University of Debrecen

Centre of Arts, Humanities and Sciences

Hungary

Faculty of Science

Mathematics, BSc Program

Curriculum

Module	Subject	Hours/week						Exami-nation	Credit	
		1	2	3	4	5	6			
B	**Trigonometry and Coordinate Geom.**	2+2						C, T	4	
A	**Sets and Functions**	2+2						C, T	4	
S	**Fundamentals of Algbera**	2+2						C, T	4	
I	**Linear Algebra I**		2+2					C, T	4	
C	**Introduction to Analysis**		3+2					C, T	6	
S	**Foundations of Computer Science**	0+3						T	3	
	Introd. to Algebra and Numb. Theory		2+2					C, T	5	
	Number Theory I			2+2				C, T	5	
	Differential and Integral Calculus			3+3				C, T	7	
	Geometry I		2+2					C, T	4	
	Geometry II			2+2				C, T	4	50
A	**Number Theory and its Applications**				2+0			C	3	
D	**Linear Algebra II**			2+2				C, T	5	
V	**Algebra**			2+2				C, T	4	
A	**Diff. and Int. Calc. for Functions in Sev. Var.**				3+3			C, T	7	
N	**Measure and Integral Theory**				2+0			C	3	
C	**Complex Analysis**					2+0		C	3	
E	**Introd. to the Theory of Ord. Diff. Eq.**					2+2		C, T	5	
D	**Convex Geometry**				2+2			C, T	5	
	Differential Geometry					2+2		C, T	5	
P	**Combinatorics**	3+2						C, T	5	
R	**Set Theory and Math. Logic**			2+2				C, T	5	
O	**Probability Theory**					3+2		C, T	6	
F	**Statistics**						3+2	C, T	6	
	Numerical Mathematics					3+2		C, T	6	
M	**Operational Research**				2+2			C, T	5	
O	**Computer Geometry**				0+3			T	3	
D	**Computer Algebra**				0+2			T	2	
U	**Comp. Number Theory**					0+2		T	2	
L	**Analysis with Computer**						0+3	T	3	
E	**Statistics with Computer**						0+2	T	2	85
E	**History of Mathematics**	*2+0*						C	2	
L	**Inequalities**				*2+0*			C	3	
E	**Calculus of Differences**				*2+0*			C	3	
C	**Projective Geometry**			*2+2*				C, T	5	
T	**Introd. to Descriptive Geometry**				*2+2*			C, T	5	
I	**Introd. to Lie Theory**				*2+2*			C, T	5	
V	**Elementary Topology**				*2+2*			C, T	5	
E	**Topics in Elem. Number Theory**					*2+2*		C, T	5	
	Topics in Algebra				*2+2*			C, T	5	
	Fundam. of Cryptography					*2+1*		C	4	
	Financial Mathematics						*2+2*	C, T	5	
	Appl. of Probability Theory						*2+0*	C	3	
	Information Theory						*2+0*	C	3	12
O	**Physics I**		2+1					C	4	
T	**Physics II**				2+1			C	4	
H	**Basic Environmental Science**	1+1						C	2	
E	**European Union**	1+0						C	1	
R	**Basic Economics and Management**			1+0				C	1	
S	**Quality Management**					1+0		C	1	13
	Thesis					x	x	T	5+5	10
	Free Optional Courses								10	10
	Total Credits									**180**

Subjects

Subject: Trigonometry and Coordinate Geometry
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 4
Prerequisites: None
Lecturer: László Kozma, PhD.

Topics: Axiomatic theory, definition, theorem, necessary, sufficient conditions, indirect proof. Negation of statements, the converse of a statement. Elements of mathematical logic.

Vectors, addition of vectors, multiplication by scalars, coordinates. The definitions of trigonometric functions, their basic properties. Addition theorems, sine and tangent theorems. Trigonometric equations and inequalities. The inner product of vectors, cross and mixed products of vectors. Coordinate systems. Parametric representation of straight lines in the plane and space. Equation of circles and spheres. The definition of ellipses, hyperbolas and parabolas, and their equations. Polar coordinates, focal equation of cone sections. Problems related to vectors, and the usage of coordinate method in problem-solving.

Compulsory/Recommended Readings:
Anton, Howard: Calculus, with analytic geometry: late trigonometry version, 3rd ed. New York [etc.] : Wiley, 1989.

Subject: Sets and Functions
Class/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 4
Prerequisites: None
Lecturer: Attila Gilányi, PhD.

Topics: Basic notion, axiom, definition, theorem. Necessary condition, sufficient condition. Proof by contradiction. Negation of statements. Converse of a theorem.

Basic symbols in mathematical expressions (quantifiers, sum and product symbols).

Set, subset, power set. Basic set operations and their properties. Venn diagrams.

The notion of power with rational exponent, identities of powers (including their proofs). The concept and the identities of the logarithm, changing the base of the logarithm.

The notion of (arithmetic, geometric, harmonic, and power) means and the inequalities among them. Bernoulli inequality.

Mappings (injective, surjective, bijective) and their properties. Functions and notions concerning the description of functions. Composite function, inverse function. Graphs of real functions. Simple functions (integer part, fraction part, modulus).

Concepts for the description of functions in one variable (odd, even, periodic, monotone, bounded, convex, concave functions). Elementary functions (power functions with positive integer exponents and their inverses, exponential and logarithmic functions, trigonometric functions and their inverses).

Equations involving absolute values, roots, trigonometric functions, exponential or logarithmic functions. Sets of the solutions of inequalities involving fractions, roots, exponential functions, logarothmic functions, trigonometric functions.

Compulsory/Recommended Readings:
P.R. Halmos: Naive set Theory. D. Van Nostrand Co., Princeton, N.J.–Toronto–London–New York, 1960; Springer-Verlag, New York–Heidelberg, 1974.
Gy. Pólya: How to Solve it. A New Aspect of Mathematical Method. Princeton University Press, Princeton, 1948.

Subject: Fundamentals of algebra
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 4
Prerequisites: None
Lecturer: Viktor Bódi, PhD.

Topics: Operations, properties of operations, basic algebraic structures, examples, applications. Elementary algebraic identities: square and cube of the sum (difference) of two terms. Factorization of the difference of two n^{th} powers. The concept of powers with rational exponents, basic identities of raising to powers (including their proofs). Divisibility of integers, prime numbers, composite numbers, prime factorization, greatest common divisor, least common multiple. Polynomials and rational fraction fields, partial fractions. Euclidean division of polynomials. Multiple roots, splitting a polynomial knowing its zeros. Zeros of quadratic polynomials. Solution of several types of equations. Cubic and quartic equations of special type. Equations containing absolute values. Irrational equations. Systems of equations in two and three unknowns.
Compulsory/Recommended Readings:
A. G. Kuros, Higher Algebra
Faddeev, D. K.; Sominskii, I. S. Problems in higher algebra
Secondary school textbooks

Subject: Linear algebra I
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 4
Prerequisites: Fundamentals of algebra
Lecturer: István Gaál, DSc.

Topics: Vector spaces, basis, dimension, subspaces. Quotient space, direct product. Linear mappings, linear transformations and their matrices. Image and kernel of a linear mapping. Determinants, expansion theorems. The algebra of matrices, invertibility, rank. Systems of linear equations, solvability, Cramer's rule. Eigenvalues, eigenvectors, characteristic polynomial.
Compulsory/Recommended Readings:
A. G. Kuros, Higher Algebra
I.M. Gelfand, Lectures in Linear Algebra
P.R. Halmos, Finite Dimensional Vector Spaces

Subject: Introduction to Analysis
Class/week: 3 hour lecture, 2 hour seminar
ECTS Credit Points: 6
Prerequisites: Sets and Functions
Lecturer: László Székelyhidi, DSc.

Topics: Real numbers, complex numbers. Sequences of numbers. Bolzano-Weierstrass theorem, Cauchy sequences. Number series. Basic topological notions on the real line. Limit and continuity of real functions, basic properties of continuous functions. Sequences and series of functions. Power series, elementary functions.

Compulsory/Recommended Readings:
W. Rudin: Principles of Mathematical Analysis. McGraw-Hill, 1964.
E. Hewitt, K. R. Stromberg: Real and Abstract Analysis. Springer-Verlag, 1965.
K. R. Stromberg: An introduction to classical real analysis. Wadsworth, California, 1981.

Subject: Introduction to algebra and number theory
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 5
Prerequisites: Fundamentals of algebra
Lecturer: Ákos Pintér, PhD.

Topics: Natural numbers, integers, rational numbers. Ordering. Complex numbers, roots of unity. Roots of polynomials. The fundamental theorem of algebra. Unique irreducible factorization in polynomial rings over fields. Irreducible polynomials in the ring of polynomials with rational, real and complex coefficients. Rational fraction fields. Ring of multivariate polynomials, symmetric polynomials. Divisibility and its properties in the ring of integers and in the ring of polynomials over fields.
Compulsory/Recommended Readings:
G. Birkhoff, T. C. Bartee, Modern Applied Algebra;
A. G. Kuros, Higher Algebra;
L. A. Kalushnin, Introduction to Abstract Algebra;
M. Bhubaneswar, Algorithmic Algebra;
Á. Szendrei, Diszkrét matematika.

Subject: Number Theory I
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 5
Prerequisites: Introduction to algebra and number theory
Lecturer: Kálmán Győry, DSc

Topics: The fundamental theorem of number theory. Linear congruences, systems of congruences and linear diophantine equations. The Euler-Fermat theorem. Classical congruence theorems. Number-theoretic functions. Elementary prime number theory, number of primes, sum of the reciprocals of primes. Connection of rational and irrational numbers, algebraic and transcendental numbers, famous problems in number theory.
Compulsory/Recommended Readings:
Kenneth H. Rosen: Elementary number theory and its applications
Don Redmond: Number theory
Paul Erdős, János Surányi: Topics in the theory of numbers

Sárközy András, Surányi János: Számelmélet feladatgyűjtemény

Subject: Differential and Integral Calculus
Class/week: 3 hour lecture, 3 hour seminar
ECTS Credit Points: 7
Prerequisites: Introduction to Analysis
Lecturer: László Losonczi, DSc

Topics: Derivative of real functions in one variable. Rules of differentiation. Mean value theorems. Differentiation of limits and infinite sums of functions. Derivatives of elementary functions. Derivatives of higher order, Taylor series. Investigation of real functions by means of the differential calculus. The notion of the primitive of a function, methods for determining the primitives of functions. Riemann integral of real functions in one variable. Criteria of integrability. Basic properties of the Riemann integral. Newton-Leibniz formula. Continuity and differentiability of the integral as a function of the upper limit. A few applications of the Riemann integral.

Compulsory/Recommended Readings:
W. Rudin: Principles of Mathematical Analysis. McGraw-Hill, 1964.
K. R. Stromberg: An introduction to classical real analysis. Wadsworth, California, 1981.

Subject: Geometry 1
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 4
Prerequisites: Trigonometry and Coordinate Geometry
Lecturer: József Szilasi, CSc (PhD).

Topics: Euclidean geometry in the plane and in space. Parallel lines and planes. Distance and angle. A classification of isometries in the plane and in space. Polygons, polyhedra, regular polyhedra. Area and volume. Geometry of triangles, special quadrilaterals and circles. The conic sections.

Suggested Reading:
George E. Martin: The Foundations of Geometry and the Non-Euclidean Plane, Springer-Verlag, Berlin, 1975.
Richard S. Millman and George D. Parker: Geometry, A Metric Approach with Models, Springer-Verlag, Berlin, 1981.
Edwin E. Moise: Elementary Geometry from an advanced Stand point (3rd ed.), Addison-Wesley, Reading, Massachusetts, 1990.

Subject: Geometry 2
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 4
Prerequisites: Linear algebra 1, Geometry 1
Lecturer: József Szilasi, CSc (PhD)

Topics: Affine spaces, affine transformations. The real affine plane. Theorems of Thales, Pappus and Desargues. Euclidean vector spaces, Euclidean affine spaces. Orthogonal transformations and isometries. The projective completion of an affine plane and space. The vector space model of a projective space. Projective transformations. Conics and quadrics. Euclidean, affine and projective classification of quadrics. Geometry of projections.

Suggested Reading:
M. Audin: Geometry, Springer-Verlag, Berlin, 2003.
M. Berger: Geometry I-II, Springer-Verlag, Berlin, 1987.
K. W. Gruenberg and A. J. Weir: Linear Geometry (3nd ed.), Springer-Verlag, Berlin, 1977.

Subject: Physics I.
Classes/week: 2 hours of lecture, 1 hour of problem-solving seminar
ECTS Credit Points: 4
Prerequisites: None
Lecturer: József Pálinkás, DSc

Topics: Physical quantities, dimensions, systems of units. Kinematics: velocity, acceleration, motion in three dimensions. Mass, linear momentum, forces and Newton's laws, centre of mass, conservation of linear momentum. Elementary applications, projectile motion, vibrations. Rotation, angular momentum, moment of inertia, torques, planetary orbits. Motion and equilibrium of a rigid body. Work and energy, potential energy, conservation of mechanical energy. Principle of Galilean relativity, non-inertial forces. Elasticity, stresses, strain, Hook's law, elastic modulus. Gases and liquids, hydrostatics, phenomena of capillarity. Introduction to transverse and longitudinal waves. Superposition and interference of harmonic waves. Standing waves. The Doppler effect. Temperature scales, equations of state, the first law of thermodynamics, specific heat. Reversible and irreversible processes. Carnot-cycle, heat-pump and refrigerator. The second law of thermodynamics. Entropy, Helmholtz- and Gibbs-free energy functions. Chemical potential, phase transformations, transport phenomena.

Compulsory/Recommended Readings:
1. Halliday, Resnick, Walker: Fundamentals of Physics., John Wiley & Sons Inc.
2. Sears, Zemansky, Young: University Physics, Addison-Wesley Publishing Company

Subject: Physics II.
Classes/week: 2 hours of lecture, 1 hour of problem-solving seminar
ECTS Credit Points: 4
Prerequisites: Physics I.
Lecturer: József Pálinkás, DSc

Topics: Phenomena and physical quantities of electrostatics. Electric intensity, Gauss's law, electric potential, electric dipoles. Conductors and isolators in electric fields: influence, capacitors, polarization. Current, resistivity, Ohm's law, simple electric circuits. Electric currents in metals, semiconductors, liquids and gases. Magnetic field, flux density. Induction, Faraday's law, Lenz's law. Alternating currents and electromagnetic vibrations and waves. Light as electromagnetic waves, interference, diffraction, polarization, absorption and scattering. Thermal radiation, photoelectric effect. The Rutherford experiment, the Bohr model, the Franck-Hertz experiment. Particle-wave dualism, de Broglie's relation, wave function, Schrödinger-equation. The Heisenberg uncertainty principle. Atomic structure, Pauli's principle. Band model of solids, conduction phenomena in semiconductors, lasers, superconductivity. Radioactivity, radiations. Nuclear structure, properties of nuclei. Fission and fusion. Elementary particles, fundamental interactions, basic terms of cosmology.

Compulsory/Recommended Readings:
1. Halliday, Resnick, Walker: Fundamentals of Physics., John Wiley & Sons Inc.

2. Sears, Zemansky, Young: University Physics, Addison-Wesley Publishing Company

Subject: Basic Environmental Science
Classes/week: 2 hour lecture
ECTS Credit Points: 2
Prerequisites: -
Lecturer: Gyula Lakatos, CSc

Aims of the course: The student should acquire the more important natural science and social science connections of the based on ecology and focused on living organisms. The student have knowledge based on ecology and environmental elements of the environmental sciences. The student should be able to understand the necessity to recognise the sustainable development, knowing the history of environment protection and nature conservation.

The course involves: Environmental sciences and the ecological principles. Terminological system of our environment. Environmental sciences and interdisciplinary. Challenge for science. The principle of precaution. Environmental problems. Natural environment. The surface of the Earth. Soil, the hydrosphere, the atmosphere.
The history of the natural conservation and the environmental protection; the sustainable development. Sustainable development. The economics of the human populations and the environmental sources. Limits of the growth. Human demography. The future of human populations. Resources and reserves. The soil as natural resource and the sustainable agriculture. The water supply and the water as power source. Biological resources. The effect of the human activity on the natural environment. The pollution of the atmosphere. Water pollution. The environmental pollution of industry. Technological forecast and the environment. Sustainable development: as a challenge

Literature:
Jackson, A,R.W., Jackson, J.M. 1996: *Environmental Science. The natural environment and human impact.* Longman, Singapore.
Brundtland, G.H. (Chair) 1987: *Our common future.* Oxford: Oxford University Press.
Cunningham, W.P. & Saigo, B.W. 1995: *Environmental Science. A global concern.* Dubuque: Wm.C. Brown Publishers.

Subject: European Union
Courses/week: 1 hour lecture
ECTS Credit Points: 1
Prerequisite: -
Lecturer: Dr. István Süli-Zakar

Aim of the course: The objective of the course is to provide information about the theoretical background of integrations in general, the history of the European Union and its role in the world economy.

Topic: The process of reformation of the integration is going to be shown by the presentment of the institutions of the European Union. The process of enlargement, the characteristics of the fifth phase of the enlargement and the EU membership of Hungary is going to be emphasized especially.

Literature:
Farkas B.-Várnay E.: Bevezetés az Európai Unió tanulmányozásába. – JATE Press Kiadó, Szeged, 1997

Palánkai T.: Az európai integráció gazdaságtana. – Aula Kiadó, Budapest, 2001
Horváth Z.: Kézikönyv az Európai Unióról. – Akadémiai Kiadó, Budapest, 2005

Subject: Basic Economics and Management
Classes/week: 1 hour of lecture
ECTS Credit Points: 1
Prerequisites: None
Lecturer: István Országh, PhD

Topics: History and basic theoretical foundations of management science. Development of different management techniques, preparation for understaning and use of specific management techniques (project management, change managamenet, marketing management, innovation management, crisis management, financial management). Tools of management, conditions in technics, informatics and human resources.

Compulsory/Recommended Readings:

Subject: Quality Management
Classes/week: 1 hour of lecture
ECTS Credit Points: 1
Prerequisites: None
Lecturer: Jenő Borda, PhD

Aim of the course: The aim of the lecture is to provide students basic knowledge on the quality management and the ISO standards.
Short description of course: History of quality management. Development of the ISO standard system, advantages. The essence of the TQM and EFQM. The ISO 9000:2000 standard system; the idea of quality and quality management, customer in the focus, respect for law, process management and control, the PDCA ring, sustained development, the ISO 9004:2000. Presentating the ISO 9000:2000 standard; the system (handbook, documents), responsibility of the management (quality policy, quality aims, sources of power, communication, revision), production and supply in the ISO, customer service, measurement and control, correction and prevention.

Literature:
1. ISO 9001:2000 Standard
2. ISO 9004:2000 Standard
3. Quality Management (5th Edition) by David L. Goetsch, Stanley B. Davis. Prentice Hall; 5 edition (June 1, 2005)
4. Quality Management: Introduction to Total Quality Management for Production, Processing, and Services (4th Edition) by David L. Goetsch, Stanley B. Davis Prentice Hall; 4 edition (April 17, 2002).

Subject: Number theory and its applications
Classes/week: 2 hour lecture
ECTS Credit Points: 3
Prerequisites: Number theory I
Lecturer: Lajos Hajdu, PhD.

Topics: Prime number theory (prime number theorem, Dirichlet's theorem). Prime tests, factorization methods and their applications. Fundamentals of geometric number theory

(lattices, Minkowski's theorem, short vectors in a lattice, the LLL-algorithm and its applications). Classical and modern diophantine problems. Chapters from the modern number theory, applications.
Compulsory/Recommended Readings:
K.H. Rosen: Elementary Number Theory and Its Applications, Addison Wesley, 1985.
H. Riesel: Prime Numbers and Computer Methods for Factorization
Henri Cohen, Number Theory
Freud Róbert, Gyarmati Edit: Számelmélet

Subject: Linear algebra II
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 5
Prerequisites: Linear algebra I
Lecturer: István Gaál, DSc

Topics: Eigenvalues, eigenspaces, invariant subspaces. Characteristic polynomials. Bilinear forms and quadratic forms. Euclidean spaces, orthonormal basis, orthocomplement of a subspace. Self-adjoint and orthogonal transformations. Diagonalization.
Compulsory/Recommended Readings:
A. G. Kuros, Higher Algebra
I.M. Gelfand, Lectures in Linear Algebra
P.R. Halmos, Finite Dimensional Vector Spaces

Subject: Algebra
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 4
Prerequisites: Introduction to algebra and number theory
Lecturer: Viktor Bódi, PhD.

Topics: Algebraic structures, quotient structures, homomorphisms. The fundamentals of group theory, Lagrange's theorem. Permutation groups, Cayley's theorem. Group-action on sets. Group constructions, the fundamental theorem of finite Abelian groups. The fundamentals of ring theory. Ideals in commutative groups and questions of divisibility in commutative rings. Quotient field of integral domains. Unique prime factorization in integral domains. Principal ideal domains, Euclidean rings. Extension fields. Finite fields and their applications: algebraic codes. Applications of abstract algebra.
Compulsory/Recommended Readings:
van der Waerden: Algebra I
van der Waerden: Algebra II
Bódi Béla: Algebra I
Bódi Béla: Algebra II

Subject: Differential and Integral Calculus for Functions in Several Variables
Classes/week: 3 hour lecture, 3 hour seminar
ECTS Credit Points: 7
Prerequisites: Differential and Integral Calculus
Lecturer: Zsolt Páles, DSc

Topics: Sequences in $\mathbf{R}^n$. Basic topology of $\mathbf{R}^n$. Limit and continuity of functions in several variables, basic properties of continuous functions. Differential calculus for functions in several variables. Directional and partial derivatives. Sufficient condition of differentiability.

Extremums of functions in several variables. Concepts of the integral for functions in several variables. Calculation of integrals.

Compulsory/Recommended Readings:
W. Rudin: Principles of Mathematical Analysis. McGraw-Hill, 1964.
K. R. Stromberg: An introduction to classical real analysis. Wadsworth, California, 1981.

Subject: Measure and Integral Theory
Classes/week: 2 hour lecture
ECTS Credit Points: 3
Prerequisites: Differential and Integral Calculus
Lecturer: Gyula Maksa, DSc

Topics: Measure space. Construction of measures. Lebesgue measure, Lebesgue-Stieltjes measure. Measurable functions. Lebesgue integral. L^p-spaces. Comparison of the Riemann and the Lebesgue integrals. Absolutely continuous functions. Fubini's theorem.

Compulsory/Recommended Readings:
H. Federer: Geometric Measure Theory. Springer-Verlag, 1969.
Paul R. Halmos: Measure Theory. D. Van Nostrand Company, Inc., New York, 1950.
Anthony W. Knapp: Basic Real Analysis. Birkhäuser, Boston-Basel-Berlin, 2005.

Subject: Complex Analysis
Classes/week: 2 hour lecture
ECTS Credit Points: 3
Prerequisites: Differential and Integral Calculus for Functions in Several Variables
Lecturer: Árpád Száz, CSc

Topics: Differentiability of complex functions, Cauchy–Riemann equations. Power series, elementary functions. Path integration. Cauchy's integral theorem and integral formula. Taylor series, Laurent series. Properties of analytic functions. Residue theorem and its applications.

Compulsory/Recommended Readings:
J. Bak, D. J. Newman, Complex Analysis, Springer-Verlag, 1982.
J. B. Conway, Function of One Complex Variable, Springer-Verlag, 1973.
J. Duncan: The elements of complex analysis. John Wiley & Sons, London–New York–Sydney, 1968.

Subject: Introduction to the Theory of Ordinary Differential Equations
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 5
Prerequisites: Differential and Integral Calculus for Functions in Several Variables
Lecturer: László Székelyhidi, DSc

Topics: Basic concepts. Reduction of *n*th order differential equations to systems of first order differential equations. Elementary methods. Existence and uniqueness theorems. Linear first order systems. Linear *n*th order scalar equations. Fundamental problem of variation calculus, Euler–Lagrange differential equations.

Compulsory/Recommended Readings:

E. A. Coddington, N. Levinson: Theory of Ordinary Differential Equations. McGraw-Hill, 1955.
E. Kamke: Differentialgleichungen I. Gewöhnliche Differentialgleichungen. Leipzig, 1962.

Subject: Convex Geometry
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 5
Prerequisites: Linear algebra II, Geometry II
Lecturer: Csaba Vincze, PhD.

„Geometry is a skill of the eyes and the hands as well as of the mind" (J. Pederson, [3])

Topics: Convex sets and the convex hull. Caratheodory theorem. Helly-type theorems; the „art galery" theorem. Separation theorems, supporting hyperplanes. Polytopes and polyhedra. Euler's polyhedral formula. The five Platonic solids. Cauchy's rigidity theorem.

Compulsory/Recommended Readings:

[1] F. A. Valentine, Convex sets, Macgraw-Hill, New York, 1964
[2] S. R. Lay: Convex sets and their applications, John Wiley & Sons, 1982.
[3] Peter R. Cromwell, Polyhedra, Cambridge University Press, 1997.

Subject: Differential geometry
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 5
Prerequisites: Linear Algebra II, Differential and Integral Calculus for Functions in Several Variables
Lecturer: Tran Quoc Binh, PhD.

Topics: Plane and space curves: regular curves, arc length, curves parametrized by arc length, curvature, torsion, fundamental theorem of the local theory of plane curves and fundamental theorem of the local theory of space curves. Global properties of plane curves: rotation index of plane curves, the four-vertices theorem.
Surfaces in 3-dimensional Euclidean space: parametrized surfaces, regular surfaces, change of parameters, differentiable functions on surfaces, the tangent plane, differential of a differentiable map. Curves on surfaces, normal section, normal curvature, main curvature, Gauss curvature, mean curvature. The first fundamental form, Gauss map and the second fundamental form. Gauss's Theorema Egregium.

Suggested Reading:
B. O'Neill: Elementary differential Geometry, 2nd ed, San Diego, Academic Press, 1997.
M. P. Do Carmo: Differential Geometry of Curves and Surfaces, Englewood Cliffs, N.J.: Prentice-Hall, 1976.

Subject: Combinatorics
Classes/week: 3 hour lecture, 2 hour seminar
ECTS Credit Points: 5
Prerequisites: None
Lecturer: Lajos Hajdu, PhD.

Topics: The binomial and the polynomial theorem. Basic enumeration procedures. The sieve formula. The method of generating functions. Recurrence sequences. Fundamentals of graph theory. Special graphs and their properties. Colouring of graphs, the five colour theorem. Biparrtite graphs and independent systems of edges, König's theorem. Euler graphs, Hamilton graphs. Characterization of planar graphs. Trees, Krushkal's algorithm. Linear algebra and graphs. Algorithms and questions connected to complexity theory in combinatorics and graph theory.

Compulsory/Recommended Readings:

Diestel Reinhard: Graph Theory
G. Gutin & J. Bang-Jensen: Digraphs: Theory, Algorithms and Applications (2000)
B. Bollobás: Graph Theory;
V.G. Boltanski, I.C. Gohberg: Theorems and Exercises from Combinatorial Geometry;
R. G. Busacker, T. L. Saaty: Finite Graphs and Networks;
H. Halbertsam, H.-E. Richert: Sieve Methods;
L. Lawler, Eugene: Combinatorial Optimalisation: networks and matroids;
L. Lovász: Combinatorial Problems and Exercises;
W. Mayeda: Applied Graph Theory;
Y. Motohashi, Sieve Methods and Prime Number Theory;
O. Ore: Graphs and their Applications;
L. S. Pontrjagin: Combinatorial Topology;
N. Ya. Vilenkin: Combinatorics.

Subject: Set theory and mathematical logic
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 5
Prerequisites: Algebra and number theory, Introduction to analysis
Lecturer: Péter T. Nagy, DSC.

Topics: Definition of equivalence of sets. The concept of cardinality. The Axiom of Choice. Countabée cardinal, continuous cardinal. Comparison of cardinals. Operation with sets and cardinals. Ordered sets, order types, ordinals. Wellordered sets, the ordinal operations. Transfinite induction and recursion.
Propositions and connectives. Formulas, truth functions. Conjunctive and disjunctive normal forms. Boole functions. Deduction. Completeness theorem of propositional logic. Compactness theorem. First-order languages and structures. Terms and formulas of predicate logic. Deduction. Consistency of propositional logic.

Recommended Readings:

Hajnal A. – Hamburger P.: Set Theory, Cambridge University Press, New York, 1999.
Dirk van Dalen: Logic and Structures, Springer, 1997.
Mendelson, Elliott: Introduction to Mathematical Logic, Van Nostrand, New York, 1979.

Subject: Probability Theory
Classes/week: 3 hour lecture, 2 hour seminar
ECTS Credit Points: 6
Prerequisites: Measure and Integral Theory
Lecturer: Gyula Pap, DSc

Topics: Algebra of events, probability, probability space. Conditional probability, formula for total probability, Bayes's theorem, independence of events. Random variables, distribution functions. Discrete distributions, important discrete distributions (hypergeometric, binomial,

Poisson, and negative binomial distributions). Density function, important absolute continuous distributions (uniform, exponential,Cauchy, gamma, normal, chi-square, t-, and F-distributions). Expectation, variance, moments. Joint distribution and independenceof random variables, conditional distribution and conditional expectation, correlation coefficient. Convolution of probability distributions, distributions of functions of random variables. Random vectors, multinomial distribution, multivariate normal distribution. Generating function, characteristic function. Law of large numbers, central limit theorem. Random walk.
Recommended Readings:
I. Fazekas, Introduction to Probability Theory (in Hungarian), Lecture Notes, Kossuth University, Debrecen, 1992;
A. Rényi, Probability Theory, North-Holland, Amsterdam, 1970;
A.N. Shiryayev, Probability, Springer, New York, 1984.

Subject: Statistics
Classes/week: 3 hour lecture, 2 hour seminar
ECTS Credit Points: 6
Prerequisite: Probability theory
Lecturer: István Fazekas, PhD

Topics: Statistical sample, sampling. Empirical distribution, empirical distribution function, estimators, Glivenko-Cantelli theorem. Fisher information, joint information of independent random variables, information and reparametrization.
Point estimation: unbiased, efficient, admissible, and minimax estimators. Rao-Blackwell theorem. Completeness. Rao-Cramer inequality. Estimation methods: method of moments, maximum-likelihood estimator. Asymptotic properties of maximum likelihood estimators.
Basic concepts of testing statistical hypotheses. Neyman-Pearson lemma. Asymptotic properties of the power of a test. Classical tests for the parameters of normal distribution: u-, t-, and F-tests, Fisher-Bartlett theorem. Chi-square tests for goodness of fit, homogeneity and independence. Testing goodness of fit with estimated parameters. Multivariate normal distribution, testing its parameters, their properties.
Regression analysis, linear regression, regression with bounded rank. Linear model, estimation and tests for linear model. Analysis of variance.

Recommended Readings:
Williams, D. Weighing the odds. A course in probability and statistics. Cambridge University Press, Cambridge, 2001.
N.C. Giri, Introduction to Probability and Statistics, Dekker, New York, 1975.
Stoodley, K.D.C. – Lewis, T. – Stainton, C.L.S.: Applied statistical techniques. Ellis Horwood, Chichester, 1980.

Subject: Numerical Mathematics
Classes/week: 3 hour lecture, 2 hour seminar
ECTS Credit Points: 6
Prerequisite: Differential and integral calculus of multivariate functions
Lecturer: István Fazekas, PhD

Topics: Transformations of matrices (solving systems of linear equations, finding eigenvalues and eigenvectors). Gauss elimination and its versions (algorithms, operations count, pivot search, non-complete Gauss elimination). Factorisation of matrices (Schur, LU, LDU, Cholesky, QR).

Iterative methods for solving systems of linear and non-linear equations (Gauss-Seidel, conjugate gradient; Newton's method, local and global convergence, Broyden's method).
Finding eigenvalues of matrices (method of powers, inverse iteration, shifting, QR).
Interpolations and approximations of functions (Lagrange, Hermite, spline; Chebyshev's approximation).
Numerical integration (Newton-Cotes quadrature formulas, Gauss quadrature).

Recommended Readings:
Atkinson, K.E.: Elementary Numerical Analysis. John Wiley, New York, 1993.
Lange, K.: Numerical analysis for statisticians. Springer, New York, 1999.
Press, W.H. – Flannery, B.P. – Tenkolsky, S.A. – Vetterling, W.T.: Numerical recipes in C. Cambridge University Press, Cambridge, 1988.
Engeln-Müllgens, G. – Uhling, F.: Numerical algorithms with C. Springer, Berlin, 1996.

Subject: Operational Research
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 4
Prerequisites: Linear Algebra II, Geometry I
Lecturer: László Kozma, PhD.

Topics: Decision making and subject of operations research. Theoretical bases of linear programming: matrices and convex polyhedrons. Basic problem of linear programming. Graphical solution of two-dimensional linear programming problem. Simplex method. Initialization: big M-method, two-phase simplex method. Degeneracy and the convergence of the Simplex method(Lexicographic method). Duality in linear programming and its economic interpretation: shadow costs and shadow prices. Sensitivity analysis. Modifications of the simplex method. Special problems of linear programming: transportation, transshipment, assignment, blending. Transportation simplex method. Finding basic feasible solutions for transportation problem(North-West corner method, Vogel's method, method of minimum cost). Hungarian method. Generalization of linear programming problem: foundation of fractional-linear programming, quadratic programming methods and applications.

Compulsory/Recommended Readings:
J. C. Turner: Modern Applied Mathematics: Probability, Statistics, Operational Research, London, English Universities Press, 1970.

Subject: Computer Geometry
Classes/week: 3 hour labor
ECTS Credit Points: 3
Prerequisites: Fundamentals of Informatics, Geometry II
Lecturer: Zoltán Kovács, PhD.

Topics: Mathematical methods of computer vision: homogeneous coordinates, 2D and 3D geometric transformations, projections. Theory of parametric and implicit curve and surface models: polar forms, Bezier arcs and de Casteljau subdivision, continuity constraints, B-splines, tensor product, and triangular patch surfaces. Representations of solids and conversions among them. Programming projects in PostScript language and/or OpenGL API.

Compulsory/Recommended Readings:
Farin, G. Curves and Surfaces for CAGD, Academic Press, 1998. *Recommended.*

Mortensen, E. M. Geometric Modeling (Second Edition). Wiley Computer Publishing, 1997. *Required.*
Rogers, Adams: Mathematical elements for computer graphics (McGraw-Hill, 1989). *Required*

Subject: Computer algebra
Classes/week: 2 hour seminar
ECTS Credit Points: 2
Prerequisites: Fundamentals of Informatics, Combinatorics, Linear algebra II, Number theory I
Lecturer: Piroska Lakatos, PhD.

Topics: Study of optimal algorithms for algebraic and number theoretical problems. Review of computer algebra packages.
Solution of problems from linear algebra over real, complex and finite fields using a concrete computer algebra software.
Application of the algorithms in cryptography, algebraic coding theory, to the solution of equations, and in the algebraic theory of geometric constructions.
Ordering, searching, basic algorithms in graph theory, polynomial time algorithms.
Compulsory/Recommended Readings:
Victor Shouo: A computational introduction to number theory and algebra, http://shoup.net/
A. Menezes, P. van Oorschot, and S. Vanstone, Handbook of Applied Cryptography, www.cacr.math.uwaterloo.ca/hac
Pethő Attila: Algebraische Algorithmen

Subject: Computational number theory
Classes/week: 2 hour seminar
ECTS Credit Points: 2
Prerequisites: Foundations of Computer Science, Combinatorics, Linear algebra II, Number theory I
Lecturer: Ákos Pintér, PhD.

Topics: Computer algebra packages. Introduction to a concrete package: fundamental tools of programming (data structures, loops, conditional statements, functions, procedures), the Euclidean algorithm and its applications, congruences, representation of algebraic structures, ring of integers, field of the rational, real and complex numbers, polynomial rings, residue class rings.
Compulsory/Recommended Readings:
Pethő Attila: Algebraische Algorithmen
J. Canon – W. Bosma: Handbook of MAGMA (e-book)
J. Canon, C. Playoust: An Introduction to Algebraic Programming with MAGMA (e-book)

Subject: Analysis with Computer
Classes/week: 3 hour seminar
ECTS Credit Points: 3
Prerequisites: Foundations of Computer Science, Numerical Mathematics
Lecturer: Attila Gilányi, PhD.

Topics: Solution of problems in analysis. Illustration of functions and surfaces. Procedures in numerical analysis.

Compulsory/Recommended Readings:
W. Gander, J. Hrebicek: Solving Problems in Scientific Computing Using Maple and MATLAB. Springer-Verlag, Berlin, Heidelberg, New York, 1993, 1995.

Subject: History of mathematics
Classes/week: 2 hour lecture
ECTS Credit Points: 2
Prerequisites: None
Lecturer: Zsolt Páles, DSc

Topics: The birth of mathematical ideas. The characteristics of Greek mathematics, the great Greek mathematicians. Mathematics of Middle Ages: China, India, the Arabians, Europe. The development of the main branches of mathematics: geometry, algebra, theory of numbers, analysis, probability. History of Hungarian mathematics, Bolyai's Appendix.

Suggested Reading:
P. Dedron and J. Itard: Mathematics and Mathematicians (2 vol.), Open University Press, Milton Keynes, 1974.
J. Dieudonné: Mathematics – The Music of Reason, Springer-Verlag, Berlin, 1992.
B. L. van der Waerden: Science Awakening, Wiley, New York, 1963.

Subject: Inequalities
Classes/week: 2 hour lecture
ECTS Credit Points: 3
Prerequisites: Differential and Integral Calculus
Lecturer: Attila Gilányi, PhD

Topics: Notion of convexity and its characterizations. Regularity properties of convex functions. Characterizations of differentiable convex functions. Inequalities of Jensen and Hadamard type. Majorization and its conditions. Various generalizations of convexity. Notion of quasi-arithmetic means, comparison and coincidence theorems. Further properties of quasi-arithmetic means, homogeneity. Power means and their comparison. Minkowski and Hölder type inequalities for power and quasi-arithmetic means. Inequalities of Ingham-Jessen, Nanjundiah, Hardy, and Carleman type.

Inequalities involving sums of powers. Comparison of Gini means. Minkowski and Hölder type inequalities for Gini means. Means built up from elementary symmetric polynomials and the related inequalities.

Compulsory/Recommended Readings:
E. F. Beckenbach, R. Bellman: Inequalities, Ergebnisse der Mathematik und ihrer Grenzgebiete. Springer-Verlag, New York, 1965.
G. H. Hardy, J. E. Littlewood, Gy. Pólya: Inequalities. Cambridge University Press, 1952.
A. W. Roberts, D. E. Varberg: Convex Functions. Academic Press, New York, London, 1973.

Subject: Calculus of Differences
Classes/week: 2 hour lecture
ECTS Credit Points: 3
Prerequisites: Differential and Integral Calculus
Lecturer: Zoltán Boros, PhD

Topics: Divided differences, interpolation. Lagrange's and Newton's formulae. Summation of functions, the case of elementary summation. Solution of the equation $\Delta F(x) = p(x)$, where p is a polynomial. Bernoulli numbers and polynomials. Euler's formula. First order linear difference equations. General theory of linear difference equations. Linear equations with constant coefficients.

Compulsory/Recommended Readings:
A. O. Gelfond: Calculus of finite differences. International Monographs on Advanced Mathematics and Physics. Hindustan Publishing Corp., Delhi, 1971.
Charles Jordan: Calculus of finite differences. Hungarian Agent Eggenberger Book-Shop, Budapest, 1939; Chelsea Publishing Co., New York, 1965.

Subject: Projective Geometry
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 5
Prerequisites: Geometry I, Linear Algebra I
Lecturer: László Kozma, PhD.

Topics:
Affine transformations of the Euclidean plane, axial affinities. The affine image of the circle. Constructions related to ellipses. The projective extension of the Euclidean plane and space. Perspectivities and projectivities. Cross ration, Pappos' theorem. Central collineations and their applications. The analytic model of projective geometry. The projective theory of curves of second order, theorems of Pascal, Brianchon and Steiner.

Compulsory/Recommended Readings:
Coxeter, H.S:M.: Projective Geometry, Springer, 1987.
Beutelspacher, A.: Projective geometry: from foundations to application, Cambridge University Press, 1998.

Subject: Introduction to descriptive geometry
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 5
Prerequisites: Introduction to projective geometry
Lecturer: Péter T. Nagy, DSC.

Topics: Affine transformations and collineations. Orthogonal and central projection of the 3-space onto a plane. Monge projection's method. Reconstruction problems. Representation of points, lines and planes. Intersection, transversality, orthogonality, visuability. Conic sections. Projections of polyeders, regular solids. Intersection of polyeders. Shadows.

Recommended Readings:
Ryan, Daniel L.: CAD/CAE Descriptive Geometry, CRC – Taylor and Francis, 1991,
Stewart, Susan Ann: Applied descriptive geometry, Albany, N.Y., Delmar, 1986.

Subject: Introduction to Lie theory
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 4
Prerequisites: Linear algebra II, Geometry II
Lecturer: Zoltán Muzsnay, PhD.

Topics: Linear Lie groups. Coordinates. Invariant vector fields, Lie algebras. The Lie algebras of classical Lie groups. 1-parameter subgroups. Exponential map. The classification of 2 and 3-dimensional Lie algebras. Linear representation.

Compulsory/Recommended Readings:
J. F. Adams: Lectures on Lie groups, Benjamin, New York, 1969.
J. Tits: Liesche Gruppen und Algebren, Springer-Verlag, Berlin, 1983.
T. Bröcker – T. Dieck: Representations of compact Lie groups, Springer-Verlag, Berlin, 1985.

Subject: Elementary topology
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 5
Prerequisites: Geometry II
Lecturer: József Szilasi, CSc (PhD)

Topics: Basic topological concepts, topological equivalence. Famous topological constructions: the *n*-tours, the Möbius band, the Klein bottle, the real projective plane. Topological manifolds. Simplicial complexes, triangulation. Combinatorial invariants, the Euler characteristic. Classification of connected 1-manifolds and compact 2-manifolds.

Suggested Reading:
W. G. Chinn and N. E. Steenrod: First Concepts of Topology. Mathematical Association of America, Washington, 1966.
D. Hilbert and S. Cohn-Vossen: Geometry and the Imagination, Chelsea, New York, 1952.
John M. Lee: Introduction to Topological Manifolds, Springer-Verlag, Berlin, 2000.

Subject: Topics in elementary number theory
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 5
Prerequisites: Number theory and its applications or Number theory II
Lecturer: Lajos Hajdu, PhD

Topics: The low of the quadratic reciprocity, Legendre and Jacoby symbols, cogruences of higher degree, primitive roots, discrete logarithm, continued fractions and their applications, Pell equations, Farey fractions.

Compulsory/Recommended Readings:
K.H. Rosen: Elementary Number Theory and Its Applications
Don Redmond: Number theory
Serge Lang: Introduction to diophantine approximation

Subject: Topics in algebra
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 5
Prerequisites: Algebra
Lecturer: Piroska Lakatos, PhD

Topics: Comparison of algebraic structures (semigroups, groups, vector spaces, rings, fields, algebras). Theorems of the same type in the above structure (special substructures, homomorphisms, direct decompositions, representation theorems). Applications in discrete mathematics (finite structures) and in computer science.

Compulsory/Recommended Readings:
van der Waerden: Algebra I
van der Waerden: Algebra II
Bódi Béla: Algebra I
Bódi Béla: Algebra II

Subject: Fundamentals of cryptography
Classes/week: 2 hour lecture, 1 hour seminar
ECTS Credit Points: 4
Prerequisites: Number theory and its applications or Number theory II
Lecturer: Lajos Hajdu, PhD.

Topics: Basic concepts of cryptography. Symmetric versus public key cryptography. Caesar's cryptosystem, the affine cryptosystem, DES, AES, RSA. Basic protocols in cryptography. Digital signatures. Introduction to the PGP package.

Compulsory/Recommended Readings:
J. Buchmann: Introduction to cryptography
N. Koblitz: A Course in Number Theory and Cryptography
A. Menezes, P. van Oorschot, and S. Vanstone, Handbook of Applied Cryptography, www.cacr.math.uwaterloo.ca/hac

Subject: Financial Mathematics
Classes/week: 2 hour lecture, 2 hour seminar
ECTS Credit Points: 5
Prerequisites: Probability Theory
Lecturer: Sándor Baran, PhD

Topics: Preference ordering, utility theory, utility maximization, some classical utility functions, expected utility, risk aversion and its measures, optimal portfolios, demand for financial assets, first and second order stochastic dominance, mean variance portfolio analysis, CAPM, APT, risk measures.

Compulsory/Recommended Readings:

Chi-fu Huang, R.H. Litzenberg: Foundations for financial economics, Prentice Hall, 1988.
U. Schmidt: Axiomatic utility theory under risk, Springer, 1998.
J.E. Ingersoll: Theory of financial decision making. Rowman & Littlefield, 1987.
E. Barucci: Financial Markets Theory: Equilibrium, Efficiency and Information, Springer, 2006.
J. Gáll, G. Pap: An introduction to portfolio management, Lecture notes, mobiDIÁK series, 2006, http://mobidiak.inf.unideb.hu/.

Subject: Applications of Probability Theory
Classes/week: 3 hour lecture
ECTS Credit Points: 6
Prerequisite: Probability theory
Lecturer: István Fazekas, PhD

Topics: Stochastic models and their statistical analysis. Random walk (arc sine law, large deviations. law of the iterated logarithm, ruin problems). Point processes (Poisson process). Branching processes (Galton-Watson process, continuous time Markovian branching process). Queuing models (stationary birth and death processes, queuing systems).

Compulsory/Recommended Readings:
Nummelin, E, General Irreducible Markov Chains and Non-negative Operators. Cambridge University Press, Cambridge, 1984.
W. Feller, An Introduction to Probability Theory and its Applications, Vol. 1., 2. John Wiley & Sons, New York, 1966., 1971.
S. Karlin, H.M. Taylor, A First Course in Stochastic Processes, Academic Press, New York, San Francisco, London, 1975.

Subject: Information Theory
Classes/week: 2 hour lecture
ECTS Credit Points: 3
Prerequisite: Probability Theory
Lecturer: Sándor Baran, PhD

Topics: Shannon entropy and properties of entropy, notions and measures of information, models for communication channels, discrete channels, coding and decoding of information, irreducible and uniquely decipherable codes, the Kraft-Fano inequality, the McMillan inequality, construction of optimal codes, Huffman code, some other classical codes, block codes, channel capacity, fundamental theorems of information theory, continuous channels, entropy in continuous case.

Compulsory/Recommended Readings:
Robert Ash, Information Theory, John Wiley & Sons, New York, London, Sydney, 1965.
I. Csiszár, J. Körner: Information theory: Coding theorems for discrete memoryless systems, Budapest, Akadémiai K., 1986.
M. Reza Fazlollah, Introduction to Information Theory, McGraw-Hill Book Company, London.
J. Gáll, G. Pap: Információelmélet (Information Theory), lecture notes, mobiDIÁK series, 2006, http://mobidiak.inf.unideb.hu/.