETE15AX03

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

Machine Elements 1

BMEGEGEAGG1

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

Environmental Management Systems

BMEGT42A003

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

Mathematics A3 for Mechanical Engineers

BMETE90AX10

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

Analysis of Technical and Economical Data

BMEGEVGAG14

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

Measurement Technology

BMEGEMIAMG1

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

Basics of Electrical Engineering

BMEVIAUA007

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

Machine Elements 2

BMEGEGEAGG2

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

Manufacturing

BMEGEGTAG01

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

Fluid Mechanics

BMEGEÁTAG11

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

Engineering Thermodynamics

BMEGEENAETD

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

Polymer Materials Science and Engineering

BMEGEPTAG0P

The main goal of the Materials Science and Engineering is to introduce the students to the polymers as structural materials with emphasis on their differences from traditional engineering materials. The role of polymers in the engineering materials. Classification of polymers, thermoplastics and thermosets, Crystal structure and morphology. Mechanical, dynamic mechanical and thermo-mechanical behaviour of

polymers. Melt-rheology of thermoplastics. Polymer melts as non-Newtonian viscous liquids. Flow of polymer melts in tubes and rectangular ducts. Extrusion of thermoplastics. Manufacturing of polymer sheets on calanders. Polymer processing technologies of complex 3D parts and products. Main parts and function of reciprocating screw-injection moulding machines. Thermoforming. Processing technologies of thermosets. Rubber technology. Processing technologies of high strength, reinforced polymer composites. 5 hours/6 credits.

Vibrations

BMEGEMMAGM4

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

Electromechanics

BMEVIAUA008

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

Control Engineering

BMEGEMIAGEI

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

Heat Transfer

BMEGEENAEHK

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

Diffusion Processes

BMEGEVÉAG02

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

Measurement at Energy and Environmental Protection

BMEGEENAG51

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

Measurement Technique of Processes

BMEGEVGAG03

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

Fundamentals of FEM

BMEGEMMAGM5

Short history of the finite element method. The principle of the total potential energy minimum. Ritz's method for slender beams, matrix formulation. Basic algebraic operations in Maple. The basics of the finite element discretization, element types. Detailed description of the TRUSS2D and BEAM2D elements. Local-global coordinate transformations. Lagrangian and Hermitian interpolation functions. Derivation of element and structural stiffness matrices, load vectors. Modelling examples: beams and frames, symmetric structures. Solution of the finite element equations. Longitudinal, torsional and bending vibration of slender beams. Finite element analysis of vibration problems, frequency and mode shape analysis. Eigenvalue problems in Maple. Critical angular velocities of rotating shafts with disks. Plane elasticity, linear triangle element, stiffness matrix, load vector, modelling example. Solution of FE problems in Maple. Laboratory practices using ANSYS and COSMOS/M. 3 hours/3 credits.

Management and Business Economics

BMEGT20A001

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

Business Law

BMEGT55A001

The problems of the area will be treated in two major parts. Part One introduces students to the general topics, for example the concept of law, the functions of the law in the socioeconomic life. Some basic legal problems, like the conception, characteristics and functions of the modern state and, in a comparative view, the characteristics of the Anglo-Saxon and continental systems of business law and the development of the Hungarian business law will be also discussed. The emphasis of Part Two is on the questions of company law and competition law presented in a European context. The lec-

tures of this part outline not only the regulations of the Hungarian Company Act and Company Registry Act but they cover EU directives and regulations on companies and competition as well. 2 hours/2 credits.

Marketing

BMEGT21A002

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

Communication Skills - English

BMEGT63A061

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

Technical Acoustics and Noise Control

BMEGEÁTAG15

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

Fluid Machinery

BMEGEVGAG02

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

Heat Engines

BMEGEENAEGK

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

Numerical Simulation of Fluid Flows

BMEGEÁTAGO6

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

Processes and Equipment of Chemical Industry

BMEGEVÉAG03

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

Air Pollution, Wastewater and Solid Wastes Management

BMEGEÁTAG04

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

Independent Study 1

BMEGEVGAG06

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

Heating

BMEGEÉPAG61

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

Crosscultural Communication

BMEGT63A091

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

Fluid Flow Systems

BMEGEVGAG07

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

Energy Processes and Equipments

BMEGEENAG71

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

Volumetric Pumps and Compressors

BMEGEVGAG04

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

Measurement for Chemical and Environmental Processes

BMEGEVÉAG04

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

Final Project

BMEGEÉPAG62

One-semester long individual project work.
10 hours/15 credits.

Air-Conditioning

BMEGEÉPAG62

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

Additional and optional courses on BSc level Pre-requisites: BSc final exam (diploma)

Modeling of Processes and Equipment

BMEGEÉEAG01

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

Laboratory

BMEGEÉEAG00

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

Independent Study 2

BMEGEVGAIP2

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

English for Engineers

BMEGT63A051

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

Analytical Mechanics

BMEGEMMMW01

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

Advanced Fluid Mechanics

BMEGEATMW01

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

Advanced Thermodynamics

BMEGEENMWAT

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

Description of M.Sc. Subjects in Mechanical Engineering Modeling

Basic Subjects

Differential Equations and Numerical Methods

BMETE90MX46

Ordinary differential equations. Well-posedness of initial value problems. Various types of stability. Stability of equilibria by linearization and Liapunov functions. Phase space analysis near equilibria and periodic orbits. The loss of stability in parametrized families of equations. Explicit/implicit Euler and Runge-Kutta methods. Comparing exact and approximate dynamics, error estimate between exact and approximate solutions. Retarded equations. Partial differential equations. The standard initial and boundary value problems of mathematical physics. Separation of variables. Fourier series as coordinate representation in Hilbert space. The method of finite differences for the heat equation: error estimate and the maximum principle.

Laser Physics

BMETE12MX00

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

Analytical Mechanics

BMEGEMMMW01

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

Advanced Fluid Mechanics

BMEGEÁTMW01

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

Advanced Thermodynamics

BMEGEENMWAT

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

Electronics

BMEVIAUM001

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

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

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

Advanced Control and Informatics

BMEGEMIMW01

The aim of subject to introduce the construction of advanced computer controlled systems and main control algorithms. Introducing the sampling theory - conditions and limitations. Feature and application of Z transformation. Modeling of systems using sampled discrete transfer function and sampled state space equations. Introducing the most important analytical methods of discrete time systems. Showing design methods creating control systems with the next methods: the pole-placement with tracking and regulation objectives, the minimum-variance control, the moving-average control, the dead-beat control, the mean-level control, and linear-quadratic-gaussian (LQG) control designs.

Machine Design and Production Technology

BMEGEGEMW01

(Special Compulsory Subject)

Machine design: Design principles and methods. Requirements. Modern design techniques. Structural behavior and modeling. Design of frame structures. Polymer and composite components. Load transfer between engineering components. Structural optimization (object function, design variables, constrains, shape and size optimization).

Production: Machine-tools and equipment, devices and fixtures, kinematics, machining principles, production procedures and processes, production volume, batches and series. Manufacturability and tooling criteria, preliminary conditions and production analysis, methods of sequencing operations, production planning and scheduling. Production management (TQC and JIT), automated production; cellular manufacturing, machining centres and robots. Product data and technical document management (PDM, TDM), engineering changes and production workflow management (CE, ECM).

Fluid Mechanics module

Computational Fluid Dynamics

BMEGEÁTMW02

Main objective of the subject is providing sufficient theoretical background and practical knowledge for professional CFD engineers. Detailed thematic description of the subject: Derivation of differentiation and integration schemes; accuracy and stability. Approximation of surface integrals, divergence and gradient terms in finite volume method. Numerical fluxes, upwinding schemes. Solution methods for the pressure-velocity coupling: psi-omega method, pressure correction methods. Solution of linear systems of algebraic equations with special respect to the iterative Poisson solvers. Characteristics of the governing equations of compressible fluid flows. Method of characteristics. Finite volume method with explicit time marching scheme for compressible fluid flows. Numerical mesh: quality requirements and advanced meshing techniques. Main characteristics of the turbulence. Length scales. Overview of turbulent models: Reynolds-averaged models, transport equation of turbulent kinetic energy, two-equation models. Analyses of the sources of errors and uncertainties. Error estimation. Simulation exercises in computer laboratory.

Flow Measurements

BMEGEÁTMW03

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

Major Project in Fluid Mechanics

BMEGEÁTMWD1

The aim of the course is to develop and enhance the capability for complex problem solving of the students under advisory management of their project leader and advisors. Each student's project is guided by the project leader and depending on the problem -if applicable- by advisor(s). They form the so-called evaluation team.

Detailed thematic description of the subject: Several experimental and/or numerical (CFD) major project proposals will be announced by the project leaders on the registration week or before. The major project proposals are defined as being complex problems for the 3rd semester and also can be continued in course of the Final Project (BMEGEÁTMWD2) in the 4th semester, hence resulting in the Master Thesis of the student.

In course of the Major Project one single student or group of max. 2 students will work on one selected challenging problem of fluid mechanics.

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

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

3rd evaluation team meeting on the 13th week: 3rd major project presentation by the student

On the 14th week: submission of the major Project Report in printed and electronic (CD/DVD) format.

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

Special subjects / Major or Minor Elective Subjects

Large-Eddy Simulation in Mechanical Engineering

BMEGEÁTMW05

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

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

Fluid Technical Process Modeling

BMEGEÁTMW06

The main objective of the subject is to get acquainted with various industrial fields, with special regard to ones based on fluid mechanical processes. Obtainment of skill in recognition and solution of industry-related problems, on the basis of real case studies.

Detailed thematic description of the subject: Case studies from various fields of industry regarding problem solution related to fluid flow technology. Outline of the technological process, problem setting. Practical aspects of problem setting. Error analysis. Field work: on-site measurements and additional studies. Simulation case studies. Interactive solution of industry-related diagnostic problems. Proposals for elimination of the problem and their justification. Future remarks.

Multiphase and Reactive Flow Modeling

BMEGEÁTMW07

The main objective of the subject is to understand the physical phenomena occurring in fluid systems with more than one chemical components or more than one phases. Familiarization with special measurement techniques used in such systems. Outlining the concepts of possible theoretical models and numerical modeling, understanding limitations due to restricted range of validity and computational resources. Detailed studying of models used in some typical engineering applications.

Detailed thematic description of the subject: Physical phenomena, major concepts, definitions and modeling strategies. Lagrangian vs. Eulerian description. Equilibrium vs. non-equilibrium models. Dimensionless numbers. Modeling free surface and fluid-fluid interfaces. Bubble growth and collapse. Gravity and capillary waves. Dispersed particle transport. Flow regimes and model options. Sedimentation and fall-out. Flow regimes in vertical, horizontal and inclined pipes.

Closure relations. Advanced two-phase flow instrumentation. Phase change and heat transfer in single-component systems: boiling, cavitation, condensation. Related heat transport problems and industrial applications. Phase interactions: particle agglomeration and break-up. Modeling chemical reactions: flames, combustion models, atmospheric reactions. Computational Multi-Fluid Mechanics (CMFD): general methods and limitations, usage of general purpose computational fluid dynamics codes, design of specialized target software. Applications in power generation, hydrocarbon and chemical industry.

Unsteady Flows in Pipe Networks

BMEGEVGMW02

Structure of piping systems. Description of steady flow as initial condition for computing transient operation. Derivation of the basic equation system for 1D unsteady flow in pipe sections. Solution methods: method of characteristics, implicit methods. Boundary condition treatment. Modeling gas release and cavitation. Open channel flow modeling. Possibilities to protect the system from dangerous pressure surges, check valves, air chambers. Electrodynamic analogy, the impedance method.

Measurement Techniques and Signal Processing

BMEGEMIMW07

Signals and systems in the time and frequency domains. Mathematical methods in signal processing. Methods of digital data acquisition and signal processing.

Measurement errors and probability. Signal to noise ratio improvement. Analogue signal filtering and processing. Filtering and processing of digital signals.

Noisy periodic signals, stochastic signals, amplitude density function, cross- and autocorrelation. Statistical methods of signal processing: non-parametric and parametric statistical tests.

Building Aerodynamics

BMEGEÁTMW08

The main objective of the subject is to extend the knowledge of students in Aerodynamics in general and in Building Aerodynamics and transport of pollutant in particular as well as to contribute to development of skills of students in practical use of theoretical knowledge.

Detailed thematic description of the subject: Structure and properties of atmospheric boundary layer, characteristics of wind. Bluff-body aerodynamics: boundary layer separation, characteristics of separated flows, vortices, their effects on the flow description of complex 3-dimensional flow fields. Arising and characterisation of wind forces. Wind and structure interaction, aero-elasticity. Building aerodynamics (buildings, chimney and towers). Bridge aerodynamics. Computational wind engineering. Wind codes and standards: fundamentals and philosophy (ASCE and EUROCODE). Wind loading estimates based on wind tunnel measurements, numerical simulation and standards. Dispersion of pollutants in urban environment, effect of buildings on dispersion. Relationship between wind effects and ventilation of halls and rooms in building. Wind tunnel and CFD case studies.

Aerodynamics and Its Application for Vehicles

BMEGEÁTMW09

The main objective of the subject is to extend the knowledge of students in Aerodynamics in general and in Vehicle Aerodynamics in particular as well as to contribute to development of skills of students in practical use of theoretical knowledge.

Detailed thematic description of the subject: Streamlined body aerodynamics: theory of airfoils, streamlined bodies of revolution, streamlined bodies of finite extension. Compressibility effects, flows with variable air density. Impact of aerodynamics on aircrafts at subsonic and supersonic speeds. Bluff body aerodynamics: boundary layer separation, characteristics of separated flows, vortices, their effects on the flow and their detection techniques, description of complex 3-dimensional flow fields. Principles of aerodynamic design and optimization of passenger car bodies, trucks and buses. Basics of flow control: control techniques without flow separation (turbulators, boundary layer blow down and suction), and with flow separation (high lift devices, vortex generators, winglets). STOL aircraft, delta wing aircraft, Formula 1 race car aerodynamics.

Advanced Technical Acoustics and Measurement Techniques

BMEGEÁTMW10

The main objective of the subject is to extend the knowledge in technical acoustics and measurement techniques with the help of presentation of acoustic design and measurement methods, common in the engineering practise.

Detailed thematic description of the subject: The ray theory, sound propagation in non-homogeneous media. Sound propagation in duct and higher order modes. Spherical waves, and the point monopole, dipole and quadrupole sound sources. The flow generated sound, Lighthill's acoustic analogy and the inhomogeneous wave equation. Attenuation of sound waves. Acoustic measurements, microphones, analysers, calibrators, intensity measurement, anechoic and reverberating chambers.

Hemodynamics

BMEGEVGMW06

Fluid mechanical and structural questions of the arterial system. Models and methods for the description of blood flow in blood vessels (fluid mechanical and mechanical equations), numerical solution of the equations. Major invasive and non-invasive methods of blood flow and blood pressure measurements, methods for numerical modeling of blood pressure. Characteristic physiological quantities and their influence in hemodynamics.

Flow Stability

BMEGEVGMW07

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

Theoretical Acoustics

BMEGEVGMW08

Lighthill's theory. Green functions, jet noise. Effect of rigid walls,.the Ffowcs-Williams - Hawkings equation. Effect of flows on sound propagation, the Philips and the Lilley equation. Vibrating string, membrane and plate. Sound radiation from planes, cylinders and spheres. Sound waves in ducts, higher modes, dissipation, flexible wall. Diffraction of sound waves.

Final Project in Fluid Mechanics

BMEGEÁTMWD2

The aim of the course is to develop and enhance the capability for complex problem solving of the students under advisory management of their project leader and advisors. Each student's project is guided by the project leader and depending on the problem -if applicable- by advisor(s). They form the so-called evaluation team.

Detailed thematic description of the subject: Several experimental and/or numerical (CFD) final project proposals will be announced by the project leaders on the registration week or before. The final project proposals are defined as being complex problems of fluid mechanics, that's solving started in the 3rd semester in course of the Major Project (BMEGEÁTMWD1) and is to be continued in course of this Final Project (BMEGEÁTMWD2) in the 4th semester, hence resulting in the Master Thesis of the student. In course of the Final Project one single student will work on the selected challenging problem of fluid mechanics.

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

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

3rd evaluation team meeting: on the 13th week: 3rd final project presentation by the student

On the 14th week: submission of the final Project Report (ie. the Master Thesis) in printed and electronic (CD/DVD) format.

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

Solid Mechanics module

Special subjects / Major or Minor Compulsory Subjects

Finite Element Analysis

BMEGEMMMW02

The basic equations of linear elasticity. The principle of the total potential energy mimum. Finite element discretization. Shear effect in beams, Timoshenko beam theory. FE formulation of Timoshenko beams. Isoparametric Timoshenko beam element, shear locking, interpolation with exact nodal solution, examples. The basic equations in plane elasticity. Isoparametric quadrilateral elements, shape functions, Jacobian matrix and deteminant. Numerical integration, Gaussian rule. Stiffness matrix and load vectors of quadrilaterals. Stability of linear elastic systems, the method of Trefftz. FE formulation of stability problems, geometric stiffness matrix. Buckling, lateral buckling and lateral-torsional buckling of slender beams with symmetric cross section, examples. Torsion of straight prismatic beams. Free vibration analysis with FEM, vibration of Timoshenko beams. FE solution of damped forced vibrations, Duhamel integral. Direct time integration, central difference method, Newmark's method, numerical examples. Second order dynamics, buckling vibration of beams. Dynamic stability. Modelling examples in ANSYS including elasticity, plasticity, elastic stability, dynamics and thermomechanics problems.

Continuum Mechanics

BMEGEMMMW03

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

Major Project in Solid Mechanics

BMEGEMMMWD1

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

Special subjects / Major or Minor Elective Subjects

Elasticity and Plasticity

BMEGEMMMW05

Elasticity: Covers vector and tensor analysis, indicial notation. Displacements and small strains. Compatibility of strain. Theory of stress. Principle stresses. Generalized Hooke's law. Strain energy function. Isotropy and anisotropy. Equilibrium equations. Problems in plane stress and plane strain. Airy stress function. Torsion of prismatic bars. Thick-walled tube, rotating disk. Principle of virtual work. Rayleigh-Ritz methods. Introduction to the finite element method. Truss and beam elements. Plasticity: Reviews stress and strain deviators, invariants and distortional energy. Principal and octahedral stresses and strains. Tresca and von Mises yield criteria. Yield surface and Haigh-Westergaard stress space. Lode's stress parameters. Subsequent yield surface. Prandtl-Reuss relations. Work and strain hardening. Isotropic and kinematic hardening rules. Incremental and deformation theories. Time-dependent deformations: visco-elasticity, elasto-viscoplasticity and creep. Simple truss. Bending of straight beams. Thick-walled tube. Plasticity equations in finite element methods. Stress updating algorithms and consistent tangent modulus.

Nonlinear Vibrations

BMEGEMMMW06

Phase plane analysis of single degree-of-freedom nonlinear systems. Construction of trajectories and their analysis in case of conservative nonlinear systems. The effect of nonlin-

ear damping. Harmonic excitation of nonlinear mechanical systems, resonance in nonlinear systems. Self-excited vibrations. Liénard and Bendixson criteria for limit cycles. Hopf bifurcations. Chaotic oscillations.

Coupled Problems in Mechanics

BMEGEMMMW07

Diffusion problems: thermomechanical, chemomechanical, hygromechanical fields. Coupled piezo-electromechanical equations. Fluid-structure interaction. Smart structures, micro-electromechanical systems. Contact stresses in deformable bodies. Finite element modeling. Mesh coupling. Partitioned analysis. Case studies.

Mechanisms

BMEGEMMMW08

Structural analysis of kinematical chains: degrees of freedom, groups, six-bar chains, equivalent chains. Straight-line guide. Four-bar linkage. Planar motion: relative centers of zero velocity, transmission, theorem of Kennedy. Curvature theory: fixed and moving centrodes, envelopes, inflexion circle, return circle, centre of curvature, theorem of Euler-Savary, theorem of Bobillier. Acceleration field. Cams and gears.

Beam Structures

BMEGEMMMW09

Torsion and shear of thin walled beams, calculation of warping-sector area function, shear center, shear flow. Constrained torsion of prismatic beams. Stability problems of beam structures, bending and flexural-bending buckling. Application of numerical methods based on the Trefftz principle. Dynamic problems, application of modal decomposition method. Example: seismic excitation.

Experimental Methods in Solid Mechanics

BMEGEMMMW10

Strain measuring methods, theory and practice, strain gauges. Application to an aluminium block. Linear elastic fracture mechanics of composites, fracture model of Griffith. Manufacturing of composite specimens. Evaluation of fracture mechanical tests. Direct and indirect data reduction schemes. J-integral, improved beam theory schemes, elastic foundation beams, crack tip shear deformation in composite beams. Application of the virtual crack-closure technique. Mode-I and mode-II fracture tests. The mixed-mode bending problem. Mode partitioning in mixed-mode I/II tests. Fracture envelopes and fracture criteria. Stability of delaminated beams. Experimental equipments and measuring methods. Self-excited vibrations of wheels. Dynamic measurements of wheels. Measuring methods, equipments and evaluations for vibration analysis. Modal analysis.

Final project in Solid Mechanics

BMEGEMMMWD2

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

Thermal Engineering module

Combustion Technology

BMEGEENMWCT

Types of fuels, ultimate/proximate analysis, fuel technology, analysis methods and results, excess air factor, calorific value, stoichiometric calculation, practical analysis of combustion products. Physical parameters of combustion, reaction types, flame velocity, combustion aerodynamics; premixed and diffusion flames, atomization, pulverization, different types of burners. Fuel technology: properties of various solid, liquid and gaseous fuels. Equipment constructions. Modeling methods and techniques in combustion.

Laboratory: Flame velocity. Flame demonstrations. Emission measurement.

Measurement in Thermal Engineering

BMEGEENMWM1

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

Major Project in Thermal Engineering

BMEGEENMWD1

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

Special subjects / Major or Minor Elective Subjects

Energy Conversion Processes and Its Equipement

BMEGEENMWEE

Energy sources, demands and utilizations. Power generation. Steam cycles (superheating, reheating, regeneration, combined). Boilers and steam generators. Nuclear power stations. Combined heat and power generation. Internal combustion engines. Centralized - distributed power generation. Calculation of energy balance, software's for system planning and modeling. Environment protection.

Simulation of Energy Engineering Sytems

BMEGEENMWSE

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

Thermal Physics

BMEGEENMWTP

Physical backgrounds. Mechanism and models of heat conduction in solids. Non homogeneous materials. Determination methods and techniques of thermophysical properties. (Solution of inverse problem of heat conduction.) Steady state and transient methods.

Thermo-Mechanics

BMEGEMMMWTM

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

Steam and Gas Turbines

BMEGEENMWTU

Classification of turbines. Flow in nozzle. Historical notes. Principal elements. Axial flow turbines: impulse stage, reaction stage, velocity compounded stage. Losses, design considerations. Calculation of nozzles and stage parameters, power and torque. Efficiency, characteristic curves. Gas turbine cycles (inter-cooling, reheating, aircraft engines etc.). Compressors, combustion chambers, turbines, co-operation of elements. Efficiency and losses. Constructions.

Thermo-Hydraulics

BMEGETEMWTH

Heat generation and removal in different type of nuclear reactors. General differential equation of heat conduction. Material properties of UO2. Equations of hydraulic systems. Convective heat transfer. Thermal instabilities. Natural convection. Boiling heat transfer. Boiling curve, boiling crisis. Condensation. Two phase flow patterns, flow maps. Temperature distribution in the fuel. Thermohydraulics of the coolant subchannels. Design limits of nuclear fuel. Computer codes in thermohydraulics. Fundamentals of reactor safety, the role of human factor. Design Basis Accidents. Beyond Design Basis Accidents. Relevant nuclear accidents (e.g. TMI-2, Chernobyl).

Final Project in Thermal Engineering

BMEGEENMWD2

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

Design and Technology module

Special subjects / Major or Minor Compulsory Subjects

Product Modeling

BMEGEGEMW02

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

Advanced Manufacturing

BMEGEGTMW01

Mechanics of metal cutting. Machinability, advanced tool materials, coatings and tool wear. New generation of cutting tools and tool holders. Dry machinig. HSM-High speed machining. Machining of hard materials. Micro and nano technology. Reverse Engineering. Rapid Prototyping. Methods for machinig for different parts, dies and moulds. CAD/CAM and CNC structures. Monitoring of manufacturing. In-Process measuring methods in manufacturing.

Major Project in Design and Technology

BMEGEGEMWD1

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

Special subjects / Major or Minor Elective Subjects

CAD Technology

BMEGEGEMW04

CAD tools and methods in machine design. Concurrent design. Product modeling. Surface and solid models. Parametric design. Feature based design. Integrated approach. Kinematic simulation. Conceptual design. Product data management. Product lifecycle management. Distributed design approach. Virtual prototyping. Rapid prototyping.

Material Science

BMEGEMTMW01

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

Structural Analysis

BMEGEGEMW05

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

Process Planning

BMEGEGTMW02

Manufacturing errors, methods of prevention and elimination; surfaces of positioning, manufacturing allowances, preproduct design and selection. Manufacturing planning, machine tools and equipment, manufacturing processes and procedures, operations, electro-chemical (ecm, edm) and thermal processes, survey of surface technology. Type and Group Technology, basics of automation; cellular manufacturing, tooling criteria. Parameter planning, operation element plans, basics of primary and secondary optimisations. Adaptation, principles of NC technology; NC programming. Quality and statistical process control (SPC). Principals of computer aided manufacturing (CAM).

NC Machine Tools

BMEGEGTMW03

Fundamentals of the kinematics of machine tools and the NC technology. Machine elements and structural building blocks. Lathes and turning centres. Milling machines and machining centres. Parallel kinematics machine tools. Integration of machine tools into production systems. Synthesis, analysis and optimisation of configuration alternatives. Dynamic modeling techniques. Mechatronic modeling, analysis and simulations. Controllers. Control loops, velocity control, position control. Positioning systems. Interpolators, algorithms, software and hardware solutions.

Fatigue and Fracture

BMEGEMTMW02

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

Final Project in Design and Technology

BMEGEGEMWD2

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

Industrial Electronics module

Special subjects / Major or Minor Compulsory Subjects

Power Electronics

BMEVIAUM002

Components. Transients. Analytical methods of calculation. Computer simulation software. Rectification, single and multiphase systems. Topologies. Various loads, unidirectional, and bidirectional power flow. Electromagnetic Compatibility (EMC). DC/DC converters. Resonant, quasi-resonant circuits. Single and three phase AC/AC conversion. Cycloconverters. Matrix converters

Motion Control

BMEVIAUM003

Classification of rotating electric machines: AC machines, Induction motors Servo motors, PM DC motors, Brushless motors, Switched Reluctant Motors, Stepper motors.

Controlled electric drives: Cascade control of PM servo motors (current, speed and position control loops), Torque control, Electrically commutated servo drives, Variable frequency induction motor drives, Field oriented control.

Internet based tests of electric drives: Microprocessor and DSP controlled electric drives.

Special subjects / Major or Minor Elective Subjects

Analog Electronics

BMEVIAUM004

The role of analogue electronics in complex systems: filtering, amplifying, transforming signals. Actuators. Semiconductors: basic principles, diodes, transistors. Special devices. Varicap. Integrated circuits. Characteristics and applications. Amplifiers: single and multistage transistor amplifiers, analysis and design. Feedback: gain and impedances. Application of operational amplifiers. Power amplifiers. Analogue transducer, PID controller. Filters. The analogue switch. Sample & hold, A/D and D/A converter, analogue multiplexer, demultiplexer. Simulation of analogue circuits

Digital Electronics

BMEVIAUM005

Introduction, number systems, Boolean and switching algebra. Codes, BCD and alphanumeric codes. Redundant coding for error detection and correction. Minterms, maxterms, logic functions. Combinational networks. Elementary and complex combinational circuits. Reduction of combinational networks, dynamic behaviour (hazards). Sequential networks (Introduction, description and representation). Asynchronous and synchronous sequential networks. Elementary sequential networks. Systematic design of synchronous sequential networks. Complex sequential networks. Electrical properties of digital circuits. IC fabrication technology. Integrated circuit logics (bipolar, MOS, CMOS). Interfacing. Application specific ICs (ASICs). Programmable circuits. Methods of digital control. Laboratory activities and problem solving activities.

Real Time Systems

BMEVIAUM006

Introduction to real-time systems; System decomposition and scheduling techniques; Programming language and oper-

ating systems support; Formal specification, analysis, and verification techniques; Embedded programming techniques; Sensor Input/Actuator Output; Power-aware computing (dynamic voltage/frequency scaling, shutdown techniques); Real-time rule-based expert systems; Fault detection, fault recovery, and reliability issues; Time-critical distributed systems and communication networks.

Programmable Digital Devices

BMEVIAUM007

Application specific ICS (ASICs), essentials, classification, comparison, application. Programmable logic devices (principle, categories, types, programmability, comparison). CPLDs and FPGAs in detail. Programmability, development methods. Applications. Storage elements: semiconductor memories (principle of storage, classification, features) Non-volatile and Read/write memories (principle of storage, properties, programming methods, applications). Microprocessors and microcontrollers (basics, operation, architecture, application). Programmable interface elements (functions, architecture, operation, programming, usage).

Industrial Vision Systems

BMEVIAUM008

Sensors, Optics & Lighting; Simple color models (RGB, HLS, CMYK, CNS, CIE) camera calibration, filters, Fundamental techniques in Computer Graphics Coordinate systems in 2D and 3D CG, homogeneous coordinates, affine transformations, Fourier transformation, viewing transformations, frame to window mapping, line and polygon clipping. Stereo vision, Graphic Communication, Basic rendering - Point Operations; Neighborhood Operations Intelligent Vision - Imaging Techniques; Sample Problems & Review.

Web-Based Laboratory

BMEVIAUM009

Remote supervising and measurement. Features of SCADA (Supervisory Control and Data Acquisition) systems, architectures, requirements. Facilities offered by the Web, problems and security issues. Intelligent measuring instruments. Communication protocols. Software meters. Web application architectures, Web services, Java-based web systems, Human-machine interface. Development tools.

Industrial Embedded Systems

BMEVIAUM010

Hardware/software systems and codesign: Architecture selection, microcontroller selection, IDE selection, operating system considerations, programming selection and costs.

Models of computation for embedded systems, Partitioning, scheduling, and communication, Embedded device that uses the following communication protocols: Bluetooth, IrDA (Infrared Data Association), and WiFi, ASI and Profibus. Simulation, synthesis, and verification, Hardware/software implementation, Performance analysis and optimization.

Robotics module

Special subjects / Major or Minor Compulsory Subjects

Robot Constructions

BMEGEGTMW04

Review of robot arm structures and the rules of motions and motion simulations. The actuators as robot arm components: electromagnetic actuators (AC/DC drives), fluid power actuators, non-conventional actuators. The structure of micro robots. Sensory functions, sensors. Grasping theory and grippers. Analysis of units and components. Design and simulation of a selected robot arm unit, a gripper unit, as well as the selection of the relevant sensors. Laboratory tests, control parameter setting on existing robot arms and grippers.

Robot Control

BMEGEGTMW09

The course is an introduction to the basics and fundamental problems of robot modeling and control. The curriculum focuses mainly on the most common robot class in industrial use, i.e. rigid, open-chain robots, dealing with their modeling and control on the usual three levels of kinematics, differential kinematics and dynamics. Furthermore, the course gives an outlook on the properties of other robot classes (e.g., mobile robots), conditions and typical problems of practical application, and strives to provide advice concerning acquisition of further knowledge and solving problems not covered by the curriculum.

Completing the course contributes to the students learning to solve practical robotics-related modeling, planning and control problems on their own, using exact methods, while keeping up with today's quickly evolving technical knowledge.

Prerequisites: Required knowledge are the basics of control engineering, as well as a few selected areas of mechanical engineering. It is recommended to complete the mathematical curriculum prescribed for the first 4 semesters, especially with respect to the basics of linear algebra (matrix operations)

Major Projects in Robotics

BMEGEGTMWD1

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

Special subjects / Major or Minor Elective Subjects

Production Planning and Control

BMEGEGTMW10

The aim of subject to introduce the basic problem of the production management planing and control, the nominations, connections and methods. The topics dealing with warehouse management, for short and long time period the production and capacity planning, short time scheduling and analyzing methods of production management systems. The students became familiar with classical methods - they applied in the production management systems nowadays - and they have a view about the results of future trends. Primary importance given for the modeling and abilities of analyzing. We close a bigger series of the performance with a demonstration so the students can get a real view about the limits and development trends of production planning.

Software Technologies

BMEGEMIMW03

Compararison of the traditional and component based program technologies. Principles of object based programming. Component based technologies. Theoretical bacj-

ground and practical aspects of software modeling. The Internet as a resource. Development of Java applet. Construction and elements of Net Framework. .Net applications, ASP.NET applications. The ADO.Net. Distributed systems. Cliend serving applications. Programming in Java and C# (based on Java).

Artificial Neural Networks and Hybrid Systems

BMEGEGTMW11

Symbolic and subsymbolic forms of knowledge representation and processing. Basics of pattern recognition, discriminant functions, preprocessing, feature extraction and selection, learning algorithms and their classifications, the Bayes decision algorithm. Concept of artificial networks, multilayer perceptrons, the back-propagation learning algorithm. Further models of ANNs and their applications. Handling of uncertainty, basics of fuzzyness, fuzzy control, fuzzy expert systems. Neuro-fuzzy approaches. Genetic algorithms.

Robot Programming

BMEGEGTMW06

Hardware and software architectures of robot controller. Robot coordinate systems, robot kinematics, transformation between coordinate systems, interpolation modes, path planning. Robot programming methods, teach-in, numerical codes, high level program languages. Main structure of a robot language, commands, parameters, variables, input/output controlling, program organizing solutions. Programming of sensors and actuators of the robot.

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Simulation of CNC Machines and Robots

BMEGEGTMW12

Overview of simulation programs. Mathematical principals (homogenious transformation matrices, graphs, Jacobi matrix). Modeling of mechanical systems (modeling of low level kinematical pairs, kinematical graphs). Modeling of machines with open kinematic chain (industrial robots). Solution of inverse kinematical problem (symbolically and numerically). Modeling of kinematical systems (calculation of velocity and acceleration functions). Simulation of traditional CNC machines. Structured reading and process of input files (lex/yascc type browsers). Calibration of simulation models (origos, setting of extremities). Usage of simulation (exercise of coincidence, problems of interpolation, choosing of solution branch, positioning of objects). Mechanical modeling based on graph structures (generating independent constrain functions). Simulation of parallel robots. Simulation of material selection.

Assembly

BMEGEGTMW07

Assembly (objects); definitions of assembly; units and items, object oriented assembly tree and documents;

Assembly (process); assembly procedures, operations, methods and organisation structures; process oriented assembly tree and documents;

Automation: Initiating, financial and social analysis of automation, specific and universal equipments, organizing and scheduling of the process;

Design for assembly

Quality control (object oriented view of quality assurance); probability functions and distributions, dimensional chains and analysis; calculation of resulting error and tolerance based on full and partial changeability;

Quality control (process oriented view): sensors and monitoring, control and statistical process control.

Special Robots and Robot Applications

BMEGEGTMW08

Review of robot applications excluding the industrial robot applications. Personal, office, rehabilitation, surgery, house keeping, toy, construction, transport, agriculture, sea/deepwater, space, defence, civil protection robots. User and system requirements. Analysis of units and components. Design and simulation of a selected service robot application including a mobile unit, an arm unit, a gripper unit, as well as perception sensors. Laboratory tests, control parameter setting on existing medical, civil protection, and cleaning robots.

Microelectronics in Control

BMEGEMIMW06

Basics of control systems. Microelectronic devices in control engineering tasks. Building blocks, architecture and programming of microprocessor systems, development tools. Microcontrollers. Embedded systems. Programmable logic controllers (PLCs). Interfacing computers and other devices to real-world processes. RF and mobile devices. Mobile robotic applications.

Final Project in Robotics

BMEGEGTMWD2

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

Subjects in Economics

Marketing

BMEGT20MW01

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

Management

BMEGT20MW02

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