Faculty of Natural Sciences

IMPORTANT NOTES

If for one subject you can find several different types (lecture, practice, laboratory) of courses then please choose one and only one course from each type in order to be able to perform the subject's requirements successfully.Civil Engineering courses are on the website seperately. Courses chosen from the offer of Faculty of Civil Engineering will be checked and arranged individually by the departmental coordinator.

Subject code	Subject name	Requirement	ECTS credit
BMETE11AP59	Mechanics	Exam	8

Course type	Course code	Course language	Timetable information
Lecture	T0	English	
Practice	T2	English	
Practice	T1	English	
Practice	T3	English	

.cs73E18CB{font-size:10pt;font-weight:normal;color:#000000;background-color:transparent;font-style:normal;font-family:Verdana;} .cs3270F94{margin:0pt 0pt 0pt 0pt;text-align:left;text-indent:0pt} Introductory course to mechanincs, with special emphasis on the basic physical and mathematical methods and terms. I. Kinematics: basic terms, mass point. Force. Newton’s laws. Momentum. Gravitation, inertial mass and weight, choice of units. Examples from dynamics, describing motion in different reference frames, the principle of relativity, inertial forces in accelerating and rotating reference frames. Work, kinetic and potential energy. System of mass points, conservation laws in mechanics. The statics, kinematics and dynamics of rigid bodies (rotation around a fixed axis, inertial moment, free axes, gyroscope with and without weight). Elastic deformation of solid bodies. Liquids and gases: statics, surface effects, frictionless and viscous flow, forces on a moving body moving in a medium. II. Oscillations: free, harmonic, damped, forced. Decomposition and superposition of vibrations. Coupled oscillations. Waves and wave function. Harmonic wave, phase velocity, non-harmonic waves, group velocity. Wave equation in an elastic rod, propagation of energy in a wave. Polarization. Reflection and refraction. Interference, coherence, diffraction. Standing waves. Wave equation in a gas and on a string. Standing wave equation, whistles, strings, the physics of music. Doppler shift. Ultrasonic diagnostics. – Raymond A. Serway, John W. Jewett: Physics for Scientists and Engineers (Cengage Learning; 10th edition, 2018) ISBN 978-1337553278– Herman Gewirtz, Jonathan S. Wolf: Barron's SAT Subject Test in Physics 9th Edition (Barron’s, 2010) ISBN 978-0-7641-4353-3

Subject code	Subject name	Requirement	ECTS credit
BMETE11AX22	Physics 2	Exam	4

Course type	Course code	Course language	Timetable information
Lecture	VN0	German	
Lecture	VE0	English	TUE:12:15-14:00
Practice	VN1	German	
Practice	VE1	English	TUE:14:15-16:00

Elektrodynamics: Faradayrsquo;s law. Self induction, mutual induction. Magnetic properties of materials. Magnetic data storage. Maxwell equations. Generation, propagation and reflection of electromagnetic waves. Basics of geometrical optics. Wave optics, interference, diffraction. Polarized light. Basics of atomic Physics: Natural and coherent light sources. Physical foundations of optical communication. Matter waves of de Broglie. The Schrouml;dinger equation. The electron structure of atoms. Electron spin. Free-electron theory of metals. Band structure of solids. Superconduction. Quantum-mechanical phenomena in modern electronics. Basics of nuclear physics. Nuclear reactors. Elementary particles. Curiosities in cosmology. Fundamentals of the physics of the atomic kernel, elementary particles, selected topics in cosmology.

Subject code	Subject name	Requirement	ECTS credit
BMETE15MF10	Random Matrix Theory and Its Physical Applications	Exam	3

Course type	Course code	Course language	Timetable information
Lecture	T0	English	

Random matrix theory provides an insight of how one can achieve information relatively simply about systems having very complex behavior. The subject based on the knowledge acquired in quantum mechanics and statistical physics together with some knowledge of probability theory provides an overview of random matrix theory. The Dyson ensembles are defined with their numerous characteristics, e.g. the spacing distribution, the two-level correlation function and other quantities derived thereof. Then the thermodynamic model of levels is obtained together with several models of transition problems using level dynamics. Among the physical applications the universality classes are identified in relation to classically integrable and chaotic systems. The problem of decoherence is studied as well. Then the universal conductance fluctuations in quasi-onedimensional disordered conductors are investigated. Other models are investigated: the disorder driven Anderson transition and the random interaction model of quantum dot conductance in the Coulomb-blockade regime. We use random matrix models to investigate chirality in two-dimensional and Dirac systems and the normal-superconductor interface. The remaining time we cover problems that do not belong to strictly physical systems: EEG signal analysis, covariance in the stock share prize fluctuations, mass transport fluctuations, etc.

Subject code	Subject name	Requirement	ECTS credit
BMETE15MF11	Evolutionary Game Theory	Exam	3

Course type	Course code	Course language	Timetable information
Lecture	T0	English	FRI:10:15-12:00

The main goal of this course is to demonstrate the ways how the game theory and evolutionary game theory describe real-life situations affecting human behavior, economics, and biological systems. After a brief survey of the basic concept of the traditional game theory (e.g., games, strategies, Nash equilibrium, etc.) we will study evolutionary games that combine the concepts of game theory with the spirit of Darwinism. We will discuss the decomposition of games and also the potential games related to physical systems. Using simple multi-agent mathematical models we will investigate the effects supporting the maintenance of cooperative behavior in the situations of different social dilemmas (e.g., prisoner's dilemma or public goods game) when the individual interests prefer defection to cooperation. The predictions of the mathematical models will be contrasted with human and animal experiments. Finally we study systems where the evolution is controlled by the competition between different spatial strategy associations.

Subject code	Subject name	Requirement	ECTS credit
BMETE15MF21	Crystalline and Amorphous Material	Exam	3

Course type	Course code	Course language	Timetable information
Lecture	T0	English	

1. Introduction 1.1. Historical overview: Science and applications 1.2. Definitions Crystalline, non-crystalline, amorphous, glassy materials, 2. Preparation techniques 2.1. Growth of thin-film forms 2.2. Melt-quenched glasses 2.3. Other techniques 2.4. Phillips constraints theory 3. Structure 3.1. Differences between amorphous and crystalline semiconductors 3.2. Projection from three dimensional structures to one dimensional functions Diffraction measurements 3.2. Three dimensional structure derivation from one dimensional function 3.3. Atomic interactions. Computer simulation methods, Models 3.4. Phase change materials and its application 4. Electronic structure 4.1. Chemical bonds, 4.2. Electronic density of states, 4.3. Defects 4.4. Optical and electronic properties 5. Photo induced phenomena 5.1. Photoinduced volume changes (PVE), photodarkening, photobleaching (PD), 5.2. Photoinduced defect creation (PDC): the Staebler-Wronsky effect, 5.3. In-situ simultaneous measurements of PVE, PD, and PDC 5.4. Photoinduced amorphization or crystallization, 5.5. Some applications of photo-induced effects (solar cells, XEROX, sensors, DVD, etc.)

Subject code	Subject name	Requirement	ECTS credit
BMETE15MF74	Computer Simulation in Physics	Mid-semester mark	5

Course type	Course code	Course language	Timetable information
Lecture	TA1	English	THU:18:15-19:00(F3213)
Lecture	TA0	English	THU:16:15-18:00(F3213)

Subject code	Subject name	Requirement	ECTS credit
BMETE15MF76	Complex Networks	Exam	4

Course type	Course code	Course language	Timetable information
Lecture	E0	English	WED:12:15-14:00
Practice	E1	English	

Basic graph theory, adjacency matrix, distance, path, connectedness, clustering. Random (Erdős-Rényi) networks, degree distribution, clustering, Watts-Strogratz network. Preferential attachment, scale free networks, configuration model. Temporal networks, burstiness. Growth models and cascades. Diffusion, spreading. Local measures, link prediction. Mesoscopic description: communities (stochastic blok model, inference, modularity, node/link hierarchical clustering, clique percolation), hierarchical, core-periphery structures. Sampling of networks. Navigation, search on networks.

Subject code	Subject name	Requirement	ECTS credit
BMETE80AF36	Introduction to Fusion Plasma Physics	Exam	3

Course type	Course code	Course language	Timetable information
Lecture	T0	English	TUE:16:15-18:00

Subject code	Subject name			Requirement	ECTS credit
BMETE80AF45	Monte Carlo Methods			Exam	4
Course type	**Course code**	**Course language**	**Timetable information**		
Practice	T1	English			

Subject code	Subject name			Requirement	ECTS credit
BMETE80MFAD	Monte Carlo Methods			Mid-semester mark	5
Course type	**Course code**	**Course language**	**Timetable information**		
Lecture	T0	English	WED:12:15-14:00		

Subject code	Subject name			Requirement	ECTS credit
BMETE80MX07	Radiation Protection			Exam	3
Course type	**Course code**	**Course language**	**Timetable information**		
Lecture	T0	English	FRI:10:15-12:00		

Physical fundamentals of generating ionizing radiations: radioactivity, radioactive decay, operation of equipment for generating ionizing radiations. Definition of doses. Biological effects of ionizing radiations: deterministic and stochastic effects, somatic and genetic effects. Control of applications of ionizing radiations in connection with the explanation of generic principles of radiation#160; protection (justification, optimization, and individual limitations). Procedures and conditions of generating ionizing radiations: external and internal exposure situations, natural and artificial radioactivity. Practical implementation of radiation protection: workplace and environmental radiation protection, monitoring, management and disposal of radioactive wastes, applications of radiation shielding. management of nuclear and radiological emergencies.#160;H. Cember, T.E. Johnson: Introduction to Health Physics#160;

Subject code	Subject name			Requirement	ECTS credit
BMETE90AX02	Mathematics A2a - Vector Functions			Exam	6
Course type	**Course code**	**Course language**	**Timetable information**		
Lecture	EN0-EMK	English	MON:16:15-18:00(KF88); MON:16:15-18:00(KF88); THU:16:15-18:00(KF88); THU:16:15-18:00(KF88)		
Practice	EN1-EMK	English	WED:16:15-18:00(K371); WED:16:15-18:00(K371)		

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

Subject code	Subject name			Requirement	ECTS credit
BMETE90AX22	Calculus 2 for Informaticians			Mid-semester mark	6
Course type	**Course code**	**Course language**	**Timetable information**		
Lecture	EN0-EB0	English	MON:12:15-14:00; TUE:10:15-12:00		
Practice	EN1-EB1	English	THU:14:15-16:00		

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

Subject code	Subject name			Requirement	ECTS credit
BMETE90AX26	Mathematics A2f - Vector Functions			Mid-semester mark	6
Course type	**Course code**	**Course language**	**Timetable information**		
Lecture	EN0-VIK	English	MON:10:15-12:00; WED:08:15-10:00		

Practice	EN1-VIK	English	WED:10:15-12:00

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

Subject code	Subject name	Requirement	ECTS credit
BMETE90AX34	Mathematics EP2	Mid-semester mark	2

Course type	**Course code**	**Course language**	**Timetable information**
Practice	EN1	English	WED:08:15-10:00

Limit, continuity, partial derivatives and differentiability of functions of multiple variables. Equation of the tangent plane. Local extrema of functions of two variables. Gradient and directional derivative. Divergence, rotation. Double and triple integrals and their applications. Polar coordinates. Substitution theorem for double integrals. Curves in the 3D space, tangent line, arc length. Line integral. 3D surfaces. Separable differential equations, first order linear differential equations. Algebraic form of complex numbers. Second order linear differential equations with constant coefficients. Taylor polynomial of exp(x), sin(x), cos(x). Eigenvalues and eigenvectors of matrices.

Subject code	Subject name	Requirement	ECTS credit
BMETE91AM43	Informatics 2	Mid-semester mark	4

Course type	**Course code**	**Course language**	**Timetable information**
Laboratory	EN1	English	WED:16:15-18:00
Lecture	EN0	English	WED:10:15-11:00

The course aims to learn the programming through understanding the Python language. Introduction to programming and Python language, data types, expressions, input, output. Control structures: if, while. Flowchart, structogram, Jackson figures. Complex control structures. Fundamental algorithms (sum, selection, search extrema, decision..., many practical examples). Lists. For cycle. Newer algorithms (sorting, splitting into two lists...). Exception handling. Abstraction of a part of the program, name it, using as a building block = function. Function call process, parameters, local variables, passing by value. Abstraction: complex data types from simple ones, for example fraction (numerator + denominator), complex numbers (real amp;amp; imaginary part). OOP concepts: object, method. File management. Command-line arguments. Recursion (painting of an area, building a labyrinth). Algorithms efficiency, quick sorting, binary search versus linear search, O(n). Data structures: binary tree (algorithms), effectiveness: search trees (Morse tree). Mathematical libraries. Modules.

Subject code	Subject name	Requirement	ECTS credit
BMETE91AM44	Informatics 3	Mid-semester mark	4

Course type	**Course code**	**Course language**	**Timetable information**
Laboratory	EN1	English	WED:12:15-14:00
Lecture	EN0	English	TUE:12:15-14:00

The aim of the course is to understand the basic elements of C++ language fundamental in effective scientific calculations. Compiling C++ programs, programming environments for C++. Input/Output. Built-in data types: int, double, char, bool, complex. Control commands: if, switch, for, while, do. Exception handling(recall Python). Functions. Extending operators (fractions struct), references (a += b, cout lt;lt; fraction, cin gt;gt; fractions). Object-oriented programming in C++: object, class, encapsulation, member functions, constructors, destructors (in complex class with re + im or r + fi data members). Using arrays in C++. Pointers, relationship with arrays. File management. Basic algorithms: search, sort, etc. Command-line arguments. Dynamic memory management, new[], delete[]. Inheritance. Templates. Libraries. Header files.– E. Scheinerman: C++ for Mathematicians. An Introduction for Students and Professionals, CRC Press

Subject code	Subject name	Requirement	ECTS credit
BMETE91AM59	Number Theory	Exam	2

Course type	**Course code**	**Course language**	**Timetable information**
Lecture	T0	English	WED:16:15-18:00

Basic Number Theory: Divisibility, greatest common divisor, Euclid's algorithm, congruences, Chinese remainder theorem, Hensel lifting, primitive roots, discrete logarithm, quadratic residues, Legendre and Jacobi symbol. Law of quadratic reciprocity. Analytic Number Theory: Prime numbers and its properties, primes of special forms. Primes in arithmetic progressions, gaps between primes, Bertrand's postulate, the Prime Number Theorem. The Riemann zeta function, Riemann Hypothesis, Dirichlet characters. The generating function and its applications, partitions. Sieve methods, application of Brun's sieve to estimate the number of#160; twin primes, Goldbach's conjecture. Additive and multiplicative arithmetic functions. Additive Number Theory: Sumsets, direct and inverse problems. Sum-product estimates.#160;Combinatorial Number Theory: Schnirelman density, Schur's theorem,#160; van der Waerden's theorem, Szemerédi's theorem about arithmetic progressions. Zero-sum combinatorics: the polynomial method, Combinatorial Nullstellensatz, applications.#160;Diophantine equations: sum of two, three, four squares, representations as the sums of k-th powers, Waring problem.#160; Fermat's last theorem.#160; Mordell equation. The abc conjecture. Miscellaneous modern topics (sketch only):#160;Number Theory in Cryptography: The RSA and the ElGamal scheme. Primality tests.#160;Diophantine Approximation Theory: Continued fractions. Pell equation. Wiener attack against RSA. p-adic numbers.#160;

Subject code	Subject name	Requirement	ECTS credit
BMETE93BG02	Mathematics G2	Exam	6

Course type	**Course code**	**Course language**	**Timetable information**
Lecture	EN0	English	TUE:16:15-19:00(KF81); WED:16:15-17:00(KF81)
Practice	EN1	English	WED:17:15-19:00(KF81)

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 integrals.