MODULE SYLLABUS

Below is the syllabus of each module classified according to their code no.

9001 MATHEMATICAL ANALYSIS I

1st semester
Core Prog.

Elements of Set Theory: Sets and functions, finite and infinite sets. Introduction to Real numbers: Axioms and basic definitions. Natural numbers. Mathematical induction. Countable and uncountable sets. Cardinality. The algebraic and order properties of R, The completeness Axiom. Least upper bound. Sequences of real numbers. Upper and Lower Limits of Sequences. Convergent and Cauchy sequences. Series of real numbers. Limits and continuity of functions. Basic theorems. Continuity on compact sets and uniform continuity. Elementary functions and their inverses. The basic rules of differentiation. Fermat's lemma and Rolle's theorem, Taylor's Formula. Convex functions. Riemann integral. Indefinite integral. The mean value therorem. Techniques of Integration. Applications of the integrals. Improper integrals.

9002 ANALYTIC GEOMETRY AND LINEAR ALGEBRA

1st semester
Core Prog.

Vector calculus. The notion of the free vectors. Coaxial and plane vectors. Coordinate systems. The inner (dot), the exterior (cross) and mixed products. Geometrical interpretation of vector products. Planes and straight lines in 3-space. Curves in the plane and in 3-space. Introduction to algebraic structures: Groups, rings and fields. Vector spaces and subspaces. Linear dependence and independence. The notion of the basis and the dimension of vector spaces. Matrices and determinants. The rank of a matrix. Linear systems and their solvability. The Gauss elimination method. The Cramer system. Linear mappings and the associate matrices. Change of the basis system. Equivalent and similar matrices.

9003 INTRODUCTION TO PROGRAMMING

1st semester
Core Prog.

Introduction to Computer Science. *Simple algorithms and data structures.* Programs and programming languages. Integrated program development environments. *Introduction to object oriented programming in Java.* Objects, classes and methods. Implementation methods. Data types and operators. Parameter passing. Selection and flow control instructions. *Introduction to the Application Programming Interface* (API, basic java libraries). Strings, arrays, linked lists. Recursion. Debugging. Lab: Series of supervised lab exercises in Java. Use of dedicated to teaching integrated programming environment (BlueJ).

9004 PHYSICS I (MECHANICS) INCLUDING LABORATORY

1st semester
Core Prog.

Introduction, Mathematical tools, Vector analysis. Newtonian Mechanics: The laws of Physics in vector notation. Forces. Newton's laws. Conservation of energy, momentum and angular momentum.

The harmonic oscillator. Systems of many particles. Elementary dynamics of sold bodies. Central forces – Forces of inverse-square law. Two-body problem, reduced mass.

9006 MECHANICS I: STATICS

1st semester
Core Prog.

Introductory concepts and definitions. Elements of vector analysis. Force and Moment of a force: The force as a vector in 2 and 3 dimensions. The moment of a force about a point and about an axis. Varignon's theorem. Reduction of systems of forces and moments. Central axis (wrench). Systems of parallel forces. The concept of distributed loading. *Properties of plane areas:* 1st moment of area. Centroid and centre of mass. 2nd moment of area. Steiner's theorem. *Equilibrium:* Degrees of freedom. Restrictions-Supports. Free Body Diagram. Equilibrium of a rigid body in 2D and 3D. Application: Elements of hydrostatics. Forces on submerged bodies. *Structures:* Trusses – Beams and frames – M, V, N diagrams. *Special application:* Cables-Catenary. *Friction. Virtual Work:* Work and virtual work. Principle of virtual work. Principle of virtual power.

9007 INTRODUCTION TO PHILOSOPHY

3rd semester
Core Prog.

The Historic and Systematic Approach to Philosophy. Problems and Periods of Western Philosophy. Systematic presentation and analysis of central issues in Philosophy: the validity of knowledge, truth, mind and matter, language and the real world, the significance of Philosophy today.

9012 MATHEMATICAL ANALYSIS II

2nd semester
Core Prog.

Prelimaries Eucledian space R^n. The topology of R^n. Sequences and their convergence. Connected and path-connected sets. Limit and continuity of functions of several variables, Derivatives of one variable vector functions and applications to Differential Geometry (curvature, torsion and the Frenet frame) and Classical Mechanics. The curvilinear coordinates and the corresponding unit vectors. Derivatives of vector functions of several variables. The concept of the partial derivative of first and higher order. Schwarz theorem. Directional derivatives. Differentiable functions and relative theorems. Differentials of first and higher order. The best linear approximation. On the tangent planes to surfaces. The differential operators: gradient, divergence and rotation. The Laplacian. Applications in Physical Sciences: The flow lines of vector fields and the notion of the Material Derivative. Mean value theorem. Taylor formulae. Inverse function theorem. Implicit functions. Functional dependence. Extremum points. Lagrange multipliers.

9013 ORDINARY DIFFERENTIAL EQUATIONS

3RD SEMESTER
CORE PROGR.

◆*Introduction:* The concept of the solution and its geometrical properties. Initial - boundary value problems. Well posed problems. ◆*First order differential equations:* Separable type equations, homogeneous, exact, Riccati, Lagrange, Clairaut equations. Qualitative theory. Existence and uniqueness of solutions. Picard's theorem, Peano's theorem. ◆Lin*ear ordinary differential equations:* Basic theory, linear independence. Wronski determinant. Homogeneous equations with constant coefficients. Method of variation of parameters (Lagrange method) – The method of undetermined coefficients. The Euler equation. ◆*The method of power series:* The concept of the solution near an ordinary point, Fuchs theory Legendre's equation. Solution near regular singular point, Frobenius method. Bessel's equation. ◆*Systems of ordinary differential equations:* Introduction, Elimination method, Basic theory. Systems with constant coefficients, homogeneous, non - homogeneous. ◆*Laplace transform:* Introduction, properties, inverse Laplace transform. Applications, Heaviside function. Dirac delta function. Convolution. Integrodifferential equations. ◆Use of computational software for the study of problems in ordinary differential equations.

9014 | DESIGN AND DEVELOPMENT OF COMPUTER APPLICATIONS | 2nd SEMESTER CORE PROGR.

Object oriented programming in Java. Inheritance and polymorphism. Abstract classes and interfaces. Exceptions. Data input and output. Data collection classes. Graphical user interfaces. Applets. *Design of object oriented programs. Analysis of simple algorithms and data structures.*

Lab: Series of supervised lab exercises in Java. Use of dedicated to teaching integrated programming environment (BlueJ).

9015 | PHYSICS – II (ELECTROMAGNETISM I) | 2nd SEMESTER CORE PROGR.

Electrostatics. Coulomb's law. The electric field. Electrostatic potential. Potential difference. Gauss's law. Energy stored in the electric field. Theorems of Gauss and Stokes. Poisson's and Laplace's equations. Conductors. Electric currents. Ohm's law. The magnetic field. Biot – Savart law. Ampere's law. Electromagnetic induction. Energy stored in the magnetic field. Maxwell's equations. Electromagnetic waves.Introduction to Electric and Magnetic Field in matter.

9018 | INTRODUCTION TO THE HISTORY OF SCIENCES AND TECHNOLOGY | 3rd SEMESTER CORE PROGR.

This introductory course is dealing with the major characteristics of the scientific phenomenon the technical achievements and their relation, the period from 6th century BC to the so called scientific revolution of the 16th-17th century. The focus is on natural philosophy- science of the ancient Greeks, some elements are given on the Latin medieval period and emphasis is also put on the era of the formation of the classical science. Ancient Greek mathematics, the production of energy during the long duration and on the history of engineers focused to the Greek case, are talked rudimentary

9019 | HISTORY OF ECONOMIC THEORIES | 3RD SEMESTER CORE PROGR.

Mercantilism and its decline, The theory of mercantilism at its height: Thomas Mun, The reaction against mercantilism: Dudley North, William Petty, David Hume. The Physiocrats, The Quesnay's Tableau Economique, The theoretical legacy of the Physiocrats. Adam Smith: The theory of value, The theory of distribution, The theory of capital and productive work. David Ricardo: Theory of value, Ground rent, Wages and profit. The decline of the Classical School: Th. Malthus, J.B. Say, The conflicts sorrounding the theory of value, Senior, Carey & Bastiat, Sismondi, The Utopian Socialists, John Stuart Mill. Karl Marx: Abstract labour and value, The theory of capital, Reproduction of the total system of production, Values and prices of production. The Neoclassical School: Marginal utility and equilibrium of supply and demand, The neo-Ricardian School: Systems of production and relative prices, Basic and non-basic commodities, The problem of “negative prices”. J. M. Keynes: The “General Theory” and its era, The effective demand and the multiplier, long-term expectations and marginal efficiency of capital.

9024 PHILOSOPHY OF SCIENCES

4TH SEMESTER
CORE PROGR.

The (perennial) problem of the Rupture with our (recent or remote) epistemological past. The distinction of truths into necessary and contingent (Leibniz). The employment of the distinction by Hume in his criticism of causality. Kant’s concept of synthetic a priori. Rupture as a conflict with truths of reason (necessary). The contextualist account of Analyticity. The refutation of Quine. Incommensurability as the conflict with a topical truth. The philosophy of J. L. Austin. The Darwinian view of language. Locution. Illocution and Perlocution. The suppression of Rupture.

9029 LINEAR ALGEBRA AND APPLICATIONS

2nd SEMESTER
CORE PROGR.

Matrices and Linear Mappings. Matrix Representation of a Linear Mapping. Characteristic values of a matrix: Eigenvalues and eigenvectors. Matrix diagonalisation. The Theorem of Cayley-Hamilton, the minimal polynomial. Applications of matrix diagonalisation: exponential function of matrices, differential systems and discrete dynamical systems. Inner product vector spaces. Linear mappings between vector spaces with inner product. Normal forms of matrices: Jordan form, rational normal form. Linear and bilinear forms, quadratic forms. Curves in space and surfaces. Classification of 2nd order curves and surfaces. Applications to Applied and Physical sciences. Orthonormal Bases. Gram-Schmidt Orthogonalization Proces. Orthogonal Matrices. Orthogonal Transformations. Diagonalization of Symmetric Matrices. Classification of 2nd order curves and surfaces.

9030 MATHEMATICAL ANALYSIS III

3RD SEMESTER
CORE PROGR.

Calculus of functions of several variables. ◆*Multiple integrals*: Double and triple integrals, change of variables, Fubini’s theorem, geometrical and physical applications. Line integrals of 1st and 2nd kind with applications. Green’s Theorem. ◆*Surface Integrals:* Elements of surface theory, Surface integrals of 1st and 2nd kind with applications. ◆*Elements of Vector Analysis:* Special forms of vector fields. Divergence and rotation of vector fields. Gauss and Stokes theorem with applications.

9032 PROBABILITY

5TH SEMESTER
APPLIED MATHEMATICS
COURSE

The notion of probability. Axioms of probability. Probabilistic spaces, Combinatorial Analysis. Conditional probability and independent events. Theorem of total probability and Bayes’ rule. Random variables. Density function. Special density functions (Binomial, Negative Binomial, Geometric, Hypergeometric, Poisson, Uniform, Normal, Exponential, Gamma, Lognormal, Weibull, Chi-Square, Student’s t, Snedecor’s F). Multivariate distributions (Multinomial, Multivariate Normal). Expected value, variance and covariance. Conditional expectation. Distributions of functions of random variables. Convolution. Probability and moment generating functions. Characteristic functions. Convergence of sequences of random variables. Laws of large numbers. Central limit theorems and applications.

9033 | PHYSICS – III (OSCILLATIONS AND WAVES) INCLUDING LABORATORY | 3RD SEMESTER CORE PROGR.

The harmonic oscillator (undamped and damped). Forced oscillations. Resonance. Coupled oscillators, normal modes of vibration, system with many degrees of freedom. Electric oscillations. Waves in 1-dimension continuous media Phase and group velocity, dispersion. Reflection, transmission at a discontinuity. Fourier methods, band-width theorems. Waves in 2-dimensions. Waves in 3-dimensions. Electromagnetic Waves, Interference. Diffraction.

9036 | ECONOMIC ANALYSIS --I | 4TH SEMESTER CORE PROGR.

The tools of economic analysis. Economic models. Prices, income and demand. Elasticities. The theory of consumer choice. Complementary and substitute goods. Organisation and behaviour of enterprises. Revenue cost and profits. Theory of supply: cost and production. Perfect competition and pure monopoly: the extreme cases of the market structure. Competition in the international markets. Market structure and imperfect competition. Analysis of factor markets. Labour market. Capital and land. Demand of production factors by the enterprise.

9041 | NUMERICAL ANALYSIS I AND LABORATORY | 3RD SEMESTER CORE PROGR.

Introduction to Fortran, Matlab and Mathematica. *An Introduction to Rounding Errors*: Numbers Arithmetic Representation, Basic Rounding Errors. *Linear Systems*: Gauss Elimination Method, LUandCholeski Factorization Methods. Norms (Vector, Matrix, Function).Stability of Linear Systems.Fixed Point Iteration Schemes.Jacobi, Gauss-Seidel and Relaxation Methods.Least Squares Methods and Applications.Numerical Computation of Eigenvalues/Eigenvectors.*Nonlinear Equations*: Bisection Method. Fixed Point Iteration Methods, Newton-Raphson (for Equations and Systems).*Interpolation and Approximation*: Lagrange Interpolation.Newton Polynomial.Hermite Interpolation.Cubic Splines.Best Approximation via Least Squares. Orthogonal Polynomials.*Numerical Integration*: Newton-CotesRules (Trapezoidal, Simpson, 3/8). Gauss Integration.*Introduction to ODEs*: Euler, Taylor and Runge-Kutta Methods

9042 | COMPLEX ANALYSIS | 4TH SEMESTER CORE PROGR.

Complex numbers. Algebra of complex numbers, stereographic projection, topology of C, sequences of complex numbers. Analytic functions. Derivate of a complex function, Cauchy-Riemann equations, harmonic and conjugate harmonic function, Elementary functions. The exponential function, trigonometric functions and their inverses, complex logarithm. Complex integration. Cauchy's theorem and applications. Liouville theorem, maximum principle, Schwarz's Lemma. Series of analytic functions, power series. Taylor's theorem. Laurent series and residues. Classification of singular points, residue theorem and applications The argument principle and Rouche's theorem.

Meromorphic functions, theorem of Mittag-Leffler. Harmonic functions, basic properties of harmonic functions. Conformal mapping. Mobius transformations. Riemann mapping theorem. The Schwarz-Christoffel transformation. Applications of the conformal mapping.

9045	PHYSICS – IV (QUANTUM MECHANICS I)	4TH SEMESTER CORE PROGR.

Introductory concepts. Schrödinger's equation. The uncertainty principle. Motion of a particle in potential wells: Bounded and unbounded eigenstates. Wave packet motion of a free particle. Scattering of a particle from a potential barrier. Tunneling and current density. Measurement in Quantum Mechanics. Expected values of physical quantities. Harmonic oscillator.

9047	SOCIOLOGY OF SCIENCE	4TH SEMESTER CORE PROGR.

The study of science as a social institution and practice. Science in the laboratory, social relationships in science practice, gender politics of science. What is science from a sociological and anthropological point of view. Ethnomethodology of science and social constructivism of scientific knowledge

9048	ECONOMIC ANALYSIS –II (MACROECONOMICS)	6TH- SEMESTER

National Accounts. Gross national product and net national product. The basic macroeconomic identities. Indices of prices and time value of money. Income, expenditure and the production equilibrium. The multiplier. Public sector and income equilibrium. Money, interest and income. The market of goods and the IS curve. The asset markets and the LM curve. Aggregate supply and aggregate demand. International interconnections of an open economy. Consumption, saving and investment. Investments of fixed capital: the neoclassical and the Keynsian approach. Long-run growth and productivity.

9053	REAL ANALYSIS	6TH SEMESTER APPLIED MATHEMATICS COURSE.

Real, natural and rational numbers. Axiom of Peano. Dedekind cuts. ◆*Metric spaces*: fundamental definitions, constructions of metrics deducible from norms in vector spaces. Sequences and continuous functions on metric spaces. Open and closed subsets of metric spaces. Accumulation points of a set. Equivalent metrics. Dense subsets and separable metric spaces. Zorn's Lemma. ◆*Complete metric spaces*: Completeness, Baire's theorem, Uniformly continuous functions. ◆*Compact metric spaces*: Properties, continuous functions on compact metric spaces, connectedness, totally bounded subsets of metric spaces. ◆ *Function sequences*: pointwise and uniform convergence of sequences of real functions. Vector normed spaces. *The space C[a,b]*: Equicontinuous sets of functions, the Arzela theorem. ◆*Products of metric spaces*: finite and infinite countable products of metric spaces.

9054	NUMERICAL ANALYSIS II AND LABORATORY	5TH- SEMESTER APPLIED MATHEMATICS COURSE

Introduction: InitialValueProblems, Picard'sTheorem, Euler'sMethod, Consistency, Stability, Error Estimates. *Single Step Methods*: Basic Theory, Consistency, Stability, Error Estimates, Implicit Methods, Applications to Systems of ODEs. *Runge-KuttaMethods*: Construction and Numerical Implementation, Consistency, Stability, Error Estimates, Applications to Systems of ODEs.*Multistep*

Methods: Construction and Numerical Implementation, Root Conditions, Convergence, Stability, Error Estimates. *Boundary Value Problems*: Introduction and Basic Theory, Finite Differences,Stability, Error Estimates, Shooting Methods, Sturm-Liouville Problems, An Introduction to Finite Element Methods.

9056	INTRODUCTION TO CONTINUUM MECHANICS	5TH- SEMESTER APPLIED MATHEMATICS COURSE

The Basic Hypothesis in Continuum Mechanics. Kinematical Description (Material and Spatial Descriptions). Displacement Gradient. Material Derivative. Reynolds Transport Theorem. Balance Laws (Mass, Momentum, Energy). Introduction to Fluid Mechanics. Incompressible Fluids. Inviscid Fluids. Equations of Continuity. Bernoulli's Equation. Constitutive Equations for Solids and Fluids. Simple Problems of Motion and Deformation of Solids. Simple Problems of Motion and Deformation of Fluids. Introduction to Partial Differential Equations of the 1^{st} Order and the 2^{nd} Order. Waves in Solids. Waves in Fluids. Navier-Stokes Equations. Prandtl's Boundary Layer Theory.

9057	DISCRETE MATHEMATICS	5TH- SEMESTER APPLIED MATHEMATICS COURSE

Combinatorics: Permutations, combinations, orderings. Applications of binomial coefficients, the binomial theorem and its applications. Permutations and combinations of multisets. Multinomial coefficients and the multinomial theorem. The pigeonhole principle. Ramsey's theorem and Ramsey numbers. The inclusion-exclusion principle. Permutations with forbidden positions and some applications. *Recurrenie relations and generating functions.* The Fibonacci sequence. Linear homogeneous recurrence relations with constant coefficients. Inhomogeneous equations. *Catalan and Stirling numbers.*

9058	ALGEBRA AND APPLICATIONS	7TH- SEMESTER APPLIED MATHEMATICS COURSE

Partitions and equivalence relations. Introduction to Group Theory. Groups of symmetries, the dihedral groups. Cyclic groups: the nth roots of unity, remainder classes, the integers, the classification of cyclic groups. The Theorems of Fermat and Euler, linear congruences. Permutation groups, Cayley's theorem. Cosets (application to linear codes), Lagrange' theorem, normal subgroups, quotient groups. Free groups, free abelian groups, group presentations. The classification of finitely generated abelian groups. The abelianizer of a group. Introduction to rings, integral domains and fields.

This course is particularly useful to those who have selected the stream «Mathematics for Information Sciences».

9059	INFORMATION AND CODING THEORY	5TH- SEMESTER APPLIED MATHEMATICS COURSE

The origins of Information Theory. The concept of probability. Shannon's information measure and the concept of entropy. Conditional, joint and mutual information measures. Axioms. The communication model. *The discrete memoryless information source.* Coding methods: Fano, Shannon, Huffman, Gilbert – Moore. Kraft's inequality. McMillan's inequality. Shannon's first theorem. The discrete information source with memory. Error – correcting codes. Humming's sphere – packing bound. Plotkin's bound. Hadamard codes. Codes and Block designs. Reed – Muller codes. Codes and

Latin Squares. *Linear Codes.* Equivalence of Linear codes. The Hamming and Golay codes. Dual codes. Sydrome decoding. Perfect codes. Cyclic codes. Weight enumerators.

9060 | SET THEORY | 5^{TH} SEMESTER APPLIED MATHEMATICS COURSE

Introduction. Countable and non countable sets, the set of real numbers. Cantor Set. Cantor's theorem. Schroeder-Bernstein' theorem. *Paradoxes and axioms.* Russell's paradox and Zermelo foundations. *The axioms of set theory.* Orders, relations and functions. Natural and real numbers. *Well ordered sets.* Transfinite induction and recursion. Hartogs' and fixed point theorems. *Axiom of Choice*, Zorn Lemma. Well ordering theorem *Applications*. Cardinal and ordinal numbers and their arithmetic. Cantor's normal form theorem.

9061 | EXPERIMENTAL STRENGTH OF MATERIALS | 7^{TH} SEMESTER APPLIED MATHEMATICS COURSE

Elastic and Plastic behaviour of materials (constitutive equations, mechanisms of deformation, study of the effect of sample geometry, type of loading, temperature etc. *Failure of materials* (macroscopic and microscopic failure criteria). *Time dependent material behaviour* (creep, stress-relaxation, fatigue, impact, principles of viscoelasticity). *Experimental part*: Tension, compression, torsion, bending, hardness measurement, creep, relaxation, fatigue, impact).

9062 | ANALYTICAL MECHANICS | 5^{TH} SEMESTER APPLIED MATHEMATICS COURSE

The general problem of Dynamics: Statement, Integrability, Solvability. *Spaces*: Configuration, Event and Phase Space. *Constraints*: Holonomic, Non – holonomic. Independence. The constraint forces. *Generalized Coordinates and Displacements*: Definition, virtual and actual displacements. The Pfaffian forms of constraints. Catastatic and acatastatic constrains. *The Principles of Virtual Works and D' Alemberts*: Virtual work, Generalized forces, the Lagrange's multipliers. *The Principles of Hamilton and Least Action*: Contemporaneous and Noncontemporaneous Variations, the Euler – Lagrange equation. Statement of the two principles. Application into holonomic and non holonomic systems. *The Lagrange's Equations*: Kinetic Energy, the general form of Lagrange equations, the Jacobian Integral, ignorable or cyclic coordinates, the Routhian function. *Hamiltonial Mechanics*: The Legendre Transformation, the Hamiltonian function. The canonical equations of Hamilton. Poisson brackets. *The solution of dynamical problems*: Separation of variables. Autonomous and non – autonomous systems. Equilibrium. The study of stability by the methods of Liapunov and Poincare.

9068 | COMPUTATIONAL PHYSICS – I | 7^{TH} SEMESTER APPLIED MATHEMATICS COURSE

Introduction: Operating system, programming language. Programming techniques, compiling, linking, optimization. Electrostatics: Field and equipotential lines of the electric field of a planar distribution of point charges. Solution of Laplace and Poisson equation on the plane. Particle dynamics in 1 dimension: Integration methods of initial value problem, Euler and Runge-Kutta methods. Data analysis, plotting. Study of convergence and systematic errors. Applications: Harmonic oscillator with damping and external force. Simple pendulum with damping and external force and study of its chaotic behaviour. Particle dynamics in 2 dimensions: Motion in the gravitational field, friction. Planetary motion. Scattering. Particle Dynamics in 3 dimensions: Adaptive Runge-Kutta methods. Interface with third party code. Particle motion in space under newtonian and special relativistic dynamics. Motion of ultrarelativistic particles in the dipole magnetic field.

9070 EXPERIMENTAL STRENGTH OF MATERIALS

7TH- SEMESTER
APPLIED MATHEMATICS
COURSE

For description see the module with code 9061, ("Experimental Strength of Materials", Applied Mathematics Course)

9071 PHILOSOPHY OF PHYSICS

7TH- SEMESTER
APPLIED MATHEMATICS
COURSE

Foundations of spacetime theories, symmetry principles and covariance (Newtonian physics, special and general relativity). Conventionality of geometry. Conventionality of simultaneity. Causal theories. Substantivalism and relationism (the Newton-Leibniz debate, the hole argument). Foundations of quantum theories. Uncertainty principles and early attempts at interpreting quantum mechanics (Einstein, Heisenberg, Bohr). The EPR argument. Bell inequalities, locality and separability. The problem of quantum measurement. The doctrine of determinism. Determinism in physics (Newtonian mechanics and gravitation, classical field theories, special and general relativity, quantum mechanics).

9072 ANALYTICAL MECHANICS

7TH SEMESTER
APPLIED MATHEMATICS
COURSE

For the description, see the course with code 9062, (Applied Mathematics Course)

9074 CONDENSED MATTER PHYSICS

6TH- SEMESTER
APPLIED MATHEMATICS
COURSE

Free electron model (Thermal equilibrium and transport properties). Crystal lattices. X-Ray Diffraction from crystals. The reciprocal lattice. Crystal bonding (Classification of crystal lattices). Motion of electrons in a periodic potential. Bloch theorem. Energy bands. Semiconductors. Effective mass. Density of states. Fermi level in intrinsic and extrinsic semiconductors. Lattice vibrations. Thermal properties. Surfaces. Amorphous solids.

The course includes laboratory exercises

9075 GENERAL CHEMISTRY

5TH- SEMESTER
APPLIED MATHEMATICS
COURSE

Atomic theory. The periodic system. Chemical bonds. Solid state Chemistry. Chemistry of complexes and organometallic compounds. Chemical kinetics – chemical equilibrium. Electrochemistry. Photochemistry and photo-electrochemistry. Nuclear Chemistry. *Special subjects:* Chemistry of water, Chemistry of the atmosphere. Materials, *Laboratory exercises: Chemistry of water solutions.* Characteristic reactions of anions and cations. *Physical Chemistry:* Chemical kinetics. Corrosion. Galvanic Cells. Electrolysis.

The course includes laboratory exercises

9076 INTRODUCTION TO CONTINUUM MECHANICS

7TH- SEMESTER
APPLIED MATHEMATICS
COURSE

For the description see the course with code 9056, (Applied Mathematics Course)

9077 QUANTUM MEACHANICS – II

5TH- SEMESTER
APPLIED MATHEMATICS
COURSE

Mathematical foundation of Quantum mechanics. Schrödinger's equation. Application to stationary states. Tunneling. Transition from Classical to Quantum Mechanics. The harmonic oscillator. Three dimensional potentials, Coulomb potential. Charged particles in electromagnetic fields. Theory of angular momentum. Introduction to spin. Addition of angular momentum. Time – independent perturbation theory and time-dependent, applications. The WKB approximation.

9078 FUNCTIONAL ANALYSIS I.

7TH- SEMESTER
APPLIED MATHEMATICS COURSE

◆*Elements of Linear Algebra*: vector spaces, linear operators, convex sets. *Norms in vector spaces*: The fundamental definitions, balls in normed spaces. The interrelation b etween algebraic and topological structure of normed spaces. Banach spaces. ◆*Continuous or bounded operators*: basic properties, the norm in the space B(X,Y), the space X* of linear functionals defined on X, isomorphisms and isometries between normed spaces, the subsequent continuity of linear operators in finite dimensional spaces. ◆*Hilbert spaces*: Inner product, the dual space of a Hilbert space, orthonormal systems. ◆*Hahn-Banach Theorem*: The consequences of the theorem, the natural imbedding of X into X**, the dual spaces of L_p. ◆ *The geometrical form of Hahn-Banach Theorem*: The Minkowski functional, the Hahn-Banach separation Theorems, the theorem of Krein-Milman. Applications of Baire's theorem in Banach spaces. The Uniform boundedness principle, the open mapping theorem, the closed graph theorem. Quotient spaces.

9080 DYNAMICAL SYSTEMS

5TH- SEMESTER
APPLIED MATHEMATICS COURSE

Fundamental theory: theorems of existence and uniqueness of solutions: Picard's theorem, Peano Theorem, Extension of solutions. Differentability of solutions. Continuous dependence on intial data and parameters, Gronwall inequality. Stability: Introduction. Autonomous Systems. Stability of linear systems: Introduction. Autonomous Systems. Stability of linear systems: general theory, autonomous linear systems in the plain. Stability of almost linear systems: Lyapunov's method. Theorem of central manifold. Algebraic criteria of stability. Periodic solutions: Floquet theory. Poincare-Bendixson theorem, Applications. Stability of periodic solutions. Periodic solutions of non-autonomus systems Applications: Equation of vibrations, Van der Pol Equation, Mathieu Equation. Hill's Equation. Lienard's Equation. Bifurcation theory: Introduction. Elementary examples. Bifurcation of Poincare - Andronov - Hopf. Applications.

9081 MATHEMATICAL ECONOMICS

7TH- SEMESTER
APPLIED MATHEMATICS COURSE

Preference relations and utility functions: Continuity, convexity of preference relations and utility functions. Upper and lower semicontinuous functions on metric spaces. Maximization on convex sets, representation of preference relations. Demand theory: Budget set, demand correspondence. Multivalued functions on metric spaces. Continuity. Exchange Economies: excess demand function and equilibrium. Allocations (Individually rational, Pareto optimal, core allocation, equilibrium allocation). Productions Economies: Productions sets, linear optimization. Equilibrium theory: Fixed point theorems, Equilibrium theorems.

9082 PROBABILITY THEORY

7TH- SEMESTER
APPLIED MATHEMATICS COURSE

Axioms of probability: σ-fields, probability measures, probability spaces; Sequences of events, Borel-Cantelli lemma, independence, inverse Borel-Cantelli lemma; Random variables and random vectors; Expectation as an integral with respect to a probability measure; Fatou's lemma, monotone convergence theorem, dominated convergence theorem; Multivariable normal distribution; Characteristic function; Modes of convergence: almost sure, in probability, in Lp, in distribution; Weak and strong laws of large numbers; Borel and Glivenko-Cantelli theorems; P. Lévy theorem; Limit theorems and applications; Conditional expectation; Discrete time martingales; Applications in special topics.

9083 | MATHEMATICAL LOGIC | 8TH SEMESTER APPLIED MATHEMATICS COURSE

Propositional Calculus: Language, unique readability, logical connectives, truth valuations, semantics, adequacy of connectives, disjunctive and conjunctive normal form. Compactness theorem of propositional calculus. Applications. *First order predicate calculus:* Language, variables, dependent and independent variables, substitution, the concept of structure, language and interpretation, Tarski's definition of truth. *Axiomatization of first order logic:* Axiomatic systems and algorithmic concepts, Consistency. Gödel completeness theorems. *Proof theory of propositional and predicate calculus.* Gentzen systems, propositional resolution, tableaux method and completeness.

9084 | MATRIX ANALYSIS AND APPLICATIONS | 6TH SEMESTER APPLIED MATHEMATICS COURSE

Compound matrices: calculus and derivatives of compound matrices, Kronecker product. *Rank of matrices:* properties, rank of sums, rank of products. *Normal matrices:* Unitary transformations, Schur triangularization, characterizations of normal matrices, eigenspaces of normal matrices, hermitian matrices. *Norms:* vector norms, matrix norms, norm inequalities, eigenvalue bounds, Gersgorin discs, condition numbers. *Matrix factorizations:* LU factorization, Cholesky factorization QR factorization, singular value decomposition, polar decomposition. *Matrix polynomials:* division and factorization of matrix polynomials, eigenvalues and eigenvectors, canonical forms, linearizations. *Numerical range:* basic properties, convexity, boundary, numerical estimation.

9085 | AUTOMATA AND FORMAL GRAMMARS | 6TH SEMESTER APPLIED MATHEMATICS COURSE

Languages and their representations. Grammars, context-sensitive and context-free grammars. Finite automata and regular grammars. Pushdown automata. *Turing Machines.* Automata and language recognition. Applications in programming languages syntax. (Un) decidability and complexity problems.

9086 | THEORY OF ELASTICITY | 6TH SEMESTER APPLIED MATHEMATICS COURSE

For the description see the course with code 9102, (Applied Physics Course)

9088 | INTRODUCTION TO INELASTICITY | 7TH SEMESTER APPLIED MATHEMATICS COURSE

Macroscopic description of anelastic response of materials (metals, polymers), and its physical interpretation. Effect of strain rate. Linear viscoelasticity: simple viscoelastic models, standard loading in viscoelasticity.Complex unidirectional viscoelastic models, Relaxation and compliance modulus. Constitutive equations of viscoelasticity in differential and integral form. Non isothermal viscoleastic response. Dynamic mechanical analysis, storage and loss modulus, examples.

Introduction to plasticity, yield criteria Tresca and von Mises. Simple examples. Prandl-Reuss equations, associated flow rule, Mises flow rule. Constitutive equations in plasticity. Isotropic and kinematic hardening, examples.

9092 **THERMODYNAMICS** 3RD-SEMESTER CORE PROGR.

Temperature. Heat. Work. Internal energy. Ideal gases. Ideal gas laws. Isothermal and adiabatic processes. Kinetic theory of gases. Maxwell – Boltzmann distribution. Applications. Real gases. The first law of thermodynamics. Reversible and irreversible processes. Carnot engine. Entropy. Second and third law of thermodynamics. Specific heat. Coefficient of compressibility. Chemical potential. Enthalpy. Free energy. Phase transitions. Applications.

9093 **ELECTROMAGNETISM II** 5TH- SEMESTER APPLIED PHYSICS COURSE

Electrostatic techniques. Εξισώσεις Poisson και Laplace. Separation of variables. Multipole expansion Dielectric materials. Magnetic materials. Maxwell's equations in vacuum and in matter. Electromagnetic waves in vacuum. The Poynting vector. Propagation of electromagnetic waves in conducting materials. Reflection and transmission of electromagnetic waves. Polarization. Fresnel coefficients. Dispersion

9094 **ATOMIC AND MOLECULAR PHYSICS** 6TH SEMESTER APPLIED PHYSICS COURSE

Elements of Quantum Mechanics. Introduction to the structure of atoms and molecules: (a) One-electron atoms, atomic orbitals, analytical and numerical solutions, (b) the one - electron molecule H_2^+, molecular orbitals, chemical bond (I), (c) Many-electron atoms, central field, Hartree – Fock theory, open shells, angular momentum coupling. Perturbation theory, calculus of variations and elementary applications. Interaction with external fields – lasers. Elements of atomic and molecular spectroscopy. Introduction to scattering theory – resonance states

9095 **OPTICS AND OPTICS LABORATORY** 5TH- SEMESTER APPLIED PHYSICS COURSE

Introduction to wave optics. Polarization of light. Reflection, refraction at plane and curved surfaces. Mirrors, lenses, prorerties and errors. Optical instruments (the eye, magnifyinng lens, microscope and telescope).Space and time coherence. Interference and diffraction. Optical Fourier transformations, space filters, holography. ◆ Laboratory: Six laboratory exercises: 1. Interference and diffraction, slits – diffraction gratings, delay plates. 2. Optical Fourier transformations. 3. Interferometry (Michelson, Fabry – Perot). 4. Laser modulation, Optical information transfer. 5. Holography. 6. Boundary conditions and Fresnel relation for s and p polarization.

9096 **EXPERIMENTAL PHYSICS TECHNIQUES** 9TH SEMESTER APPLIED PHYSICS COURSE

Electric noise and the precision in the measurement of physical quantities. Modulation and processing of the electric signal with passive and active elements. Shielding of sensitive instruments from electromagnetic and vibrational noise. Magnetic field production. Secondary electron emission. Faraday cage and two basic functions of the photomultiplier. Electron beam modulation, electrostatic lens. Electrostatic discharge in gases, electric discharge devices and sputtering techniques. Optical systems, vacuum systems. Basic techniques of vacuum production and measurement. CryogenicsSafety rules, experimental practice and operational rules for the research and educational laboratory.

9097 | GROUP THEORY IN PHYSICS | 6TH- SEMESTER APPLIED PHYSICS COURSE

Definition of groups and group algebra. Rotation group. Group representations and characters. Direct group product, Clebsch – Gordan coefficients, the Wigner – Eckart theorem. The Schroedinger equation group. Crystallographic point groups and space groups. Macroscopic properties and crystal symmetry, the Neumann principle. Tensor properties of materials and connection with symmetry groups. Predictions of properties and the effects of symmetry in the Physics of materials. Time inversion and magnetic groups. Lie algebra of the SU(n) group. Exponential matrices, applications to SU(2) and SU(3). Representations and products of SU(n). Other Lie algebras. Introduction to the symmetries of elementary particles.

9098 | SOLID STATE CHEMISTRY | 7TH- SEMESTER APPLIED PHYSICS COURSE

General concepts.. Bonding and energetics of solids. The nature of crystalline solids. Theory and application of X-ray diffraction. The imperfect crystal – Structural defects. Diffusion in crystalline solids. Phase equilibria and phase transformations. Chemical reactivity of solids.. Selected Topics.

The course includes laboratory exercises

9099 | MATERIAL CHARACTERIZATION METHODS | 6TH- SEMESTER APPLIED PHYSICS COURSE

This is a purely laboratory course of 4 hours per week, where the presentation of the experimental method and experimental setup is preceding (1.5 hours), while the realization of the experiment and the data collection will follow (2.5 hours). The session closes with discussion and suggestions for analyzing the results. For each exercise, each student delivers a full report, no later than one week after the completion of the exercise. EXERCISES: 1) Differential Scanning Calorimetry, 2) Dielectric spectroscopy, 3) Raman spectroscopy, 4) IR spectroscopy, 5) Atomic Force Microscopy, 6) Electrical measurements in semiconducting systems, 7) Nuclear Magnetic Resonance, 8) Scanning Electron Microscopy, 9) Magnetic measurements, 10) Photovoltaic cell study.

9101 | PRINCIPLES OF TRANSMISSION FOR MICROWAVE AND OPTICAL SIGNALS | 8TH- SEMESTER APPLIED PHYSICS COURSE

Wave transmission in vacuum. Transmission lines. Parallel-plate rectangular-cross-section waveguides. Dielectric waveguides of planar geometry. Dispersion effects and attenuation in transmission lines, waveguides and optical waveguides. Practical consequences of the waveguiding properties in the microwave and optical transmission lines. Introduction to the theory of the microwave circuits. Signal parameters and signal processing in microwave receivers.

9102 | THEORY OF ELASTICITY | 6TH- SEMESTER APPLIED PHYSICS COURSE

Elements of Tensor Analysis. Elements of Variational Calculus. Traction. Stress Tensor. Balance Laws. Equations of Motion and Equations of Equilibrium. Symmetry of Stress Tensor. Strains and Rotations. Equations of Compatibility. Constitutive Elasticity Equations. Strain Energy. Generalized Hooke's Law. Anisotropy – Isotropy. Navier-Cauchy Equations and Beltrami-Michell Equations. Boundary

Conditions. Boundary Value Problems. Energy Theorems and Methods. Rayleigh-Ritz Method. Two-Dimensional Problems. Plane Strain and Plane Stress. Airy's Stress Function. Self-Similar Problems. Flamant-Boussinesq and Kelvin Problems. Exact Theory of Torsion. Prandtl's Stress Function. Bending Problems. The Method of Kolosov-Muskhelishvili. Three-Dimensional Problems. Papkovich-Neuber Potentials. Boussinesq's Potentials. Application of Hankel Transforms.

9106	SOFTWARE FOR PHYSICS AND MATHEMATICS	2ND SEMESTER CORE PROGR.

Introduction to Mathematica: Basics, Functions with variable arguments, Basic symbolic computations, Lists. Matices, Arrays, Relational and logical operators, *Graphics in Mathematica,* Algebraic Computations, *Applications of Mathematica in mathematical problems:* Numerical solutions of nonlinear equations, systems, differential equations, system of differential equations, interpolation and optimization problems. Applications of Mathematica in Physical Sciences. *Introduction to Matlab:* Basics, Functions with variable arguments lists, Mathematical functions, Matrices, matrix generation, matrix and array operations, matrix manipulation, Operators, relational and logical operators, M-files, scripts and functions, inline function, editing M-files, Graphics, two-dimensional graphics, Basic plots, multiple plots in a figure, three-dimensional graphics, Applications of Matlab in mathematical problems, *Symbolic computations with Matlab.*

9109	ELECTRONICS & LABORATORY – I	8TH SEMESTER APPLIED PHYSICS COURSE

Fundamentals of Electric Circuits: Kirchhoff's laws, voltage and current sources, voltage and current divider. *Resistive network analysis:* The node voltage method, the mesh current method, the principle of superposition, Thevenin, Norton and Miller theorems, nonlinear circuit elements. *AC network analysis:* Dynamic circuit elements, time dependent signal sources, solution of circuits containing dynamic elements, phasors and AC circuit analysis. *Transient Analysis*: Solution of Circuits Containing Dynamic Elements, transient response first order, transient response second order. *Frequency Response and System Concepts:* Fourier and Laplace analysis, filters, Bode plots. AC power: Power in AC circuits, complex power, transformers, three phase power. *Operational Amplifiers:* The operational amplifier, active filters, Integrator and Differentiator Circuits, analog computers.

The course includes circuit simulation exercises

9110	DIELECTRIC, OPTICAL, AND MAGNETIC PROPERTIES OF MATERIALS	7TH SEMESTER APPLIED PHYSICS COURSE

Dielectric and Optical Properties of Insulators: Static fields: Local electric field. Polarizability. Dielectric constant. Alternating fields: Optical absorption. Polariton. Piezoelectricity. Ferroelectricity. ◆ *Magnetic Properties of Matter:* Diamagnetism. Paramagnetism. Ferromagnetism. Antiferromagnetism and Ferrimagnetism. ◆ *Magnetic Resonance Phenomena:* Electronic magnetic resonance. Relaxation mechanisms. Bloch equations for the steady state. Nuclear magnetic resonance. ◆ *Superconductivity*

9111	OPTIMAL CONTROL	8TH SEMESTER APPLIED MATHEMATICS COURSE

Introduction to the Calculus of Variations: Necessary and Sufficient conditions for minimization, Euler-Lagrange equations, Minimization with constraints, Lagrange multipliers, *Optimal Control*: Linear systems, Attainable sets, Topological Conditions, Controllability, Time-Optimal Control in the Linear

Case, Extremal Control,Maximum Principle, Minimization of square cost in Linear Case without Constrains in the Control, Riccati Differential Equation. Nonlinear systems: Topological and Geometric properties of Attainable sets,Extremal Control, Tangent Perturbation Cone, Pontryagin's Maximum Principle, Sufficient conditions and theorems for existence of optimal control, Hamilton-Jacobi-Bellman equations. Applications

9112 | STOCHASTIC PROCESSES | 6TH SEMESTER APPLIED MATHEMATICS COURSE

Introduction. Basic notions and definitions. Probability and moment generating functions. Characteristic functions.Limit theorems *Poisson Process*. Queuing systems and model of insurance M/G/1 Compound Poisson process. Renewal theory. *Random walk.* Simple random walk. The Wald's equation. Symmetric random walk and Arc Sine laws.The gamblers ruin problem. Applications in queuing systems and insurance. *Markov chains*.Compatibility Conditions Chapman-Kolmogorov. The Ehrenfest diffusion model. Classification of states. Properties of states. Stationary distribution and limit theorems. Markov chains in continuous time. Branching processes. Semi-Markov processes. Population processes. Martingales and convergence theorems.

9114 | REGRESSION ANALYSIS | 7TH SEMESTER APPLIED MATHEMATICS COURSE

Introduction to the linear model. Multiple linear regression. Model parameter estimation. Properties of estimators. t and F tests of hypotheses, coefficient of determination R2, confidence intervals for parameters. Residuals, diagnostic tests. Prediction. Multicollinearity, heteroscedasticity and other problems. Transformations. Weighted least squares. Model selection methods. Influence. Cook's distance. Dummy variables. Analysis of variance and its relation to the general linear model. Poisson regression. Logistic regression. Practical sessions using statistical software packages.

9115 | INTRODUCTION TO COMMUNICATION NETWORKS | 9TH SEMESTER APPLIED MATHEMATICS COURSE

Introduction to communication networks. Network evolution. Network design issues: layered architecture, services, circuit and packet switching, multiplexing, management, reference models. Physical layer: theoretical basis of data communications, communication links and their characteristics, error correction and detection. Data link layer: retransmission protocols, protocol specification and verification. Medium access sublayer: multiple access protocols, local area networks, Ethernet, rings, IEEE standard 802 for LANs (802.3, 802.4, 802.5, and 802.2), FDDI, WLANs, WiFi (802.11), Bluetooth (802.15), WiMax (802.16). Network layer: design issues, routing algorithms, congestion control. Laboratory part: Practical training of students on issues concerning network configuration, data link protocols, MAC protocols and routing algorithms based on the NS2 simulator.

9116 | ALGORITHMS AND COMPLEXITY | 7TH SEMESTER APPLIED MATHEMATICS COURSE

Techniques for asymptotic program analysis and algorithm selection criteria. Algorithm design techniques: divide and conquer, dynamic programming, greedy algorithms. Applications to graph theory (depth-first search, breadth-first search, minimum spanning tree, shortest path). Sorting and searching. Algebraic problems (evaluation of polynomials, matrix multiplication). Polynomial-time algorithms and NP-complete problems.

9117 | COMPUTATIONAL MECHANICS I | 8TH SEMESTER APPLIED MATHEMATICS COURSE

Introduction. General description of the finite element method. The displacements method. The principle of virtual work and the transformation of coordinates. Creation of the final stiffness matrix. Choose of the displacements' function. Convergence criteria. Conformal and non-conformal approximation. Practical remarks for the application of the finite element method. Truss and beam elements. Plane elements Three-dimensional stress analysis. Axisymmetric elements. General families of elements. Isoparametric elements.

9118 | GRAPH THEORY | 8TH SEMESTER APPLIED MATHEMATICS COURSE

Introduction: Definitions, Subgraphs, Connected graphs, Trees, Networks, The connector problem. *Euler and Hamilton Graphs. Necessary and sufficient condition for Euler graphs.* Fleury's algorithm. Hamiltonian graphs: Necessary conditions. Sufficient conditions. Planar graphs. Euler's formula. Kuratowski's theorem. Dual graphs. *Vertex colourings.* The Welsh Powell algorithm. The five and four colour theorems. Brook's theorem. Edge colourings. Vizing's theorem. *Connectivity.* Connectivity. Menger's theorem vertex and edge form. Max-flow, min cut. *Matchings:* Hall's marriage theorem. Matchings in bipartite graphs. The personnel assignement problem. Stable marriages. *Matrices.* The adjacency and incidence matrix. The matrix tree theorem.

9119 | MATHEMATICAL ECONOMICS | 8TH SEMESTER APPLIED MATHEMATICS COURSE

Two period Financial models: Theory of finance, allocation and equilibrium, arbitrage, incomplete markets, Pareto optimality, security pricing. Finite stochastic financial model: Probability, conditional probability, expected value, martingales. Information tree, stochastic exchange economies, stochastic financial markets, financial contract, financial strategy equilibrium and Pareto optimization. Pricing financial derivatives, binomial model in finance, call and put options, exotic options, futures, swaps.

9120 | INTRODUCTION TO OPERATIONAL RESEARCH | 7TH SEMESTER APPLIED MATHEMATICS COURSE

Operational Research approach to modeling. Formulation of OR problems and case studies. Analysis of Linear Programming models. Graphical modeling and solution. Simplex Method. Solution by using computer packages. Slack variables. Duality theory. Interpretation of Duality. Sensitivity Analysis. Transportation Problem. Project evaluation and management with or without limited resources. Integer programming. Decision making under uncertainty. Decision criteria. Decision trees. Inventory control and management. Economic order quantity and reorder point with or without uncertain demand. Queuing Theory. Dynamics of a queuing system with interarrival time and service time coming from any probability distribution, for a single or multiple servers.

9123 | STATISTICAL PHYSICS | 5TH SEMESTER APPLIED PHYSICS COURSE

The microcanonical ensemble. The canonical ensemble. Partition function. Connection with thermodynamic quantities. Parmagnetism. The grand canonical ensemble. Fermi – Dirac and Bose – Einstein distributions. Black – body radiation. Real gases. Phase transitions.

9125 | APPLICATIONS OF IONAZING RADIATION IN MEDICINE AND BIOLOGY | 8TH SEMESTER APPLIED PHYSICS COURSE

Note: The course includes laboratory exercises and visits to hospitals and to NRC "Demokritos"

Principles of the Physics of ionizing radiation. Ionizing radiation characteristics as properties of the atomic nucleus. Theory of the interaction of ionizing radiation with matter.Nuclear reactions and isotope production. Clinical application of radioisotopes and radiopharmaceuticals. Detector instrumentation for the three fundamental types of radiation, α, β, and γ. Ionizing radiation effects on biological organisms. Biological effect of neutrons and their use in clinical medicine. Advanced techniques for clinical applications and the use of accelerating apparatus. Introduction to dosimetry and radiation protetion

9128 | INTRODUCTION TO COMMUNICATION NETWORKS | 9TH SEMESTER APPLIED PHYSICS COURSE

For the description see the course with code 9115, (Applied Mathematics Course)

9129 | COMPUTATIONAL MECHANICS I | 8TH SEMESTER APPLIED PHYSICS COURSE

For the description see the module with code 9117, (Applied Mathematics Course)

9131 | INTRODUCTION TO INTERNET TECHNOLOGIES | 9TH SEMESTER APPLIED MATHEMATICS COURSE

Internet fundamentals: Introduction. TCP/IP protocol suite. Transmission. The Internet Protocol (IP). IP addressing. IP routing. Internet Control Message Protocol (ICMP). Transport Layer Protocols (TCP, UDP). IPv6. *Routing Protocols*: Static routing. Dynamic routing. Dijkstra's algorithm. Routing Information Protocol (RIP). Open Shortest Path First (OSPF). Border Gateway Protocol (BGP). *End to end congestion avoidance*: Sliding window. TCP improvements. *Internet Security*: Security Requirements, Attack Categories, Symmetric Cryptography, Asymmetric Cryptography, Digital Signature, Public Key Infrastructure. *MultiProtocol Label Switching (MPLS)*: Label distribution. Label Distribution Protocol (LDP). Constraint Routed Label Distribution Protocol (CR-LDP). Resource Reservation Protocol - TE (RSVP-TE). *Application Layer Protocols*: Introduction. FTP. DNS. HTTP. E-Mail (SMTP, POP3, IMAP). *HyperText Markup Language – HTML*.

9132 | ECONOMIC ANALYSIS V (BUSINESS ECONOMICS) | 9TH SEMESTER APPLIED PHYSICS COURSE

The subject of business economics. Types of firms. The basic operations of firm. Basic elements of accounting. Managerial accounting. Financial statements. Financial statement analysis and financial ratios. Costing - pricing - planning. Investment evaluation. Developmental incentives. Site selection. Uncertainty analysis

9133 **OPTOELECTRONICS** 7^{TH} SEMESTER APPLIED PHYSICS COURSE

Physical optics, photons, optical absorption mechanisms, photoconductivity mechanisms, optical and optoelectronic materials, spontaneous and stimulated emission, absorption, fluorescence, phosphorescence, luminescence, coherent and incoherent sources, displays, radiation detectors, noise and electronics of detectors, image intensifiers, I^2 devices, thermal imagers, couplers, modulators, liquid crystals, integrated optics, photonic logic, introduction to optical fibers – optical communications, introduction to lasers and their applications

9134 **MECHANICS II: MECHANICS OF DEFORMABLE BODIES** 2^{ND} SEMESTER CORE PROGR.

Introductory concepts and definitions: The continuum. *Stress:* The concept of stress. The stress vector and the stress tensor. Transformation of the stress tensor. Principal stresses. Octahedral shear stresses. Equilibrium equations. *Strain:* Small displacements. Rigid body rotations. Strain tensor. Transformation of the strain tensor. Principal strains. Maximum shear strain. Compatibility equations. *Stress-strain relations:* Hooke's generalized law. Influence of temperature on the stress-strain relations. *Linear elasticity elements:* The problem of linear elasticity. Stress functions. *Axial Problems:* Statically determinate and statically indeterminate problems. The stress-strain diagram. Simple models of the σ-ε curve. *Plane problems:* Thin walled pressure vessels. Mohr's circle in 2-D. *Failure and elements of plasticity:* The failure of materials. Yielding vs. fracture. Failure crirteria. Mises-Tresca-Mohr criteria. Plastic behaviour of materials. Plastic flow according to Mises. Prandtl-Reuss equations. *Elements from Fracture Mechanics.*

9135 **MECHANICS IV - KINEMATICS AND DYNAMICS OF RIGID BODIES** 4^{TH} SEMESTER CORE PROGR.

Particle or material point. The particle kinematics. The rigid body. Rigidity conditions. Degrees of freedom. Rigid body kinematics. Translation. Rotation. Infinitecimal Rotations. Angular velocity and acceleration. The theorems of Euler and Chasles. Euler angles. The general motion of rigid body. Plane motion. Relative motions. The Coriolis theorem. Systems of particles. Newton's laws. The rigid body Dynamics. Moments of inertia. The inertia tensor. Angular Momentum. Work and Energy. Kinetic energy. The theorem of Köenings. Conservation methods. The rigid body equations of motion. The Euler equations. Collision. Constraints. Generalized coordinates. The D' Alembert's principle. The principle of virtual work. Lagrange equations for holonomic conservative systems. The Jacobi's integral. Oscillations.

9136 **PHILOSOPHY OF MATHEMATICS** 7^{TH} SEMESTER APPLIED MATHEMATICS COURSE

Introduction: necessity and a priori nature of mathematics, existence and ontological status of mathematical entities (realism, idealism, nominalism), mathematical truth. Plato and Platonism in mathematics. Aristotle's philosophy of mathematics. The philosophy of mathematics in rationalism and empiricism (Descartes, Leibniz, Locke, Berkeley, Hume). Kant's philosophy of mathematics. Mill's philosophy of mathematics. Elements of formal logic. Set-theoretic and semantic paradoxes. Elements of axiomatic set theory. The main schools in early 20th century philosophy of mathematics: Logicism, Formalism, Intuitionism. Logical Positivism. Structuralism. Other contemporary views.

9137 STRUCTURAL MECHANICS

6TH SEMESTER
APPL. MATHEM. CONC.
8TH SEMESTER
APPL. PHYS. CONC.

Energy considerations: Strain energy. Betti's Law. Axial, flexural, shearing, torsional stress and deformation. Virtual displacements, virtual forces, the principle of virtual displacements, the principle of virtual forces. The unit load method, evaluation of product integrals, displacements due to temperature changes. Examples. *The Flexibility Method.* Static indeterminacy, redundant forces, redundant constrains, primary structure, equations of compatibility, coefficients of flexibility, flexibility matrix, stresses due to temperature changes, stresses due to motion of the supports, stresses due to lack of fit. Examples. *The Stiffness Method.* Kinematic indeterminacy, degree of kinematic indeterminacy, restrained structure, fixed-end actions, stiffness coefficients, equations of equilibrium, stiffness matrix, stresses due to temperature changes, stresses due to motion of the supports, stresses due to lack of fit. Examples. *Elements of Structural Dynamics.* Selection of degrees of freedom. The differential equations of motion. Derivation by the P.V.D., derivation by use of Lagrange's equations. The mass matrix, the stiffness matrix, the damping (external and internal) matrix, the matrix of applied loading. Undamped free vibrations, eigenfrequencies, eigenshapes, orthogonality conditions. Expansion theorem. Undamped forced vibrations. Modal analysis. Damped forced vibrations, proportional damping. Examples.

9138 DESIGN AND ANALYSIS OF CONTROL SYSTEMS

9TH SEMESTER
APPLIED MATHEMATICS
COURSE

Fundamental concepts and results from the theory of dynamical systems: Stability, Lyapunov, La Salle and Chetaev's theorems. Linear control systems: Attainable sets, Controllability, Observability. Equivalence of linear systems via change of coordinates and feedback. Canonical forms. Stabilization of linear systems. Optimal control of linear systems with quadratic infinite-horizon cost. Observers and design of dynamic feedback. Realization theory. Algebraic stability criteria (Routh, Hurwitz), the concept of "input to state stability", results and applications. An introduction to design problems and analysis for nonlinear systems. An introduction to design and analysis for the case of stochastic control systems.

9140 FUNCTIONAL ANALYSIS **II**

8TH SEMESTER
APPLIED MATHEMATICS
COURSE

Banach spaces. Geometric forms of Hahn – Banach theorem. Separation of convex sets. Definition and basic properties of the weak topology σ(E,E*). The weak topology σ(E,E*). Reflective spaces. Uniform convex spaces. Definition and basic properties of the compact operators. Riesz – Fredholm theory. Spectrum of compact operators. Spectrum analysis of compact operators. Unbounded operators in Banach spaces and applications. Sobolev spaces and applications in boundary value problems.

9141 COMPUTATIONAL MODELS

8TH SEMESTER
APPLIED MATHEMATICS
COURSE

Computability: Logic as a Foundation for C.S. Historical overview of decidability for mathematical sentences, of solvability and computability of problems in an effective, i.e. algorithmic way. Simple equivalent models of computation: Turing Machines, WHILE programs. Induction and Recursion, encodings and Semantics. Fix-point theory. Arithmetical Hierarchy. Complexity: Inclusions among Complexity Classes. Reductions and Completeness. Oracles. Polynomial Hierarchy. Probabilistic, Interactive and Counting classes. Advanced topics of the theory of Formal grammars. Applications on the Syntax of programming languages.

9142

LINEAR MODELS AND DESIGNS

8TH SEMESTER
APPLIED MATHEMATICS COURSE

Review of regression and analysis of variance. Multiple comparisons. Fixed and random effects models. Tests for homogeneity of variances. Nonparametric one-way ANOVA. Two-way ANOVA with and without interaction; random and mixed models. Orthogonal contrasts. ANOVA with 3 or more factors; random and mixed effects models. *Graeco–Latin square designs.* Balanced incomplete block (BIB) designs and their statistical analysis. Recovery of interblock information in BIB designs. Partially BIB designs and their statistical analysis. Youden squares. Lattice designs. *2^k factorial designs.* Design projection. The addition of centre points to the 2^k design. Yates' algorithm for the 2^k design. Confounding in the 2^k factorial design. Partial confounding. Two level fractional factorial designs. The notion of resolution. 3^k factorial designs. Confounding in the 3^k factorial design. Factorial designs with mixed levels. Response curve methodology. Nested and split-plot designs. Applications using statistical packages.

9143

APPLICATIONS OF LOGIC IN COMPUTER SCIENCE

9TH SEMESTER
APPLIED MATHEMATICS COURSE

Proofs of theorems. First order predicate calculus, models, Herbrand models, clauses, normal forms, prenex, Skolen normal form, resolution, correctness and completeness of Robinson resolution. Theory of Logical Programming, Horn clauses, negation as failure and its semantics, non-monotonic reasoning, 3-valued models. *Functional programming:* untyped, typed, proofs as programs, Curry-Howard isomorphism, second order logical systems, polymorphism. *Semantics:* programming languages, fixed point.

9144

INTEGRAL EQUATIONS AND APPLICATIONS

7TH SEMESTER
APPLIED MATHEMATICS COURSE

Introduction-Classification. Fredholm Theory. Linear operators and linear integral equations. Integral equations of Volterra and Fredholm. Exploitation of integral transfoms to the solution of integral equations. Symmetric integral equations. Singular integral equations. The method of boundary elements and application of integral equations to the solutions of problems encountered in Mathematical Physics, Fluid mechanics, theory of Elasticity, Electrodynamics etc. Elements of non linear integral equations.

9145

ANALYSIS OF TIME SERIES

8TH SEMESTER
APPLIED MATHEMATICS COURSE

Stationary stochastic processes. Autoregressive time series. Moving average time series. The ARMA model. The autocorrelation function and the partial autocorrelation function. The autocovariance generating function. Prediction with an ARMA model. Non-stationary and seasonal time series. Box-Jenkins estimation and model selection. Spectral analysis of time series. Spectral density and periodogram. The spectral density of the ARMA model. State-space models. Kalman filter and Bayesian prediction. Econometric time series.

9146 **DIFFERENTIAL GEOMETRY OF CURVES AND SURFACES**

8[TH] SEMESTER
APPLIED MATHEMATICS
COURSE

◆*Theory of curves*: General introduction. Plane curves: curvature, oscillating circle, involutes, local canonical form of a curve, implicitly defined curves, determination of a curve from its curvature, elements from the global theory of plane curves, determination of a curve from its curvature. Local theory of space curves, Frenet formulae. Canonical form of a space curve, Fundamental theorem of curves. ◆*Theory of surfaces*: Definitions of surfaces, special classes of surfaces. Surface curves, tangent vectors, tangent plane, First fundamental form. Gauss map, shape operator, Second fundamental form. Curvature of surface curves, Gauss and mean curvature. Classification of surface points, Third Fundamental form. Geodesics. Gauss theorem (Theorema Egregium). Mappings between surfaces. Covariant derivative. Exploitation of computer for the study and plotting of curves and surfaces

9147 **OPERATOR THEORY**

8[TH] SEMESTER
APPLIED MATHEMATICS
COURSE

Operators on Hilbert spaces. Properties of bounded linear operators. Bilinear forms. Operator norm. Continuity of a linear operator. The adjoint operator. Normal, self adjoint, unitary operators. Invertible operators. Matrix representation of a bounded linear operator. Orthogonal projections. Invariant subspaces. Finite rank operators, compact operators, compact self adjoint operators. Spectral theory of compact self adjoint operators. Spectral theorem, second form of the spectral theorem. Applications to integral operators and Sturm-Liouville systems. Green's functions. Introduction to linear operators on Banach spaces. Fredholm operators, index of an operator. Unbounded operators, closed operators, symmetric and selfadjoint operators.

9148 **MATHEMATICAL MODELLING**

8[TH] SEMESTER
APPLIED MATHEMATICS
COURSE

◆ *General introduction.* Mathematical models. Population dynamics. Models from Ecology and Biology. Dimensional analysis and normalization. ◆ *Perturbation methods:* regular and singular perturbation, boundary layer analysis. ◆ *Calculus of variations*: Variational problems. Euler-Lagrage equation, Hamilton's principle, isoperimetric problems. Models in traffic flow. ◆ *Elliptic Problems*: Gravitational field. Electromagnetic field, Acoustics, Scattering problems, ◆ *Parabolic problems*: Electromagnetic field. Mass and heat transfer. Telegraphic equation. Probabilistic model of heating. An Economical model. ◆ *Ware phenomena in continuous media*: Linear and non-linear waves. Burger and KDV's equations. Models in continuous media, Stochastic models.

9149 **SPECIAL TOPICS IN DISCRETE MATHEMATICS**

8[TH] SEMESTER
APPLIED MATHEMATICS
COURSE

Introduction. Difference sets. Balanced Incomplete block designs (BIBD). The incidence matrix. Existance theorems and construction theorems for BIBD. Symmetric designs (SBIBD) Pairwaise balanced designs. *Hadamard matrices,* construction methods. Orthogonal designs. *Latin squares and their applications.* Steiner triple systems and t-designs. Finite geometries and their relation to designs.

9151 **OPTIMIZATION**

6^{TH} SEMESTER
APPLIED MATHEMATICS
COURSE

Convex sets and convex functions. Fréchet and directional derivatives. Extrema of functions. Existence and uniqueness theorems. Basic necessary and sufficient conditions for optimality. Lagrange and Kuhn-Tucker-Lagrange multiplier theorems. Quadratic functions. Least-squares methods and applications. Golden section, Gradient, Conjugate gradient, Newton, Frank-Wolfe, Gradient projection, Penalty, and Mixed Gradient-penalty methods. Applications to Nonlinear Programming and Optimal Control.

9152 **COMPUTATIONAL MECHANICS II**

9^{TH} SEMESTER
APPLIED MATHEMATICS
COURSE

A general description of the finite element method. Formation of the global stiffness matrix with the application of the virtual work principle in the whole body. Calculation of the reduced global stiffness and loading matrices. Elasto-Dynamic field problems (static and dynamic behavior). Thin plate and shell elements in bending. Convergence criteria and the patch test in the case of plate bending. Discretization of large constructions with the finite element method: the case of infinite bodies. Pre-processing and post-processing of data and other techniques in the FEM. A generalization of the finite element method. The method of weighted residuals, variational methods and the Rayleigh – Ritz Method. Applications in the case of field and fluid mechanics problems.

9153 **COMPOSITE MATERIALS**

9^{TH} SEMESTER
APPLIED MATHEMATICS
COURSE

1. Introduction classification of materials. Ductile and fragile materials. Isotropic and non isotropic materials. 2. Composite materials. History and development. Uses and applications. Advantages and disadvantages when compared with other structural materials. Main fabrication methods. 3. Inclusions in composite materials. Particles, fibres and flakes. Characteristics and thermomechanical properties. Types of inclusions. Glass, carbon, aramid, graphite, boron fibres. Advantages and disadvantages. 4. Matrix materials. Polymeric, metal and ceramic matrices. Thermosetting and thermoplastic polymeric matrices. Thermomechanical properties of matrices. Advantages and disadvantages. 5. Phases in composite materials. Filler volume fraction and weight fraction. Voids, microcracks, microdefects in composites. Particle and fibre distribution in composite materials. Planar and special models. Applications. 6. Theoretical predictions of thermomechanical properties of particulate composites. Semi – empirical formulae in the literature. Formulae based on mechanics of material approach. Derivation of the formulae based on theory of elasticity. Applications. 7. Unidirectional fibre reinforced composites. Transversely isotropic, orthotropic, monoclinic fibrous composites. Random fibre reinforced composite materials. Laminates. 8. Stress – strain relationships in various types of fibrous composites. Stiffness matrix and compliance matrix. Mathematical constants and engineering constants in principal material directions. Applications. 9. Stress – Strain relations in off – axis composites. Stiffness and compliance matrices. Elastic constants. Applications. 10. Failure criteria in fibre reinforced composites. Max stress criterium. Max strain criterium. Tsai – Hill criterium. Advantages / disadvantages. Applications. 11. Laminates. Cross – ply, angle – ply laminates. Force and moments. 12. Non destructive tests in composite materials. Practical applications of composites. Patches and repairs in composites.

9157 METHODS OF TEACHING MATHEMATICS – MATHEMATICS EDUCATION

6[TH] SEMESTER
APPLIED MATHEMATICS COURSE

Basic concepts of teaching. Psychological considerations for learning and teaching in mathematics. The role of representation in mathematics. Semiotic representation systems and their importance in the learning process. The natural language in mathematics. The teaching contract. The socio-cultural approach to research methodology and the influence of cultural context to the understanding of mathematical concepts.

9158 PHYSICS SEMINAR - PROJECT

8[TH] SEMESTER
APPLIED PHYSICS COURSE

The students attend seminars given by their classmates. Each student presents to the class a topic related to the Physics courses that are taught in the Applied Physics Direction of Studies. The presentations are given by each student and the attendance of the course is compulsory. The target of the course is to familiarize the students with the preparation, the presentation and the active attendance of a scientific subject.

9159 NUCLEAR PHYSICS AND APPLICATIONS

8[TH] SEMESTER
APPLIED PHYSICS COURSE

Nuclear reactions – cross section. Nuclear decay law. Bound states of nucleons – deuterium – nucleon exchange forces. Nuclear models (liquid drop, shell, collective). Nuclear deformation Electric and magnetic multipoles. γ ray emission. Nuclear magnetic resonance. Rutherford scattering. Nuclear reactions. Applications of Nuclear Physics in the study of materials (RBS, ERDA, PIXE, etc.), in medicine (diagnosis – therapy), to the environment, in archaeometry, in industry

The course includes laboratory exercises

9160 DETECTING AND ACCELERATING SYSTEMS

7[TH] SEMESTER
APPLIED PHYSICS COURSE

Interaction of radiation with matter: Interaction of x and γ ray radiation with matter. Interaction of charged particles with matter. ◆ Detectors: Gas – scintillation - solid state and other detectors. Detection of x and γ ray radiation. Detection of charged particles. Neutron detection. Detecting devices in high energy experiments: trajectory detectors, energy detectors (calorimeters), muon detectors, magnets, Cerenkov detectors, gas detectors. ◆ Accelerators: Electrostatic accelerator. Beam transfer. Linear detectors. Cyclotron. Sychnotron. Colliding beam detectors. ◆ Data acquisition: Triggering and data recording conditions. Data analysis techniques and simulation methods. ◆ Experiments: Description of typical experiments.
The course includes laboratory exercises

9161 PHYSICS AND TECHNOLOGY OF LASERS

6[TH] SEMESTER
APPLIED PHYSICS COURSE

Introductory concepts, spontaneous and stimulated emission, interaction of radiation with matter, pumping processes, passive optical resonators. Behavior of continuous wave and transient types of lasers, laser beam properties, laser beam transformations, special topics on the Physics and Technology of lasers, selected laser applications, laser safety.

The course includes laboratory exercises

9162 **POLYMERS AND NANOCOMPOSITE MATERIALS**

8TH SEMESTER
APPLIED PHYSICS COURSE

Introduction. Classification of Polymers, Molecular weight, examples, Brief presentation of polymerization techniques and polymer processing. Molecular conformations, polymer crystallinity, kinetics and thermodynamics of polymer crystallization, transitions of polymers, WLF equation, DSC method. Introduction to elastomers, statistical theory of ideal elastomers, viscoleasticity, examples, dynamic mechanical analysis. Yielding of polymers. Introduction to polymer rheology, examples. Electrical properties of polymers – conducting polymers. Introduction to polymer composites and nanocomposites. Reinforcement with nanoparticles, carbon nanotubes and clays. Physical, mechanical and electrical properties of polymer composites and nanocomposites. Modeling

9163 **THEORETICAL PHYSICS**

9TH SEMESTER
APPLIED PHYSICS COURSE

Principle of least action, Euler – Lagrange equations. Lagrangian and Hamiltonian. Poisson brackets. Canonical transformations. Symmetries and conservation laws. Noether's theore. The momentum – energy tensor. Poisson bracket algebra. Continuous dynamical systems as examples of classical field theories: Klein – Gordon and Dirac equations. Lorentz transformation of solutions. Mass and spin. Plane wave solutions. Klein's paradox. Coupling with external electromagnetic fields. Hydrogen – like atoms, spin and fine structure. Discrete symmetries (C, P, T). The neutrino equation.

9165 **BIOPHYSICS**

6TH SEMESTER
APPLIED PHYSICS COURSE

Forces – interactions between biomolecules. Water and its role in the structure of living matter. Biopolymers (structure, function and physical properties). Physical methods for the study of macromolecules and cells. Membranes and transport properties of biological membranes. Generation and propagation of the nerve pulse. Bioelectric potential recording techniques. Muscle contraction, bio-thermodynamics, bioenergetics. Biophysics of vision and hearing. Effects of physical factors in living matter. ◆ *Laboratory exercises:* Spectrometry: absorption spectra of biopolymers, correlation of optical properties with the structure and behavior of macromolecules under various conditions (radiation, active substances). Amplification – recording of bioelectric signals.

Note: The course includes laboratory exercises

9166 **PHYSICS OF MICROELECTRONIC DEVICES**

8TH SEMESTER
APPLIED PHYSICS COURSE

Introduction to basic semiconductor physics and general planar technology concepts. Ohmic and rectifying contacts to semiconductors. Metal-semiconductor contacts (Shottky). Current-Voltage characteristics. Bipolar devices: (a) Junction p-n, thermal equilibrium conditions, depletion region, current-voltage characteristics, transient behavior, breakdown conditions (b) bipolar transistor, transistor action, static characteristics, switching behavior, frequency response, equivalent circuit. MOS (Metal-Oxide-Semiconductor) devices (a) MOS capacitor, band bending, surface states, Capacitance-Voltage characteristics, influence of frequency on C-V characteristics (b) MOSFET (MOS Field-Effect Transistor): Static and dynamic behavior, surface mobility, MOSFET scaling, type of devices and simple circuits (P-MOS, N-MOS, C-MOS, inverter). Nanoelectronic devices.

The course includes laboratory exercises

9167 | SIGNAL ANALYSIS | 6TH SEMESTER APPLIED PHYSICS COURSE

Introduction to signals & systems, special types of signals; Analog and discrete signals; Fourier Transform, Laplace for analog signals; Transfer function; Z transform; Difference Equations, Discrete time Fourier Transform (DTFT) and Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT), FIR & IIR Digital Filters; Design of Digital Filters; Applications of Digital Signal Processing.

9168 | COMPUTATIONAL MECHANICS II | 9TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9152 (Applied Mathematics course)

9170 | HISTORY OF PHYSICS, 19TH AND 20TH CENTURY | 8th SEMESTER APPLIED PHYSICS COURSE

This upper level course has aim to describe the basic episodes in the history of physics from the 19th c to 1945 , to show the dramatic change of ideas that occurred this period related to the social and institutional settings .

Emphasis is given to the emergence of the electromagnetic theory the undermining of the mechanical picture of the world and the construction of the quantum mechanics. The use of primary sources is an integral part of the obligatory student works.

9171 | METHODS OF TEACHING PHYSICS - PHYSICS EDUCATION | 6th SEMESTER APPLIED PHYSICS COURSE

Scientific Literature - Learning Theories – Students’ Alternative Conceptions in Physics - Models for Teaching Science – Science Processes - Inquiry Based Learning - Instructional Tools – The Use of Information and Communication Technologies in Physics Teaching – The Use of Informal Sources of Science Learning in Teaching – The Designing of Physics Lesson Plans (Teaching Aims – Student Worksheets – Lesson Assessment)

9172 | PEDAGOGICAL PRINCIPLES | 5TH SEMESTER APPLIED MATHEMATICS COURSE

The aim of this course is the theoretical training of students to basic principles of Pedagogy and General Education. During the course, learning theories are developed based on the respective instructional models. There is particular emphasis given on modern learning theories, for example, the theory of knowledge edification. Development of teaching models and attempts for a comparative approach between them based on their features such as the nature of knowledge and others. The basic components of the course are: a) Theories of learning (associative learning-classical theory, instrumental-associative learning theory, social-cognitive learning theory, logical-mathematical learning theory of Piaget, discovery learning theory of Bruner, learning theory of Ausubel, learning theory of Vygotsky), b) learning model (behaviorism, social behaviorism ¬ lish the scientific, Gnosticism / structuralism, constructivism), c) Course development. Innovations in

Education, d) Use of ICT and Modern Teaching, e) Applied pedagogy. Laboratory applications and field applications. In addition to the course the students can take the optional writing of a coursework on a theme appropriate to their interests.

9173 **MEASURE THEORY AND INTEGRATION**

7TH SEMESTER
APPLIED MATHEMATICS COURSE

Lebesgue measure, measurable and not measurable sets. Measurable functions. Egorov and Lusin theorem. Lebesgue Integral, simple measurable functions, approximation of measurable functions by simple functions. The integral of a non negative measurable function. Monotone convergence theorem. Fatou's lemma. Dominated convergence theorem. Comparison between Riemann and Lebesgue integration. Applicaion to Fourier Analysis. Riemann-Lebesgue lemma.. Cantor-Lebesgue theorem. Theorem of Lusin-Denjoy. The space L_p $[\alpha,b]$. The Minkowski, Holder and Young inequalities. On the completeness of the space $L_p[\alpha,b]$, $1\leq p<+\infty$ and the adjoint space of $C[\alpha,b]$.

9174 **PEDAGOGICAL PRINCIPLES**

5TH SEMESTER
APPLIED PHYSICS COURSE

For the description see the course with code 9172 (Applied Mathematics Course)

9175 **NONLINEAR ANALYSIS**

9th SEMESTER
APPLIED MATHEMATICS COURSE

Non linear operators. Compact operators and applications in the existence of solutions of integral equations. Monotonic operators. Basic properties. Nemitsky operators. Brower and Schauder Fixed point theorems. Applications. Ekeland variational principle. Differentiability in Banach spaces. Gateaux and Frechet derivative. Critical point theory. Applications

9176 **FLUID MECHANICS**

6th SEMESTER
APPLIED MATHEMATICS COURSE

Introduction: Fluid properties and characteristics, Units, Continuum hypothesis. *Kinematics:* Velocity and acceleration fields, System and control volume, Transport theorem of Reynolds, Forces and deformation. *Surface and body forces:* Pressure forces, Viscous forces, Stress tensor. *Governing equations in integral and differential form*: Mass, momentum and energy equations. The Navier-Stokes equations. Potential flow. *Dimensional analysis and similitude*: Pi theorem, Non-dimensional numbers. *Inviscid flow*: Circulation, vortices. *Viscous flows*: Boundary layers, Separation. *Turbulence*: Turbulent stress, Boussinesq hypothesis, Governing equations for mass and momentum transfer.

9177 **SYSTEM RELIABILITY**

9th SEMESTER
APPLIED MATHEMATICS COURSE

Basic definitions. Censoring. Reliability or survival function, hazard function. *Lifetime Distributions:* Gamma, Weibull, Gumbel, Log-logistic and others. *Non parametric estimation:* Kaplan-Meier and Nelson-Aalen estimators. Log-rank test. Graphical examination. *Model fitting* by maximum likelihood. Goodness-of-fit tests. *Regression models for lifetime data:* proportional hazards models, accelerated life models and Cox's semi-parametric model. *Model building and diagnostic methods,* Cox-Snell residuals, Schoenfeld residuals. *System reliability. Repairable systems* - recurrent events. Applications using statistical software packages.

9178 | CRYPTOGRAPHY AND COMPLEXITY | 9TH SEMESTER APPLIED MATHEMATICS COURSE

Divisibility, Chinese remainder theorem, modular exponentiation, primitive roots. Carmichael functions, Euler's "phi" function, Legendre and Jacobi symbols, square root computation, prime number theorem. Primality test and factoring. The sieve of Eratosthenes. Lucas, Pratt, and Lucas-Lehmer tests. Extended Riemann hypothesis. Solovay-Strassen test, Miller test, probabilistic tests, Rabin test. Public-Key Cryptosystems. Binomial residues in Cryptography. The Discrete Logarithm Problem. RSA and Rabin systems.

9179 | NUMBER THEORY AND CRYPTOGRAPHY | 9TH SEMESTER APPLIED MATHEMATICS COURSE

Finite Fields. Modular arithmetic. *Number Theory.* The sieve of Eratosthenes and other factoring methods. The extended Eulidean algorithm. The Euler function. Linear Diophantine equations and congruences. *The fundamental theorems:* The fundamental theorem of Arithmetic, Euler, Fermat, Wilson, the Chinese remainder theorem the prime number theorem. Quadratic congruences, Legendre and Jacobi symbols. The Quadratic reciprocity law. Numbers: perfect, Mersenne, Fermat and amicable numbers. *Cryptology.* Historical overview. Classical cryptosystems: encryption, decryption and cryptanalysis of the cryptosystems: additive, multiplicative, affine, Vigenere, Playfair and Hill. The Discrete logarithm problem (D.L.P.). Public Key cryptosystems: The R.S.A., Merkle, Hellman- the Diffie-Hellman problem, Elgamal, Massey – Omura. Digital Signatures. Elliptic Curves. Combinatorial Designs and Cryptography.

9180 | MECHANICS OF SEISMIC PHENOMENA | 9TH SEMESTER APPLIED MATHEMATICS COURSE

Introduction. Basic models and relations of continuum mechanics. Elements of fracture mechanics Seismological problems. Mathematical and physical foundations and methods of geo-electricity Mathematical models for the description of blow up and the earthquake epicenter. Seismic waves. Foundational proeblems from the static and dynamic theory of earthquake faults

9181 | NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS | 8TH SEMESTER APPLIED MATHEMATICS COURSE

Introduction: Dirichlet Problem. WeakForm.Numerical Computations based on Finite Element Methods. *Boundary Value Problems and Galerkin Methods*: General Weak Forms. Lax-Milgram Theorem.Galerkin Methods.Error Estimates.Rayleigh-Ritz-Galerkin Method.Generalized Derivatives and Sobolev Spaces. Green’s Theorems. Elliptic Problems. Existencean dUniqueness. Mixed Boundary Conditions. Applications. *Finite Element Methods for Elliptic Boundary Value Problems*.One Dimensional Elements. Polynomial Basis Functions.Cubic HermiteFunctions and Splines.Two-Dimensional and Three-Dimensional Elements.Error Estimates. Applications: Fluid Flows, Plates, Electromagnetism. *Finite Element Methods for Evolutionary PDEs*: Parabolic and Hyperbolic Problems. EulerandCrank-NicholsonMethods.Stability.ErrorEstimates. Applications: Reaction-Diffusion, Wave

Equations, Plates. *Finite Differences*: Sturm LiouvilleandDirichlet Problems. Heat Equation.Wave Equation.Consistency, Stabilityand Convergence.

9183 | STOCHASTIC DIFFERENTIAL EQUATIONS AND APPLICATIONS | 9TH SEMESTER APPLIED MATHEMATICS COURSE

Continuous time stochastic processes. Stopping times. Continuous time martingales. Markov processes. Brownian motion. Stochastic calculus. Ito stochastic integral. Ito processes, Ito formula, martingales with respect to Brownian motion, Girsanov theorem. Stochastic differential equations, Ito diffusions, Feynman-Kac formula. ◆*Applications*: Continuous time market models and Black-Scholes model; Optimal stopping.

9184 | ALGORITHMIC GEOMETRY | 8TH SEMESTER APPLIED MATHEMATICS COURSE

Introduction: Data structures. Computing machines ex. Pascal machine. Definition of complexity of algorithms. *Problems of convex closure* of the set A of E^n (= n-dim Euclidean space). *Distance problems:* Voronoi diagram. *Partition problems* of a set e.g. into triangles or polygons or according to Delaunay. *Partition problem* of a set with the help of a hyper plane. *Curves* according to Bezier and B-spline. Geometric interpretation of coefficients. Change of base in the vector space of polynomials. *Nurbs curves* with a short introduction to homogeneous coefficients. Intersections of curves. *Surfaces* according to Bezier and B-spline. Geometric interpretation of coefficients. *Nurbs surfaces.* Intersection of surfaces. Methods for visibility, shadow and reflection

9185 | ADVANCED DYNAMICS | 9TH SEMESTER APPLIED MATHEMATICS COURSE

Topics

Basic concepts: Types of dynamical systems; linear and non-linear, deterministic and stochastic, discrete and continuous. Chaotic behavior. Vectorial, Lagrangian and Hamiltonian formulation. Normalization of physical quantities. Integrals of motion. Zero-velocity curves (zvc) and surfaces (zvs). Properties of zvc and zvs.

Equilibrium states: Stationary solutions. Numerical processes for their determination. Stability. Routh-Hurwitz criterion. Parametric variation of the equilibria.

Periodic solutions: Equations of motion. Variational equations. The monodromy matrix. Properties of the monodromy matrix. Numerical methods for the determination of periodic solutions; grid search, Newton, bisection, steepest descent, analytic continuation, shooting method, Poincare surfaces of section. Symmetric orbits. Existence of symmetric orbits. Characteristic curves (families). Termination principle. Resonances. Asymptotic and escape orbits. Inverse motion. Stability in the sense of Poincare and in the sense of Liapunov. Hill's stability. Linear stability of periodic orbits in Hamiltonian systems. Henon's stability parameters. Bifurcations. Singularities and regularization.

Applications. Problems and case studies. The general N-body problem. The two-body problem. The three-body problem. The regular polygon problem of N+1 bodies.

9186 | MECHANICS OF COUPLED FIELDS | 8TH SEMESTER APPLIED MATHEMATICS COURSE

Basic relations and constitutive equations of linear theory of thermoelasticity. Basic relations and constitutive equations of linear theory of electroelasticity Elements of crystallography and crystallophysics. Interaction of physical fields in piezoelectric mediums. Waves in piezoelectric mediums. Fracture mechanics of piezoelectric materials. Basic relations and constitutive equations of magneto-thermo-elasticity.

9187

ANALYSIS OF SURFACE MECHANICAL SYSTEMS

9TH SEMESTER
APPLIED MATHEMATICS
COURSE

Elements of the differential geometry of three dimensional surfaces in oblique and orthogonal systems. The general bending theory of elastic shells (Applications). The bending theory of thin elastic shells (Applications).Methods of decoupling of partial linear differential systems of high order. The membrane theory of elastic shells (Applications).Analysis of cylindrical shells and shells of revolution under bending and membrane loading.

9188

SPECIAL COURSES OF COMPUTATIONAL MECHANICS

9TH SEMESTER
APPLIED MATHEMATICS
COURSE

Introduction to the fracture mechanics. Fatigue of metallic materials. Crack propagation laws. Fatigue of composite materials. Use of finite element programs in crack problems. Basic principles of damage tolerance. Analysis of the mechanism of crack propagation based on damage tolerance. Methodology of prediction of the remaining life of a structure. Example of computational study of a structure based on damage tolerance. Computational programs of crack propagation (AFGROW-NASGRO-RAPID). Smart materials and Structures. Introduction in the inspection of the structural integrity (structural health monitoring).

Laboratoty: Exhibition of the fatigue experiment in the test machines INSTRON

Numerical applications with the finite element method

9189

FRACTURE MECHANICS

8TH SEMESTER
APPLIED MATHEMATICS
COURSE

Introduction, Brittle and Ductile Failure, Elements from Elasticity (plane stress/strain), Airy, Mushelishvili, Westegaard), Stress Intensity Factors, Griffith Crack, Critical Stress Intensity Factors, Experimental Evaluation. Energy Approach to Crack Initiation, Griffith Criterion, Criteria for Multiaxial Crack Initiation. Nonlinear Fracture Mechanics, HRR field, Plastic Zones (Irwin, Dugdale, von Mises, ...), Crack Opening Displacement, R-Curve, J- Integral, Fatigue, Empirical Criteria (Paris, ...), Crack Propagation under Dynamic Loading (stress field). Engineering Applications.

9193

LAW

9TH SEMESTER
APPLIED MATHEMATICS
COURSE

The aim of this course is to provide students lacking a legal background with both a general overview of Greek legal system and the operation of legal rules. Thus, the course focuses on essential legal issues arising in fields such as Public law (Constitutional Law and Administrative Law), Civil Law (contracts, torts and Law of Property), Commercial law (commercial transactions, Company Law, Industrial Property rights etc.), Labour Law (work accidents, constructor liability etc.), Environmental Law (national and European legislation) and European Law (European institutions, Freedoms and rights, Free Trade, Statutory Law etc.). Lectures are followed by practical sessions, where are examined solutions to practical legal issues and court decisions. Assessment is by a mixture of examination (Multiple Choice Questions and practical cases) and coursework.

9194 | HISTORY OF MATHEMATICS | 9TH SEMESTER APPLIED MATHEMATICS COURSE

Introduction. Euclid's Elements. The Background. The first four Books and the non-Euclidean Geometry (Arabs, Saccheri, Lambert, Legendre, Lobatchevskii, Einstein's theory of relativity. Book V, *Eudoxus theory of proportions and the theories of real numbers during the 19th century. Quadratures.* Eudoxus' theory of exhaustion. The quadrature of circle. The nature of number π. The proof of π as transcendental number. *Infinitesimal methods of integration and differentiation in Archimedes' work.* The development of these methods in Middle Ages and Renaissance. *The creation of Calculus by Newton and Leibniz. The Reform of Analysis: Bolzano-Cauchy -Weierstrass.* The problem of the foundations of Mathematics: Zeno paradoxes, B. Bolzano, Fourier. Georg Cantor. *Problems and Paradoxes in Set Theory. Axiomatic Foundation of Set Theory. The Conics of Apollonius. Kepler-Newton.* Apollonius and analytic geometry Fermat-Descartes. *Diophantus and Diophantine equations.* Pierre de Fermat. Fermat's little theory and cryptography. Timaeus and the first program of mathematical physics. Euclid Elements and the mathematical introduction in such physics. Galileo-Newton. W. Heisenberg.

9195 | ELEMENTARY PARTICLE PHYSICS –II | 8TH SEMESTER APPLIED PHYSICS COURSE

Introductory concepts. Lorentz transformation and rrelativistic formalism. Klein-Gordon equation. Probability density and probability current. Negative energies. QED without spin. Scattering, cross section and invariant amplitude, decay rate. Dirac equation, γ-matrices, spin-1/2 particles, antiparticles, helicity, massless fermions. Lagrange-Hamilton formalism, Euler-Lagrange equations, Classical field mechanics, Noether's theorem. Internal tranformations and Lagrangian invariance, Non-Abelian global and local symmetries, QCD. Spantaneous symmetry violation, Case of gauge symmetries, Abelian and Non-Abelian case. The Standard Model, Higgs particle, Tha mass of particles, CKM matrix. The mass of neutrinos, Higgs particle physics.

9197 | NUCLEAR ENGINEERING | 9TH SEMESTER APPLIED PHYSICS COURSE

Nuclear reactions with neutrons. Fission. Scattering, diffusion, absorption, thermalization of neutrons. Criticality analysis for bare homogeneous thermal neutron systems. Nuclear Power Reactors. Nuclear Power Plants. Nuclear fuel. Steady-state heat removal from the nuclear power reactor core. Thermodynamic cycles and energy production. Nuclear installations safety, nuclear accidents. Fission products dispersion in the environment. Industrial applications of nuclear engineering. Principles of radiation protection and radioenvironmental analysis.

The course includes laboratory exercises

9198 | APPLICATIONS OF LASERS IN BIOMEDICINE AND ENVIRONMENT | 9TH SEMESTER APPLIED PHYSICS COURSE

Basic principles of the interaction of laser radiation with living matter. Biophysical action mechanisms. Diagnostic applications of lasers. Surgical applications of lasers. Photodynamic therapy. Medical lasers and dosimetry. Laser safety. Basic principles of the propagation of laser radiation in the atmosphere. Mie and Rayleigh scattering. Raman scattering. LIF technique. LIDAR technique (radiation propagation equation, set-up geometry, signal recording techniques). DIAL technique.Measurement of pollutants in the atmosphere and the hydrosphere.

9199 | INTRODUCTION TO MEDICAL PHYSICS | 9TH SEMESTER APPLIED PHYSICS COURSE

Terminology and modelling. Energy, heat, work and power of the human ody. Bioengineering, the muscular system and forces. Physics of the skeleton. Pressure in the body. Osmosis and kidneys. Physics of the lungs and breathing. Physics of the cardiovascular system and electric signals. Sound, speech and hearing. Interaction of ultrasound with living matter and applications to the Physics of the eyes and vision, artificial vision. Introduction to telemedicine. Designing and organizing telemedicine services. Use of the HERMES tool. Quality aspects. Service evaluation aspects. Work management aspects. PRINCE methodology. Electronic medical files. Patients' data bases. Data and image transmission. Clinical applications.

9200 | NEW TECHNOLOGICAL MATERIALS | 9TH SEMESTER APPLIED PHYSICS COURSE

Introduction. Ceramics, physical properties and preparation methods. Dielectric, Semiconducting, Superconducting ceramics, Ionic ceramic conductors, Amorphous ceramics, Glasses, Nano- and porous-ceramics, Advanced ceramic materials. Dielectrics, insulating materials, dielectric materials for capasitors, microelectronic dielectrics. Active dielectric materials, Ferroelectric, Piezoelectric and Pyroelectric materials, Electretes. Photovoltaic materials. Solid State electrolytes. Liquid crystals.

9201 | MICROSYSTEMS AND NANOTECHNOLOGY | 9TH SEMESTER APPLIED PHYSICS COURSE

Microsystems and nanosystems: Definitions and examples. Relationship between microelectronic, micro-optical and micro-electro-mechanical technology. Basic microelectronic technology processes and modeling: Thermal oxidation, dopant diffusion, ion implantation, physical and chemical deposition, lithography, etching. Examples of microelectronic device fabrication. ◆ Special processes for micromechanics and microsensor fabrication. Surface and bulk micromachining. Physical principles of sensors operation. Examples on fabrication and operation of physical and biochemical microsensors. ◆ From microtechnology to nanotechnology: Methods of fabrication at the nanoscale. Fabrication of nanoparticles and naowires, their interaction with the macro-world. Applications to nanoelectronics and microsensors

9203 | COMPUTATIONAL PHYSICS – MODELLING | 8TH SEMESTER APPLIED PHYSICS COURSE

Introduction: Statistical Physics: Canonical Ensemble, Partition function, expectation values, free energy and entropy, density of states, fluctuations. 2 dimensional Ising model. Phase transitions, correlation length, universality. Basic Principles of Monte Carlo Simulations: Sampling, importance sampling, Markov chains, detailed balance condition, acceptance ratios. Random Walks: Random walks in two dimensions. Programming language and techniques. Random number generators. Simulations of random walk models. Data analysis: expectation values, statistical errors. Study of geometrical properties of random walks. Simulations of 2d Ising model, part I: Metropolis algorithm.

Code design, modular programming, optimization, using scripts for automation. Data structure. Thermalization, autocorrelation times, times series analysis. Error calculation using binning, jackknife and bootstrap methods. Simulations of 2d Ising model, part II: Critical slowing down, cluster algorithms. Finite size scaling, calculation of critical exponents. Potts models in 2 dimensions: Cluster and heat bath algorithms. Phase transitions in Potts models. First order phase transitions.

9204 PATTERN RECOGNITION AND NEURAL NETWORKS

9TH SEMESTER
APPLIED PHYSICS COURSE

Review of linear algebra, linera transformation & probability theory, conditional probability and Bayes rule; Introduction to statistical pattern recognition, feature detection, classification; Bayesian decision theory of pattern recognition; Linear and quadratic discriminant functions; Parametric estimation and supervised learning; Theory of Perceptron; Parzen, K-Near Neighbor (K-NN) classification methods ; Dimensionality reduction, Fisher & entropy techniques; Unsupervised learning, clustering K-means; Neural networks for pattern recognition; Learning

9205 ENVIRONMENTAL PHYSICS

9TH SEMESTER
APPLIED PHYSICS COURSE

Atmosphere and biosphere structure and composition. Propagation of radiation and equations of motion in the atmosphere. The ozone layer and the ultraviolet radiation. Stability conditions in the atmosphere. Planetary Boundary Layer. Air pollution. Hydrosphere structure and composition. Propagation of radiation and equations of motion in the hydrosphere. Water pollution. Energy exchange mechanisms between the atmosphere and the hydrosphere. Worldwide climatic change.

The course includes laboratory exercises.

9206 FLUID MECHANICS

6TH SEMESTER
APPLIED PHYSICS COURSE

Introduction: Fluid properties and characteristics, Units, Continuum hypothesis. *Kinematics*: Velocity and acceleration fields, System and control volume, Transport theorem of Reynolds, Forces and deformation. *Surface and body forces*: Pressure forces, Viscous forces, Stress tensor. *Governing equations in integral and differential form*: Mass, momentum and energy equations. The Navier-Stokes equations. Potential flow. *Dimensional analysis and similitude*: Pi theorem, Non-dimensional numbers. *Inviscid flow*: Circulation, vortices. *Viscous flows*: Boundary layers, Separation. *Turbulence*: Turbulent stress, Boussinesq hypothesis, Governing equations for mass and momentum transfer.

9207 FRACTURE MECHANICS

8TH SEMESTER
APPLIED PHYSICS COURSE

For the description see course with code 9189, (Applied Mathematics Course)

9208 MECHANICS OF COUPLED FIELDS

8TH SEMESTER
APPLIED PHYSICS COURSE

For the description see module with code 9186, (Applied Mathematics Course)

9209 | LAW | 9TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9193, (Applied Mathematics Course)

9210 | ENVIRONMENTAL POLICY | 9TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9321, (Applied Mathematics Course)

9211 | INTRODUCTION TO INTERNET TECHNOLOGIES | 9TH SEMESTER APPLIED PHYSICS COURSE

Internet fundamentals: Introduction. TCP/IP protocol suite. Transmission. The Internet Protocol (IP). IP addressing. IP routing. Internet Control Message Protocol (ICMP). Transport Layer Protocols (TCP, UDP). IPv6. *Routing Protocols*: Static routing. Dynamic routing. Dijkstra's algorithm. Routing Information Protocol (RIP). Open Shortest Path First (OSPF). Border Gateway Protocol (BGP). *End to end congestion avoidance*: Sliding window. TCP improvements. *Internet Security*: Security Requirements, Attack Categories, Symmetric Cryptography, Asymmetric Cryptography, Digital Signature, Public Key Infrastructure. *MultiProtocol Label Switching (MPLS)*: Label distribution. Label Distribution Protocol (LDP). Constraint Routed Label Distribution Protocol (CR-LDP). Resource Reservation Protocol - TE (RSVP-TE). *Application Layer Protocols*: Introduction. FTP. DNS. HTTP. E-Mail (SMTP, POP3, IMAP). *HyperText Markup Language – HTML*.

9214 | DATA STRUCTURES | 6O SEMESTER APPLIED MATHEMATICS COURSE

Abstract data types and their implementations. Lists, stacks, FIFO queues, priority queues, symbol tables, disjoint sets, graphs. Implementations based on search trees (binary trees, AVL trees, splay trees, B-trees, red-black trees), heaps (binary, binomial, Fibonacci) and hashing. Sorting algorithms. Applications.

9215
9217 | EDUCATION AND NEW TECHNOLOGIES | 8O SEMESTER APPL. MATHEM. CONC. APPL. PHYSICS CONC.

The main purpose of the course is to provide the student (and teacher-to-be) with the basic skills necessary to exploit the advantages of the internet and, at the same time, make him/her capable of delivering -in an attractive way- a high school course using links, images and even interactivity through web pages. The outline of the lectures is: 1) Basic introduction to HTML. 2) Using a text processor. 3) Head and Title. 4) Text formatting (indentation, fonts, size, decoration, color etc). 5) Ordered and Unordered lists. 6) Introducing images. Images and text. 7) Links (to another page, to the same page, to a file etc). 8) Tables (borders, color, background image, caption etc). 9) Frames. 10) Forms. 11) Some special effects. 12) Introducing Freeware HTML editors.

9219 | TECHNOLOGY AND ITS HISTORY | 5TH SEMESTER APPLIED MATHEMATICS COURSE

This middle level course aims towards the understanding of the notion of technology through its historical genealogy but also the exposition of diachronic questions.

More specifically we examine the relation between technique, technology and applied science, and their relation to the society. We mention the notion of progress, the problem of technological determinism related to the appearance of modernity, and also contemporary political and ethical problems related to technology.

9222	MATHEMATICAL SIMULATION IN MECHANICS	8TH SEMESTER APPLIED MATHEMATICS COURSE

1. *Energy methods in Applied Mechanics. General Principles in Mechanics*. Mechanical Systems. Geometrical glossary. Distance in the configuration space. Paths in the configuration space. Non – holonomic systems. Generalized coordinates. Elementary. Principles of Dynamics. Kinetic energy law. First of Thermodynamics. Fourier's inequality. The principle of virtual work. Variational form of the virtual work principle. *Calculus of Variation*: Euler's equation. Specific forms of Euler's equations. The differential equation of the beam elastic curve. Isoperimetric problems. Broken path conditions of Erdmann – Weierstrass. The first variation of a double integral. The approximate method of Rayleigh-Ritz. *Buckling Theory.* Buckling of rod models. Postbuckling: Buckling and post- buckling analysis of beams. *Lagrange's equations.* Kinetic energy of a system with finite degress of freedom. Hamilton's principle. Lagrange's equations for conservative systems. Systems with two degrees of freedom. Vibrations of systems with finite degrees of freedom. 2. Perturbation Methods

Expansions. Order Symbols. Asymptotic series and expansions. Solution of equations. Algebraic equations. Cubic equations. Higher order equations. Transcedental equations. Conservative Systems with odd non-linearities. Direct expansions of solutions. Lindsteat- Poincare technique. The method of renormalization. Multiple scales technique. The method of averaging. Boundary layer problems. The idea of boundary layrer, outer and inner expomsions. The matching of the solutions. The composite expansion.

9224	TOPICS IN ANALYSIS	9TH SEMESTER APPLIED MATHEMATICS COURSE

This module depends on the teacher and its content varies each academic year.

9226	TECHNOLOGY AND ITS HISTORY	5TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9219, (Applied Mathematics Course)

9228 9229	ENVIRONMENT AND DEVELOPEMENT	8TH SEMESTER APPL. MATHEM. CONC. APPL. PHYSICS CONC.

Part I: Theoretical Background & Tools: Development and Environment, Sustainable Growth and Critical assessment, Environmental & Development Policy, Management and Technology Tools. Session II: Thematic Sub-cases (Case studies): Global climate change, waste management, recycling-energy saving-reuse, environmental-friendly air conditioning gases, Lignite, Natural gas and alternative energy sources, Environmental-technological approach, Water Resources and environment, Environment as an economic activity: a second life for former industrial sites (Lavrion). The role of justice in the environmental debate. Section III: Role of Engineers in environment and development debate.

9230	ALGEBRA **II**	8O SEMESTER APPLIED MATHEMATICS COURSE.

Group actions, Burnside's theorem and applications, p-groups, the Sylow theorems, the class equation, applications. Introduction to Ring Theory. Polynomial rings, integral domains. Prime and maximal ideals, ring homomorphisms, isomorphism theorems. Field extensions, geometric constructions, finite fields. Automophisms, Galois theory, applications.

This course is useful to those who have selected the stream «Mathematics for Information Sciences».

9301 **TECHNICS FOR GEOMETRIC DESIGN** 1ST SEMESTER CORE PROGR.

Space Eucledean Geometry: Relative position of points, lines and planes. Parallel and perpendicular lines and planes in space. Angle of skew lines. Angle of a line with a plane. Theorem of Thales. Theorem of tree orthogonal lines. Dihedral and n-hedral angles. Properties and measurement of a prism, pyramid, cylinder, cone and sphere. Applications and exercises. *Projective Geometry:* The projective space as augmented Euclidean space. Section and projection. Cross ratio. Projectivities. Homology. Special homologies. Conic sections. Applications-exercises. *Descriptive geometry:* Presentation of a point, a line and a plane in the system of two planes. Methods for solving problems. Presentation and solution of problems concerning prisms, pyramids, cylinders, cones and spheres. Axonometric presentation of solids. Applications-exercises. *Laboratory:* Exercise in drawing by electronic means.

9302 **MECHANICS III: (STRENGTH OF MATERIALS)** 3RD SEMESTER CORE PROGR.

Torsion: Torsion of circular shafts. Non-circular cross-sections. Thin walled-closed tubes. Warping function. The membrane analogue. Elasto-plastic Torsion. *Bending:* Euler-Bernoulli bending. Asymmetric bending. Eccentric tension and compression. Composite cross-sections. Elasto-plastic bending. Curved beams. Limits of Euler-Bernoulli theory. The influence of the concentrated load. The problem of the cantilever beam. *Stresses in transverse bending*. Shearing flow. Composite cross-sections. Thin-walled cross-sections. Shearing center. *Elastic curve.* Methods of deflection computation through integration. Moment-area method. Solution of statically indeterminate problems via the elastic curve. Deflection under shearing. Buckling. Critical Euler load. The bifurcation problem of buckling. Elasto-plastic buckling. *Design of columns under central and eccentric loads. Energy methods and strain energy theorems.* Castigliano theorems

9303 **STATISTICAL DATA ANALYSIS** 5TH SEMESTER APPLIED MATHEMATICS COURSE

Introduction to Statistics and the R program. Descriptive statistics: continuous variables, categorical variables, plotting in R. *Simulation:* distributions in R, testing fit, weak law of large numbers, Central Limit Theorem. *Statistical inference:* maximum likelihood estimation, confidence intervals, hypothesis testing. *Regression analysis:* simple linear model, correlation coefficient, general linear model. *Analysis of variance* with one and two factors.

9304 **FOUNDATIONS OF COMPUTER SCIENCE** 5TH SEMESTER APPLIED MATHEMATICS COURSE

Introduction to fundamental computing principles and notions: computational problems as formal languages, models of computation, computability, complexity. Reductions, completeness and hardness. Automata, formal grammars, Chomsky hierarchy. Logic in computer science. Algorithmic techniques: recursion, teration, divide-and-conquer, greedy. Basic arithmetic and graph algorithms: Euclid's algorithm, repeated squaring, multiplication, Fibonacci numbers, tree and graph traversals, shortest paths, minimum spanning tree. Applications to cryptography. The course also offers an introduction to the functional programming paradigm with the Haskell programming language and a set of lab assignments that help in demonstrating and clarifying some of the theoretical concepts taught.

9305 NUMERICAL LINEAR ALGEBRA

7TH SEMESTER
APPLIED MATHEMATICS COURSE

Introduction to Numerical Linear Algebra: Matrices, Eigenvalues, Norms, Spectral Radius, Condition Number, Basic Stability Estimates. *Basic Methods:* Computational Techniques Basedon the GEM, Error Estimates, Stability, Pivoting, Implementation, Factorizations, LU, Cholesky, Doolittle-Crout Algorithms, Factorizations LDL^T, QR. *Iterative Methods:* Basic Definitions and General Theory, Jacobi, Gauss Seidel Methods, Relaxation Techniques, JOR, SOR, Richardson Iteration Schemes,Gradient / Descent Methods, Conjugate Gradient Method, IntroductionArnoldi, Krylov, GMRES Methods. *Eigenvalues – Eigenvectors Computation:* Introductionto Geometrical Properties of Eigenvalues, Basic Stability Estimates, Power Method, QR, Householder, Givens, Lanczos Methods. *Nonlinear Systems*: Introdution to Iterative Schemes, Newton-Raphson, Implementation.

9306 PROPAGATION OF WAVES IN SOLIDS

7TH SEMESTER
APPLIED MATHEMATICS COURSE

Propagation of waves in unbounded elastic media: Stresses and strains. Generalized Hooke's law. *Equations of motion in* an isotropic elastic medium. Integration of the wave equation. Rayleigh surface waves. Love surface waves. Reflection of elastic body waves at a free boundary. Reflection and refraction of body waves at a welded interface between two elastic media. Total reflection. Elements of wave propagation in anisotropic elastic media. *Propagation of waves in bounded elastic media:* Longitudinal waves in rods. Torsional waves in rods. Flexural waves in rods. The Pochhammer equations for cylindrical bars (longitudinal waves, torsional waves and flexular waves). Propagation of an elastic pulse along a cylindrical bar. Propagation along a bar with non – circular cross section. Propagation along a conical bar. Propagation of longitudinal waves in an infinite plate.

9307 INTRODUCTION TO BIOMECHANICS OF THE MUSCULOSCELETAL SYSTEM

7TH SEMESTER
APPLIED MATHEMATICS COURSE

Introduction: Scope. Historic review. Elements of anatomy. Elements from the theory of elasticity. Anisotropy. *Bone tissue*: Composition and structure. Bone tissue under various mechanical loads. Influence of muscles on the mechanical behaviour of bones. Fatigue. Bone remodeling. Degeneration of bone tissue due to ageing. Case studies. *Fracture and failure*: Failure crtiteria. *Biomechanics of articular cartilage*: Composition and structure. Articular cartilage under mechanical loading. Lubricating role of the articular cartilage. *Spine biomechanics*: Structure and geometry of the vertebrae. *Clinical application*: Spine implants. *Elements of viscoelasticity and poroelasticity. The intervertebral disc. Elements of hyperelasticity. Biomechanics of ligaments:* Structure and composition. Biomechanical function of the ligaments. *Application: Anterior Cruciate Ligament (ACL)* - Numerical simulation of the mechanical behaviour of ACL. *Tendon biomechanics*: Structure and composition. Biomechanical function of the tendons. *Application: The Achilles tendon* – Influence of training and dopping on the Achilles tendon. *Biomechanics of Joints:* Kinematics and kinetics of joints. The knee joint. *Foot Biomechanics. Introduction to Gait Analysis.*

Laboratory tests: Three point bending of rats femurs. Tension of soft tissues. Pull-out tests with pedicle screws.

9308 | DYNAMICAL SYSTEMS AND OSCILLATIONS | 7^{TH} SEMESTER APPLIED MATHEMATICS COURSE

Many problems of contemporary research interest in the fields of Applied Mathematics, Mechanics, Economical, Physical and Life Sciences are characterized by nonlinear behavior. Emergent phenomena such as multiplicity of steady states, self-sustained oscillations, phase-transitions and chaos are paradigms of such complex dynamics.

The aim of the course is to introduce and develop the modern theory of dynamical systems with a view to Bifurcation Theory in analyzing various problems in engineering and sciences.

The syllabus of the course:

1) Review of some basic non-linear phenomena. Examples from Mechanical Systems, NeuroScience, Material-Science, Bio-Systems and Financial Markets. Introduction to Nonlinear Dynamical Systems. Orbits, steady states, oscillations, phase diagrams. Attractors and Bifurcations. The Duffing oscillator without external forcing. The Van der Pol oscillator. Introduction to the theory of invariant manifolds, stable, unstable and central. 2) The Implicit Function Theorem. Local Bifurcations and Stability in one and two dimensions. Turning points, Double, Conjugate and Cusp points. The Factorization Theorem. Stability Analysis of Bifurcating solutions. 3) Normal forms of Turning points, Transcritical and Pitchork Bifurcations. Problems with Symmetry. Imperfection Theory and symmetry-breaking. Examples. Stability of symmetry-breaking solutions. 4) Bifurcations of Periodic solutions from steady states in two and greater than two dimensions. Hopf-Andronov bifurcation. Analysis of Lorentz equations. 5) Poincare maps. The periodically forced Duffing oscillator. Stability of periodic solutions of autonomous systems. The Monodromy matrix. Bifurcations of fixed points of maps. 6) Bifurcations of limit cycles. Period-doubling bifurcation, Torus. The example of FitzHugh-Nagumo equations in Neuroscience. Phase-locking. 7) Global bifurcations. Homoclinic, Heteroclinic Bifurcation. Theorem of Andronov-Leontovich. Melnikov's method for homoclinic orbits. 8) Routes to Chaos. Strange attractors. The Lorenz equations. Lyapunov exponents and their computation. Power spectra computations.

9309 | DATA BASES | 7^{TH} SEMESTER APPLIED MATHEMATICS COURSE

Database Management Systems and architecture. Data Structures for Data Bases. Modelling. The E-R Model. Classical Models for Data Bases. The Relational Model. Languages for Data Bases. The SQL Language. Natural Design of Data Bases. Logical design and normalization. Management of data bases (integrity, optimization, reorganization, security, etc.). Other topics (object oriented systems, multi-systems and systems for personal computers).

9310 | ECONOMIC ANALYSIS III (APPLIED ECONOMICS) | 7^{TH} SEMESTER APPLIED MATHEMATICS COURSE

The goods market. The money market. The role of money. International Relations. Open Economies. International Macroeconomic Policies. The International Monetary System. Exchange Rate Regimes. International Banking. International Markets. Economiv Growth. Examples and Questions.

9312 TOPOLOGY AND APPLICATIONS

9TH SEMESTER
APPLIED MATHEMATICS
COURSE

Basic notions: Topological spaces, Basis, subbasis of topology, Open sets, closed sets, closure, interior, boundary, continuous functions, relative topology, homeomorphisms. Cartesian products: Product topology, projections, general properties. Connectedness: Definitions, properties, Connective components; Path connectedness, Applications to R^n. Separation axioms: Hausdorff spaces, regular spaces, normal spaces, completely regular spaces. Countability and Metrizable topological spaces. Separability. First and second countable spaces, Lindelof spaces, Urysohn's metrizability Theorem. Compactness: Tychonoff's Theorem, Stone Cech compactification, Superfilters, the space βN. Convergence: Convergence in topological spaces, nets, subnets.

9313 TOPICS IN ALGEBRA

9TH SEMESTER
APPLIED MATHEMATICS
COURSE

Algebraic structures: Groups, the field *R* of real numbers, the field *C* of complex numbers, quaternions, octonions, Grassmann algebras and Clifford algebras. *Matrix groups of Lie type:* The general linear groups *GL* (*n, K*), *K* = R,C,*H*, the special linear groups *SL* (*n, K*), *K* = R,C,*H*, the orthogonal groups *O* (*n*), the unitary groups *U* (*n*), the complex orthogonal groups *O* (*n,* C) and the generalized orthogonal groups *O* (*n, k*), the symplectic groups *SP*(*n*, R), *SP*(*n*, C) and *SP*(*n*), the Heisenberg's group, R', C', S^1, R, R'', the Euclidean group *E*(*n*), the group of Poincare *P*(*n*), and the polar decomposition in the groups *SL* (*n, K*), *K* = R,C. *The exponential function:* The exponential of a matrix, the logarithm of a matrix, and the Lie algebra of a matrix group. *The topology of* R^n: Open and closed sets, compactness, connectivity, simply connected sets, homeomorphisms. *Introduction to differentiable manifolds* Definitions and examples, differentiable functions between manifolds, tangent space. *Introduction to Lie groups and Lie algebras*: The general linear Lie algebra and the classical Lie algebras, Jordan – Chevalley decomposition and root systems.

9314 COMPUTATIONAL STATISTICS

9TH SEMESTER
APPLIED MATHEMATICS
COURSE

Estimation of probability density function with applications. Randomization tests and Monte Carlo. Stochastic simulation: generating uniform random deviates, inversion method, rejection sampling, variance reduction techniques. MCMC algorithms: Metropolis-Hastings algorithm. Resampling methods: Jackknife, bootstrap, cross-validation. EM algorithm. Applications of these methods using the R program.

9315 STATISTICAL QUALITY CONTROL

9TH SEMESTER
APPLIED MATHEMATICS
COURSE

Control charts for the mean, variance, standard deviation and range of a sample. P- and c-charts. Charts for controlling the number of defectives. *CUSUM charts.* Exponentially-weighted moving average charts (EWMA). *Acceptance sampling for batches.* Single sampling plans. Average outgoing quality. Double sampling plans. Operating characteristic curve. Multiple sampling plans. Robust parametric plans. Taguchi methods. Alternative designs for quality control. Factorial designs. Combined designs. Construction of combined designs from optimal designs. Practical session using statistical packages.

9316 STATISTICAL ANALYSIS AND DATA MINING

9TH SEMESTER
APPLIED MATHEMATICS COURSE

The module will not be offered in the curriculum of the academic year 2012-13

9317 COMPUTATIONAL FLUID MECHANICS

9TH SEMESTER
APPLIED MATHEMATICS COURSE

Linear and non-linear systems of algebraic equations: direct and iterative algorithms. Systems of ordinary differential equations: initial and boundary value problems, explicit and implicit algorithms, multistep methods, stability, convergence. Systems of partial differential equations: algorithms for hyperbolic, parabolic and elliptic equations. Finite difference methods: convection and diffusion operators, stability and convergence. Algorithms for the solution of mass conservation and Navier-Stokes equations.

9318 MATHEMATICAL SIMULATION IN BIOMECHANICS

9TH SEMESTER
APPLIED MATHEMATICS COURSE

Thermodynamic concepts on living systems. The basic systems for the human body, as a machine. Basic energy unit ATP. The principle of biological adaptation – reproduction and adaptation, *Genetic Algorithm. The eucariotic cell,* basic structure and functions. *Cellular body* the role of actin network. Structural molecules of cellular body of the eucariotic cell. Extra-cellular mass – basic structural elements. *Methods of measurement of mechanical properties of the cellular structure* and of the macromolecular subsystems. *Basic models of description* of the mechanical behavior of the cellular structure and extra-cellular mass. *Mechanical behavior of macromolecules* and statistical mechanical description of simple systems. Mechanical stimulation mechanism of the cellular body. Sensors for simulation in stress and shear flow. Techniques of mechanical stimulation. Elements of blood rheology. Computational methods of 3-D reproduction in biomechanics.

9319 HARMONIC ANALYSIS

9TH SEMESTER
APPLIED MATHEMATICS COURSE

Hilbert spaces: Introductory examples, the notion of the best approximation, the projection theorem, Riesz's Representation theorem, Orthonormal systems, orthonormal basis and examples (Legendre, Hermite , Laguerre polynomials, the trigonometric system, orthonormal systems of Rademacher, Walsh and Haar). Theorem of Riesz-Fischer and characterization of the orthonormal basis. ◆*Fourier series*: Lemma of Riemann-Lebesgue, Pointwise convergence of Fourier series (Fejer-Lebesgue and Dirichlet-Jordan), Gibs phenomenon and applications. Fourier transform in $L_1(R)$, the transform of the convolution of two functions, the inverse Fourier transform. Fourier transform in $L_2(R)$. Theorems of Plancherel and Shanon. ◆*Introduction to walets*: Inversion formulae and dyadic systems. The continuous wavelet transformation, Multiresolution analysis. Theory of frames.

9320 ECONOMIC ANALYSIS V (BUSINESS ECONOMICS)

9TH SEMESTER
APPLIED MATHEMATICS COURSE

For the description see the module with code 9132, (Applied Physics Course)

9321 **ENVIRONMENTAL POLICY** 9TH SEMESTER APPLIED MATHEMATICS COURSE

Traditional views for the relations between man and nature: Man and nature in Greek philosophy and Jewish religion. Christianity and nature. The scientific revolution and the concept of nature. Modern philosophy and nature.

Elements of environmental philosophy: Ecology: what it is and what it is not. Profound and shallow ecology. Metaphysical and epistemological problems. Moral, political and aesthetic problems. Animal rights. Eco-feminism. Technology, economy and environment. Environmental politics and environmental law in Greece and in European Union.

9322 **PROJECT** 9TH SEMESTER APPLIED MATHEMATICS COURSE

Implementation of an experimental or theoretical - computational project with applied character, individually or in groups. The subjects are determined by faculty members, who are responsible for the supervision and evaluation of the work. The assignment of the project can be done in collaboration with faculty members of other Schools.

9323 **MODERN PHYSICS LABORATORY** 5TH SEMESTER APPLIED MATHEMATICS COURSE

8 laboratories of 3-hours duration each, from the following list: Black body radiation, Electron Diffraction, Optical spectroscopy, Light interference and diffraction, Microwaves, Electron thermionic emission, Photoelectric effect, Measurement of thermal expansion coefficient, Measurement of sound velocity in liquids, Study of sound waves in acoustic tubes.

9324 **NUCLEAR PHYSICS** 7TH SEMESTER APPLIED PHYSICS COURSE

Introduction to the nucleus: radius, mass, charge, binding energy. Stability of the nucleus. Shell model, magical numbers. Angular momentum, spin, coupling, electric and magnetic moments. α, β, γ decay. Dosimetry. Fission, fusion, nucleosynthesis.

9325 **ELEMENTARY PARTICLE PHYSICS - I** 7TH SEMESTER APPLIED PHYSICS COURSE

Introduction to the elementary particle physics. Historical background. Natural units system. Relativistic kinematics, four-vectors. Mandelstam variables. Properties and classification of the elementary particles. Yukawa mechanism of interaction. Feynman diagrams. Symmetries and invariance laws. Space inversal, charge coupling, time reversal. Isotopic spin. G-parity. CP violation. CPT theorem. Hadron interactions in high energy. Quark model. Fundamental interactions: electromagnetic, weak and strong. Deep inelastic scattering. Standard model. Electromagnetic and weak interactions unification. Higgs Mechanism.

9326 **MATERIAL SCIENCE** 7TH SEMESTER APPLIED PHYSICS COURSE

Introduction, Atomic structure and chemical bonding in solid phase. Defects, Atomic defects, Doping, Defects at interfaces, Diffusion in solid phase, Fick’s law, Diffusion mechanisms and experimental techniques for structure and defects characterization. Solid solutions, phase diagrams, alloys, phase kinetics, Experimental techniques for phase separation and phase-diagram studies. Amorphous phase, glass transition, Structural models for amorphous materials, Percolation theory, Material processing, thermal treatment, annealing, high pressure treatment, Material failure and damage Corrosion, Aging. Low-dimensional materials: layered structures, quantum wells, wires and dots. Heterostructures. Foulerines, Nanotubes. Technological materials: metals, ceramics, glass, polymers, and composites. Growth, Properties, Applications.

9327	INTRODUCTION TO CONTINUUM MECHANICS	7TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9056 (Applied Mathematics Course)

9328	INTRODUCTION TO INELASTICITY	7TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9088, (Applied Mathematics Course)

9329	PROPAGATION OF WAVES IN SOLIDS	7TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9306 (Applied Mathematics Course)

9330	INTRODUCTION TO BIOMECHANICS OF THE MUSCULOSCELETAL SYSTEM	7TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9307 (Applied Mathematics Course)

9331	DYNAMICAL SYSTEMS AND OSCILLATIONS	7TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9308 (Applied Mathematics Course)

9332	INTEGRAL EQUATIONS AND APPLICATIONS	7TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9144 (Applied Mathematics Course)

9333	ECONOMICAL ANALYSIS III	7H SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9310 (Applied Mathematics Course)

9334	ELECTRONICS AND LABORATORY – II	9TH SEMESTER APPLIED PHYSICS COURSE

Measurement techniques. Instruments and measurements of electronic signals. Sources of noise, Circuit analysis and R, L, C analysis. Phasors. Sinusoidal and transitional response. Passive filters: high-pass, low-pass kai band-pass filters. Diode applications. Diode circuits. Rectifier configurations. Power electronics. Transistor applications. Bipolar and Field Effect transistors. Common emitter, base and collector amplifier. Operational amplifiers. Linear circuits based on operational amplifier. Non linear circuits based on operational amplifier. Differential amplifier. Application circuits. Digital circuits I: Boole Algebra, logical gates, combinational circuits and systems. Digital circuits II: Flip-Flops, sequential circuits and systems.

The course includes four laboratory exercises.

9335 | ELECTROMAGNETIC FIELDS | 9TH SEMESTER APPLIED PHYSICS COURSE

Scalar and vector potentials. Gauge transformations. Energy and momentum. Angular momentum. Electromagnetic stress tensor. Electromagnetic waves in non-conducting media. Fresnel coefficients. Dispersion in conducting, non-conducting and plasma. EM waves in waveguides. Orthogonal and cylindrical waveguides. The field of a moving pointlike charge. Retarded potentials. Radiation (pointlike charge, electric dipole, magnetic dipole). Antennas (linear, series). Relativistic notation.

9336 | MECHANICS OF SEISMIC PHENOMENA | 9^{O} SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9180 (Applied Mathematics Course)

9337 | DESIGN AND ANALYSIS OF CONTROL SYSTEMS | 9TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9138 (Applied Mathematics Course)

9338 | MATHEMATICAL SIMULATION IN BIOMECHANICS | 9TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9318 (Applied Mathematics Course)

9339 | COMPUTATIONAL FLUID MECHANICS | 9TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9317 (Applied Mathematics Course)

9340 | COMPOSITE MATERIALS | 9TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9153 (Applied Mathematics Course)

9341 | ADVANCED DYNAMICS | 9TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9185 (Applied Mathematics Course)

9342 | ANALYSIS OF SURFACE MECHANICAL SYSTEMS | 9TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9187 (Applied Mathematics Course)

9343 | MANY BODY PHYSICS | 9TH SEMESTER APPLIED PHYSICS COURSE

Second quantization formalism, Canonical transformation, Green functions, Path integrals, Symmetries and symmetry breaking, Electron interactions, Fermi liquid, quasi-particles, Hartree-Fock approximation, Collective excitations, (random phase approximations, plasmons, excitons, Nesting properties, low-dimensional systems, Spin-density and charge-density waves, delocalization, Feromagnetism, Strongly correlated electrons, Hubbard Hamiltonian. Jellium models, Peierls instability, Froelich Hamiltonian, Polarons, Spin-Fluctuation interactions, Macroscopic quantum states, Bose-Einstein condensation, Superfluidity, Superconuctivity, Ginzberg-Landau theories and BCS, Nambu-Eliasberg theory. Complex Quantum order-states of the matter, FFLO, strong defect-scattering, non-conventional magnetic-order states and charge-order states, Pomeranchuk instabilities. Quantum-state competition, non-conventional superconductors and magnets, Modern special topics.

9344 EXPERIMENTAL PHYSICS

2ND SEMESTER
CORE PROGR.

2-hour introductory theoretical courses: Introduction, analysis of experimental results – Theoretical exercise 1. Presentation of experimental results – Theoretical exercise 2. The introduction is followed by 8 laboratory exercises (of 2-hour duration, mainly from electromagnetism) chosen among the following: Mapping of electric field. Study of the capacitance and measurement of the dielectric constant. Measurement of a solenoid's magnetic field. Measurement of the Cp/Cv ratio of gases. Measurement of the e/m ratio of the electron. Oscilloscope. Telemetry. Forced electrical vibrations, resonance. Measurement of the magnetic permeability of the vacuum μ_0. Calibration of a thermocouple.

An additional laboratory exercise chosen among the above mentioned ones is mandatory for those who miss one lab practice. In the end of the semester an additional theoretical exam is held, which constitutes a percentage of the final grade.

9345 SPECIAL THEORY OF RELATIVITY

2ND SEMESTER
CORE PROGR.

Historical Introduction: Systems of reference, Galilean the transformation. The speed of light. The Michelson-Morley experiment.

Relativistic Kinematics: The Lorentz transformation. Length contraction, Time dilation. Examples. Transformation of velocities. Examples. Applications of relativistic kinematics.

Relativistic Dynamics: Relativistic mass. Conservation of mass-energy and momentum. Transformation of momentum and energy. Transformation of force. Examples. Applications of relativistic dynamics.

Electromagnetism: Charge invariance. Field transformations for E and B. The field of a moving charge. Forces exerted by moving charges on other moving charges.

9346 INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS

4TH SEMESTER
CORE PROGR.

Fourier Series: Trigonometric series, Convergence theorems, special type Fourier expansions, generalized Fourier series, orthogonal coordinate systems, complete systems, Bessel inequality. ◆ *Boundary Value Problems*: Linear boundary value problems, eigenfunctions and eigenvalues,, Sturm-Liouville problems, non-homigeneous problems. ◆ *Introduction to Partial Differential Equations*: Fundamental notions, Classification of second order semi-linear differential equations. ◆ *Laplace equation*: The Dirichlet and Newmann boundary value problems. Compatibility condition. The separation of variables technique in Cartesian, polar, cylindrical and spherical coordinates. The non-homogeneous problem. Helmholtz equation. ◆ *Heat equation*: Initial-Boundary value problems for bounded domains, the no-homogeneous diffusion problem. ◆ *Wave equation*: Initial-Boundary value problems, the infinite length string, D'Alembert solution, the circular drum problem. ◆ *Integral* *transformations*: Fourier transform, Sine and Cosine Fourier transforms, Hankel transform, application of integral transforms to the solution of initial-boundary value problems.

Use of computational software for the study of problems arising in partial differential equations.

9347 APPLIED STATISTICS

4TH SEMESTER
CORE PROGR.

Descriptive statistics. Probability: meaning and axioms, conditional probability, independent events, law of total probability, Bayes' theorem, combinatorics. *Random variables:* basic discrete and continuous univariate distributions, mean and variance of a random variable. *Multivariate distributions:* marginal distributions, independence. *Central limit theorem. Estimation:* maximum likelihood, moment estimators. *Confidence intervals:* for mean and variance of sample, difference between sample means, ratio of variances between two samples, approximate confidence intervals. *Hypothesis testing:* mean and variance of a population, inference for two populations, X^2 tests. *Correlation. Simple linear regression.*

9348 COMPUTER PROGRAMMING WITH APPLICATIONS IN ENGINEERING SCIENCE

4TH SEMESTER
CORE PROGR.

Operating system: Introduction to UNIX like systems: System commands, utilities, redirection, piping, filters. Text processing commands. Shell scripting, text editor, plotting. Programming language: Introduction to Fortran, program structure. Compiler, optimization, profiling, debugging. Particle kinematics in 2 and 3 dimensions: Programming, data analysis, plotting. Error analysis and control, instabilities. Applications: Motion in the gravitational field of earth, magnetic field, harmonic oscillator, planet motion. Diffusion equation with and without source term in one and two dimensions: Solution in one and two dimensions, Courant number, finite differences, stenci. Solution in two dimensions in the presence of a source. Electrostatics: Field and equipotential lines of the electric field of a planar distribution of point charges. Solution of Laplace and Poisson equation on the plane. Calculation of trajectories, equilibrium and oscillating solutions in simple problems of neurostimulation: Lorentz equation. Parameter continuation for tracing solution diagrams. Phase diagrams. Simple Fitzhugh dynamic model for neurostimulation. Integration in time. Construction of solution diagrams. Calculation and plotting of the many particle system motion under the influence of coupled fields: Molecular dynamics on the plane, Verlet algorithm, boundary conditions. Plotting the motion. Equilibration, conserved quantities, position/velocity distribution. Accuracy of the solution. Molecular potentials: Hard sphere, Van der Waals and Lennard-Jones potentials. Logistic Equation: Programming for determining and visualizing the trajectory of the logistic equation. Attractors, fixed points, computation of solutions using iterative contraction maps (Newton-Raphson), bifurcating solutions. Period doubling, chaotic behaviour.

9349 MATHEMATICAL STATISTICS

6TH SEMESTER
APPLIED MATHEMATICS
COURSE

Statistics: sampling distributions, sufficiency, completeness, efficiency and consistency. *Exponential families. Estimators:* unbiasedness, minimum variance unbiased estimators and their construction, Rao-Blackwell theorem, Fisher information, Cramer-Rao inequality. *Methods of estimation:* Methods of moments, maximum likelihood and Bayesian estimation. Asymptotic properties of estimators.

Construction of confidence intervals. Hypothesis testing: likelihood ratio tests, Wald tests, score tests. *Linear regression:* simple and general linear regression. *Analysis of variance* with one and two factors.

9350 | PARTIAL DIFFERENTIAL EQUATIONS | 6TH SEMESTER APPLIED MATHEMATICS COURSE

Partial Differential Equations of first order: The quasi linear differential equation of first order, Cauchy problem, existence and uniqueness of the solution. Initial value problems. ◆ *Laplace equation*: Harmonic functions, the maximum principle, on the issue of uniqueness of the Dirichlet and Newmann boundary value problems. ◆ *Introduction to the theory of generalized functions*: Distrbutions stemmed from integrable functions, Dirac and Heaviside functions, generalized derivatives. ◆ *Integral representations of the solution of Laplace equation*: Fundamental solution of Laplace equation, Green's function, the method of images for the half-space, discs and spheres. ◆ *The wave equation*: Plane and spherical waves, Initial-boundary value problems, the characteristic cone and energy theorems, the spherical means method and the Huygens principle. ◆ *The heat equation*: The initial value problem. The maximum principle. Uniqueness and regularization of the solution. Integral representation of the solution. Initial-boundary value problem.

9351 | SURVEY SAMPLING | 7TH SEMESTER APPLIED MATHEMATICS COURSE

Introduction: sampling errors, questionnaires. *Sample survey design*: simple random sampling, stratified sampling, systematic sampling, cluster sampling, single stage and multistage sampling. *Estimation*: mean, total, proportion, ratio, variance, ratio estimators, regression estimators. *Confidence intervals. Sample size*: sample size determination, optimal allocation. *Other sampling techniques*: probability sampling.

9352 | ECONOMETRICS | 8TH SEMESTER APPLIED MATHEMATICS COURSE

The module will not be offered in the curriculum of the academic year 2012-13

9353 | SYSTEM RELIABILITY | 8TH SEMESTER APPLIED MATHEMATICS COURSE

Fixed time system reliability: structure of systems, reliability block diagrams, systems of independent components, reliability via inclusion/exclusion, system reliability bounds; Time dependent component/system reliability, Lifetime Distributions: failure rate and expected lifetime of a component/system, residual lifetime; Common lifetime distributions: exponential, Weibull, Gamma/Erlang, lognormal; Aging properties of components/systems: aging models, properties and reliability bounds, aging properties of monotone systems; Repair/maintenance policies: introduction to renewal theory, age-based component replacement, component repair vs replacement; Optimal repair/maintenance policies: replacement and inspection policies.

9354 | BIOMECHANICS OF THE MUSCULOSKELETAL SYSTEM | 8TH SEMESTER APPLIED MATHEMATICS COURSE

Introduction: Scope of the course. History and elements of anatomy, kinematics of the joints. *Hard and soft tissues* of the musculoskeletal system. Biomechanical properties of the the soft tissues. Composition and structure *ligament, tendon, muscle*. Myosin-actin system, neural excitation, titanic force. Macromolecular mechanical properties, *elastic response* at large deformations, *viscoelastic properties*. Composition and structure of *articular cartilage* of the joints. General mechanical properties, fatigue, aging, remodeling of the bone. *Compact and spongy bone*. Biomechanical models of mechanical behavior of the bone. Elements of mechanics of achievements. Biomechanics of the joints: *Kinematics of the joints*, knee joint, hip joint, elbow joint, carpal joints. Elements of kinematics of gate.

Laboratory demonstration: Experimental determination of the stiffness of bovine spongy bone.

Seminar: Applications of biomechanics in the clinical practice.

9355	COMPLEX ANALYSIS	8TH SEMESTER APPLIED MATHEMATICS COURSE

Cauchy's Theorem. Complex integration. Cauchy's theorem on Complex numbers. Algebra of complex numbers, stereographic projection, topology of *C*, sequences of complex numbers. Analytic functions. Derivate of a complex function, Cauchy-Riemann equations, harmonic and conjugate harmonic function, Elementary functions. The exponential function, trigonometric functions and their inverses, complex logarithm. Complex integration. Cauchy's theorem and applications. Liouville theorem, maximum principle Lemma Schwarz-Series. Series of analytic functions, power series. Taylor's theorem. Laurent series and residues. Classification of singular points, residue theorem and application. The argument principle and Rouche's theorem Meromorphic functions, theorem of Mittas-Loftler. Harmonic functions, basic properties of harmonic functions, Poison integral type. Conformal mapping. Mobius transformations. Riemann mapping theorem. The Schwarz- Christoffel transformation. Applications of the conformal mapping

9356	HISTORY OF PHYSICS, 19TH AND 20TH CENTURY	8TH SEMESTER APPLIED MATHEMATICS COURSE

For the description see module with code 9170 (Applied Mathematics Course)

9357	ECONOMIC ANALYSIS IV	8TH SEMESTER APPLIED MATHEMATICS COURSE

1. *The multidate stochastic model of security markets.* Information partitions, event-tree, financial contracts, price vectors, portfolios, payoff equations, payoff subspace, budget sets, arbitrage and absence of arbitrage. 2. *The efficient markets' hypothesis in the event-tree model* Elements of measure and probability theory, conditional expectation and martingales, market efficiency and absence of arbitrage, pricing. 3. *The binomial model* The binomial model, description of the state space, risk–neutral measure, European and American options, pricing , replication. 4. *Derivatives in the event-tree model* European, American, exotic options and pricing. 5. *Futures and swaps*

9358	GENERAL RELATIVITY – COSMOLOGY	8TH SEMESTER APPLIED PHYSICS COURSE

General Realtivity: Equivalence Principle. Inertial observers in curved spacetime. Geodesic. Spacetime close to spherical mass. Parallel transfer and covariant derivatives, Riemann curvature tensor. Black holes. Mass-Energy tensor. *Cosmology*: Robertson-Walker metric. Red shift. Hubble expansion. Cosmological models. Inflation scenario. Background radiation. Equations in the interior of stars. Gravity waves

9359	BIOMECHANICS OF THE MUSCULOSKELETAL SYSTEM	8TH SEMESTER APPLIED PHYSICS COURSE

For the description see module with code 9354 (Applied Mathematics Course)

9360	ECONOMIC ANALYSIS IV	8TH SEMESTER APPLIED PHYSICS COURSE

For the description see course with code 9357 (Applied Mathematics Course)

9361	INTRODUCTION TO PHYSICS AND TECHNOLOGY OF THE CONTROLLED THERMONUCLEAR FUSION	8TH SEMESTER APPLIED PHYSICS COURSE

Introduction to the physics and technology of controlled nuclear fusion. Dynamics of electrons and ions in electromagnetic fields. Static and variable fields. Basic properties of the plasma. Debye length. Plasma frequency. Discrete plasma. Thermodynamical aspects of the plasma. Coulomb collisions. Characteristic times for thermalization. Introduction to fusion nuclear reactions of light nuclei. Prospects of applications in power plants. Basic structure of reactors for nuclear fusion. Present situation, ITER and DEMO. Magnetic topology for plasma retention, Stellarator, Tokamak, magnetic mirrors. Topologies of the Tokamak type. Electron and ion flow and drifting in such topologies. Models for the description of magnetically constrained plasma. Introduction to the kinetical analysis. Description of the fluid medium. Magnetohydrodynamics.

9362	CONTINUOUS GROUPS	6TH SEMESTER APPLIED PHYSICS COURSE

Introduction to Lie groups and Cartan's classification. Applications in Physics:

Classical Physics: Rotation groups in classical Mechanics. Central forces problems analyzed by group theory methods (Kepler's problem). Theory of special relativity and Lorentz and Poincare groups.

Quantum Mechanics: Solutions of simple quantum mechanical system by group theory methods. Harmonic oscillator, hydrogen atom, interactions of particles with spin in magnetic fields.

Elementary Particle's Theory: Gauge theories and the Standard Model.