Learning Outcomes based Curriculum Framework
(LOCF)

For

M.Sc. (Mathematics)
Postgraduate Programme

Syllabus

Department of Mathematics
Chaudhary Devi Lal University
Sirsa-125055

2021

(Prof. Aseem Miglani) Chairperson

(Prof. Neelam Kumari) Associate Prof.

(Mr. Sandeep Kumar) Assistant Prof.

Duly approved by staff council in its meeting held on 18-06-201 and PGBOS&R in its meeting held on 18-06-2021

MSc/Maths/9/OEC1
Basic Mathematics

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course objectives: The main objective of this course is to familiarize the students with some of the topics from matrices and determinants, characteristic equation of a matrix, differentiation of standard functions and their use, integration as an inverse of differentiation and its use in finding area under a curve.

Course Outcomes: This course will enable the students to:

1. Understand types of matrices, algebra of matrices, properties of determinants, adjoint of a matrix, inverse of a matrix, solution of a system of linear equations.
2. Know about the Characteristic equation, rank, eigen vectors and eigen values of a matrix.
3. Know about the differentiation of standard functions, derivatives of higher order and their use in finding maxima and minima of certain functions.
4. Find Integration as an inverse of differentiation summation, area under a curve, indefinite integrals of standard form, reduction formulae.

Unit: 1.
Matrices & Determinants: Definition of a matrix. Types of matrices; Algebra of matrices; Properties of determinants; Calculation of values of determinants upto third order, Adjoint of a matrix, elementary row or column operations; Finding inverse of a matrix through adjoint and elementary row or column operations. Solution of a system of linear equations.

Unit: 2.
Matrices & Determinants: Characteristic equation, Statement of Cayley Hamilton theorem. Rank of matrix, Eigen vectors and eigen values using matrices, Diagonalization, similarity transformation of matrices.

Unit: 3.
Differential Calculus: Differentiation of standard functions, theorems relating to the derivative of the sum, difference, product and quotient of functions, derivative of trigonometric functions, inverse trigonometric functions, logarithmic functions and exponential functions, differentiation of implicit functions, logarithmic differentiation, derivative of functions, expressed in parametric form, derivatives of higher order. (Only formulae to be given and applications to be emphasized).Maxima and minima.

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Unit: 4.

Integral Calculus:

Integration as an inverse of differentiation summation, area under a curve, indefinite integrals of standard form, method of substitution, method of partial fractions, integration by parts, definite integrals, reduction formulae, definite integrals of limit of sum and geometrical interpretation.

Recommended Books:

1. Seymour Lipschutz; Linear Algebra, Schaum's series publications.
2. Santi Narayan; Differential Calculus.
3. Santi Narayan; Integral Calculus.

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MSc/Maths/9/OEC2
Descriptive Statistics

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course objectives: This course has been designed to introduce basic knowledge of various types of data collection, classification. The students will come to learn measures of central tendency i.e. mean, median, mode, geometric mean, harmonic mean. Learn about measures of dispersion i.e. mean deviation, standard deviation. Learn about moments, correlation, types of correlation, scatter diagram, Karl Pearson Coefficient of correlation and rank correlation coefficient.

Course outcomes: This course will enable the students to:
1. Learn about collection, classification and tabulation of data, histogram, frequency polygon, frequency curve and ogives.
2. Know about measure of central tendency: mean, median, mode etc.
3. Learn about measures of dispersion: absolute and relative measures of range, quartile deviation, mean deviation, standard deviation, coefficient of variation.
4. Know about moments, skewness and kurtosis, moments about mean and about any point, effect of change of origin and scale on moments, correlation of bivariate data.

Unit: 1.
Introduction of Statistics, Basic knowledge of various types of data, Collection, classification and tabulation of data. Presentation of data: histograms, frequency polygon, frequency curve and ogives. Stem- and- Leaf and Box plots.

Unit: 2.
Measures of Central Tendency and Location: Mean, median, mode, geometric mean, harmonic mean, partition values.

Unit: 3.
Measures of Dispersion: Absolute and relative measures of range, quartile deviation, mean deviation, standard deviation (σ), coefficient of variation.

Unit: 4
Moments, Skewness and Kurtosis: Moments about mean and about any point and derivation of their relationships, effect of change of origin and scale on moments.
Correlation for Bivariate Data: concept and types of correlation, scatter diagram, Karl Pearson Coefficient (r) of correlation and rank correlation coefficient.

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Recommended Books:

1. A.M. Goon, M.K. Gupta, and B. Das Gupta: Fundamentals of Statistics, Vol-I.
2. S. Bernstein and R. Bernstein, Elements of Statistics, Schaum's outline series, McGraw-Hill.
3. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, 2002.

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MSc/Maths/1/CC1
Abstract Algebra

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The study of a group theory is the one of the main ideas of Mathematics. The aim of this course is to study Sylow theory and some of its applications to groups of smaller orders. An attempt has been made in this course to strike a balance between the different branches of group theory, abelian groups, nilpotent groups, finite groups, infinite groups. A study of modules, submodules, quotient modules, finitely generated modules etc. is also promised in this course. Endomorphism ring of a finite direct sum of modules, Finitely generated modules, Uniform modules, Primary modules.

Course Outcomes: This course will enable the students to:
1. Understand concepts of automorphism, normalize, conjugacy classes, class equation normal series, composition series, alternating group A_n, simplicity of A_n for $n\geq5$, Sylow's theorems and its applications.
2. Learn about commutator subgroup, three subgroup lemma of P.Hall, nilpotent groups, solvable groups, upper and lower central series.
3. Understand concepts of modules, submodules, finitely generated modules, direct sum, R-homomorphism, quotient module, completely reducible modules, free modules, representation of linear mappings and their ranks.
4. Learn about Ascending and descending chains, Noetherian modules and Noetherian rings, Hilbert Basis Theorem, Wedderburn-Artin theorem

Unit: 1.
Automorphisms and Inner automorphisms of a group G. The groups Aut(G) and Inn(G). Automorphism group of a cyclic group.Normalizer and Centralizer of a non-empty subset of a group G. Conjugate elements and conjugacyclasses.Class equation of a finite group G and its applications.Derived group (or a commutator subgroup) of a group G. perfect groups. Simplicity of the Alternating group A_n ($n\geq5$). Zassenhaus'sLemma.Normal and Composition series of a group G. Scheier's refinement theorem.Jordan Holder theorem.Composition series of groups of order p^n and of finite Abeliangroups.Caunchy theorem for finite groups.p-groups.Finite Abeliangroups.Sylow p-subgroups.Sylow'sIst, IInd and IIIrdtheorems.Application of Sylow theorems.

Unit: 2.
Commutatorsidentities.Commutatorsubgroups.Three subgroups Lemma of P.Hall. Central series of a group G. Nilpotent groups. Centre of a nilpotent group. Subgroups and factor

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subgroups of nilpotent groups.Finite nilpotent groups.Upper and lower central series of a group G and their properties.Subgroups of finitely generated nilpotent groups.Sylow-subgroups of nilpotent groups.Solvable groups.Derived series of a group G.

Unit: 3.

Modules, submodules and quotient modules. Module generated by a non-empty subset of an R-module. Finitely generated modules and cyclic modules.Idempotents.Homomorphism of R-modules.Fundamental theorem of homomorphism of R-modules.Direct sum of modules.Endomorphism Simple modules and completely reducible modules (semi-simple modules).Finitely generated free modules. Rank of a finitely generated free module. Submodules of free modules of finite rank over a PID.

Unit: 4.

Noetherianmodules and Noetherian rings.Endomorphism ring of a finite direct sum of modules.Finitely generated modules. Ascending and descending chains of sub modules of an R-module. Ascending and Descending chain conditions (A.C.C. and D.C.C.)..Finitely co-generated modules.Artinian modules and Artinian rings.Nilpotent elements of a ring R. Nil and nilpotent ideals.Hilbert Basis Theorem.Structure theorem for finite Boolean rings.Wedderburn-Artin theorem and its consequences.Uniform modules.Primary modules.

Recommended Books:

1. I.S. Luthar and I.B.S. Passi; Algebra Vol. 1 Groups (Narosa publication House)
2. P.B. Bhattacharya S.R. Jain and S.R. Nagpal; Basic Abstract Algebra
3. I.D. Macdonald; Theory of Groups
4. VivekSahai and Vikas Bist; Algebra (Narosa publication House)
5. Surjit Singh and QuaziZameeruddin; Modern Algebra (Vikas Publishing House 1990)
6. W.R. Scott; Group Theory.

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MSc/Maths/1/CC2
Real Analysis

Credits: 4 (Lectures: 60) | **Marks: 100**
Duration of exam: 3 Hrs. | **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The course aims to familiarize the learner with Riemann-Stieltjes integral, uniform convergence of sequences and series of functions, functions of several variables and power series.

Course Outcomes: This course will enable the students to:

1. Understand the concept of Riemann-Stieltjes integral along its properties; integration of vector-valued functions with application to rectifiable curves.
2. To know about convergence of sequences and series of functions; construct a continuous nowhere-differentiable function; demonstrate understanding of the statement and proof of Weierstrass approximation theorem.
3. Understand differentiability and continuity of functions of several variables and their relation to partial derivatives; apply the knowledge to prove inverse function theorem and implicit function theorem.
4. Learn about the concepts of power Series, Abel's theorem, Tauber's theorem, Taylor's theorem, exponential & logarithmic functions, trigonometric functions, Fourier series and Gamma function.

Unit: 1.

Definition and existence of Riemann Stieltjes integral, properties of the integral, reduction of Riemann Stieltjes integral to ordinary Riemann integral, change of variable, integration and differentiation, the fundamental theorem of integral calculus, integration by parts, first and second mean value theorems for Riemann Stieltjes integrals, integration of vector-valued functions, rectifiable curves. (Scope as in Chapter 6 of 'Principles of Mathematical Analysis' by Walter Rudin, Third Edition).

Unit: 2.

Sequences and series of functions : Pointwise and uniform convergence of sequences of functions, Cauchy criterion for uniform convergence, Dini's theorem, uniform convergence and continuity, uniform convergence and Riemann integration, uniform convergence and differentiation, convergence and uniform convergence of series of functions, Weierstrass M-test, integration and differentiation of series of functions, existence of a continuous nowhere differentiable function, the Weierstrass approximation theorem, the Arzela theorem on equicontinuous families. (Scope as in Chapter 9 (except 9.6) & Chapter 10 (except 10.3) of 'Methods of Real Analysis' by R.R. Goldberg).

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Unit: 3.

Functions of several variables : Linear transformations, the space of linear transformations on R^n to R^m as a metric space, open sets, continuity, derivative in an open subset of R^n, chain rule, partial derivatives, directional derivatives, continuously differentiable mappings, necessary and sufficient conditions for a mapping to be continuously differentiable, contractions, the contraction principle (fixed point theorem), the inverse function theorem, the implicit function theorem. (Scope as in relevant portions of Chapter 9 of 'Principles of Mathematical Analysis' by Walter Rudin, Third Edition)

Unit: 4.

Power Series : Uniqueness theorem for power series, Abel's and Tauber's theorem, Taylor's theorem, Exponential & Logarithmic functions, trigonometric functions, Fourier series, Gamma function (Scope as in relevant portions of Chapter 8 of 'Principles of Mathematical Analysis' by Walter Rudin, Third Edition).

Recommended Books:

1. Walter Rudin; Principles of Mathematical Analysis (3rd Edition) McGraw-Hill, 1976.
2. R.R. Goldberg; Methods of Real Analysis, Oxford and IHB Publishing Company, New Delhi, 1970
3. T.M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1985
4. Gabriel Klambauer, Mathematical Analysis, Marcel Dekkar, Inc. New York, 1975
5. A.J. White, Real Analysis; an introduction. Addison-Wesley Publishing Co., Inc., 1968
6. E. Hewitt and K. Stromberg. Real and Abstract Analysis, Berlin, Springer, 1969
7. Serge Lang, Analysis I & II, Addison-Wesley Publishing Company Inc., 1969
8. S.C. Malik and Savita Arora, Mathematical Analysis, New Age International Limited, New Delhi,4th Edition 2010
9. D. Somasundaram and B. Choudhary: A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi, 1997.

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MSc/Maths/1/CC3
Mechanics

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: Analytical mechanics deals with motion of a system as a whole not as individual particles and takes in to account the constraints of the system to solve problems.This course let the students to understand basic concepts of analytical mechanics, degrees of freedom, generalized coordinates, Lagrangian mechanics, Hamiltonian mechanics, principles of least action and Hamilton-Jacobi theory.

Course Outcomes: This course will enable the students to:

1. Understand moments and products of inertia, kinetic energy of a rigid rotating body and general motion of a rigid body.
2. Learn about three dimensional rigid body dynamics, generalized coordinates, Lagrange's equations.
3. Understand Hamiltonian, Hamilton's variable, Hamilton's principle and Jacobi equations.
4. Understand concepts of Canonical transformations and Hamilton Jacobi equation.

Unit: 1.
Moments and products of Inertia, Angular momentum of a rigid body, principal axis and principal moment of inertia of a rigid body, Kinetic energy of a rigid body rotating about a fixed point, Momental ellipsoid and equimomental systems, coplanar mass distributions, general motion of a rigid body.

Unit: 2.
Free and constrained systems, constraints and their classification.Generalized coordinates.Holonomic and Non-Holonomic systems.Scleronomic and Rheonomic systems.Generalized Potential, Possible and virtual displacements, ideal constraints. Lagrange's equations of first kind, Principle of virtual displacements D'Alembert's principle, Holonomic Systems independent coordinates, generalized forces, Lagrange's equations of second kind. Uniqueness of solution.Theorem on variation of total Energy.Potential, Gyroscopic and dissipative forces, Lagrange's equations for potential forces equation for conservative fields.

Unit: 3.

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Hamilton's variables.Donkin's theorem.Hamilton canonical equations.Routh's equations. Cyclic coordinates Poisson's Bracket. Poisson's Identity.Jacobi-Poisson theorem.Hamilton's Principle, second form of Hamilton's principle.Poincare-Carton integral invariant.Whittaker's equations.Jacobi's equations. Principle of least action

Unit: 4.
Canonical transformations, free canonical transformations, Hamilton-Jacobi equation.Jacobi theorem.Method of separation of variables for solving Hamilton-Jacobi equation.Testing the Canonical character of a transformation. Lagrange brackets. Condition of canonical character of a transformation in terms of Lagrange brackets and Poisson brackets.Simplicial nature of the Jacobian matrix of a canonical transformations. Invariance of Lagrange brackets and Poisson brackets under canonical transformations.

Recommended Books:

1. F. Gantmacher; Lectures in Analytic Mechanics, Khosla Publishing House, New Delhi.
2. H. Goldstein; Classical Mechanics (2nd edition), Narosa Publishing House, New Delhi.
3. F. Chorlton; A Text Book of Dynamics, CBS Publishers & Dist., New Delhi.
4. Francis B. Hilderbrand; Methods of applied mathematics , Prentice Hall.
5. Narayan Chandra Rana&PramodSharad Chandra Joag; Classical Mechanics, Tata McGraw Hill, 1991.
6. Louis N. Hand and Janet D. Finch; Analytical Mechanics, Cambridge University Press, 1998.

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MSc/Maths/1/CC4
Complex Analysis

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course objectives: One objective of this course is to develop the parts of the theory that are prominent in applications of the complex numbers. Other objective is to furnish an introduction to applications of residues. With regard to residues, special emphasis is given to their use in evaluating real improper integrals.

Course outcomes: This course will enable the students to:

1. Understand the concepts of differentiation and integration for functions defined over a complex plane in different regions and domains along with the fundamental results.
2. Learn about various formulae through the relevant theorems which form the base of complex analysis.
3. Understand various complex variable functions, transformations and series representation of complex functions.
4. Understand the concept of singularities, residues, poles and apply the results to solve the improper integrals.

Unit: 1.

Analytic functions, Harmonic functions, Path in a region, Smooth path, p. w. smooth path, Contour, Simply connected region, Multiply connected region, Complex integration, Antiderivatives, Cauchy-Goursat theorem, Cauchy-Goursat theorem for simply connected and multiply connected domains.

Unit: 2.

Cauchy integral formula, Extension of Cauchy integral formula for multiply connected domain, Higher order derivatives of Cauchy integral formula, Morera's theorem, Liouville's theorem, Fundamental theorem of algebra, Cauchy inequality, Maximum modulus principle, Gauss mean value theorem, Poisson integral formula.

Unit: 3.

Branches of many valued functions with special reference to arg z, Log z, z^a,Bilinear transformations, Their Properties and classification, Definition and examples of Conformal mapping.

Taylor series, Laurent series, Power series and its convergence, Radius of convergence, Sum of power series, Differentiability of sum function of power series.

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Unit: 4.

Singularity and its classification, Residues, Cauchy residue theorem, Residues at poles, Zeros of analytic functions, Cassorati-Weierstrass theorem, Evaluation of improper integrals, Meromorphic functions, The Argument principle, Rouche's theorem.

Recommended Books:

1. J. W. Brown and R. V. ChurchilI; Complex Variables and Applications, McGraw HilI, 1996.
2. J. B. Conway; Functions of one Complex variable, Springer-Verlag, International student-Edition, Narosa Publishing House, 1980.
3. L. V. Ahlfors; Complex Analysis, McGraw-Hill, 1979.
4. Mark J. Ablowitz and A. S. Fokas; Complex Variables: Introduction and Applications, Cambridge University Press, South Asian Edition, 1998.
5. S. Ponnusamy; Foundations of Complex Analysis, Narosa Publishing House, 1997.
6. H. A. Priestly; Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.

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MSc/Maths/1/CC5
Ordinary Differential Equations

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The objectives of this course are to study the existence and uniqueness theory of solutions of initial value problems, to familiarize with linear differential equation of order n and its solutions to studyWronskian theory, Fundamental set in detail, to understand Linear second order equations, the Sturm theory and boundary value problems in detail. The aim of the course is to form a strong foundation in the theory of ordinary differential equations and to learn to apply towards problem solving.

Course Outcomes: This course will enable the students to:

1. Understand concepts of an initial value problem and its exact and approximate solutions, existence of solutions, uniqueness of solutions and continuation of solutions of an initial value problem of order one. Apply the knowledge to prove specified theorems and to solve relevant exercises
2. Learn about Linear differential equation (LDE) of order n, Linear dependence and linear independence of solutions. Wronskian theory, Fundamental set. Non-homogeneous LDE. Theory of Adjoint equations and standard theorems related to these topics.
3. Have deep understanding of theory of Linear second order equations.Sturm theory and related basic theorems. Oscillatory and non-oscillatory equations.
4. Understand Second order linear, nonlinear, regular and singular boundary value problems(BVP), Sturm-Liouville BVP,eigen values and eigen functions and related theorems, Green's function and its applications for solving boundary value problemsso as to be able to develop research aptitude in this area.

Unit: 1.

Preliminaries: Initial value problem and equivalent integral equation, ε-approximate solution, equicontinuous set of functions. Basic theorems: Ascoli- Arzela theorem, Cauchy–Peano existence theorem and its corollary. Gronwall's inequality.

Lipschitz condition. Picard-Lindelöf existence and uniqueness theorem for $\frac{dy}{dt} = f(t, y)$. Solution of initial value problem by Picard's method.

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Unit: 2.

Higher order equations: Linear differential equation (LDE) of order n; Linear combinations, Linear dependence and linear independence of solutions. Wronskian theory: Definition, necessary and sufficient condition for linear dependence and linear independence of solutions of homogeneous LDE. Abel's Identity, Fundamental set.Reduction of order.

Non-homogeneous LDE.Variation of parameters.Adjoint equations, Lagrange's Identity, Green's formula.Linear equation of order n with constant coefficients.

Unit: 3.

Linear second order equations: Preliminaries, self adjoint equation of second order, basic facts. Superposition Principle.Riccati's equation.Prüffer transformation. Zero of a solution. Abel's formula.Common zeros of solutions and their linear dependence.

Sturm theory: Sturm separation theorem, Sturm fundamental comparison theorem and their corollaries. Oscillatory and non-oscillatory equations.

Unit: 4.

Second order boundary value problems(BVP): Linear problems; periodic boundary conditions, regular linear BVP, singular linear BVP; non-linear BVP. Sturm-Liouville BVP: definitions, eigen values and eigen functions. Orthogonality of functions, orthogonality of eigen functions corresponding to distinct eigen values. Green's function. Applications of Green's function for solving boundary value problems.

Recommended books:

1 E.A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, Tata McGraw-Hill, 2000
2 S.L. Ross, Differential Equations, John Wiley & Sons
3 P. Hartman, Ordinary Differential Equations, John Wiley & Sons NY, 1971.
4 G. Birkhoff and G.C. Rota, Ordinary Differential Equations, John Wiley & Sons, 1978.
5 G.F. Simmons, Differential Equations, Tata McGraw-Hill, 1993.
6 I.G. Petrovski, Ordinary Differential Equations, Prentice-Hall, 1966.
7 D. Somasundaram, Ordinary Differential Equations, A first Course, Narosa Pub., 2001.
8 Mohan C Joshi, Ordinary Differential Equations, Modern Perspective, Narosa Publishing House, 2006

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MSc/Maths/1/SEC1
Computer Programming in ANSI C
(Practical)

Credits: 2 (Hours: 60) **Marks: 50**
Duration of exam: 3 Hrs.

Note for the practical examiner: The examiner will set 4 questions at the time of practical examination. The examinee will be required to write two programs and execute one program successfully. The evaluation will be done on the basis of practical record, viva-voce, written exam and execution of the program.

Course objectives: This is a laboratory course and objective of this course is to acquaint the students with the practical use and to train for writing programme codes in ANSI-C for solving various mathematical problems.

Course Outcomes: This course will enable the students to:

1. Know the syntax of expressions, statements, structures and to write source code for a program in C.
2. Edit, compile, Debug, verify/check and execute the source program for practical problems to get the desired results.

Computing lab work will be based on programming in ANSI-C for computing various mathematical problems. There will be 12-15 problems/ programmes during the semester.

Recommended Books:

1. Y. Kanitkar; Let us C – Computer science series, Infinity Science Press.
2. E. Balagurusamy; Programming in ANSI-C, Mc-Graw Hill Publication.

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MSc/Maths/2/CC6
Advanced Abstract Algebra

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: As suggested by the name of the course itself, some of the advanced topics of abstract algebra will be taught to the students in this course including field extensions, finite fields, normal extensions, finite normal extensions as splitting fields. A study of Galois extensions, Galois groups of polynomials, Galois radical extensions shall also be made. Similar linear transformations, Nilpotent transformations and related topics are also included in the course.

Course Outcomes: This course will enable the students to:

1. Understand concepts of Characteristic of a ring with unity, field extension, algebraic and transcendental extension, algebraically closed field, splitting fields.
2. Have deep understanding of Finite fields. Roots of unity. Cyclotomic polynomials and their irreducibility over Q. Normal extension, multiple roots and separable extension.
3. Learn about automorphism of fields, fundamental theorem of Galois theory, roots of unity, Construction with ruler and compass.
4. Have understanding of similar linear transformations. Invariant subspaces of vector spaces. Reduction of a linear transformation to triangular form, Primary decomposition theorem. Jordan blocks and Jordan canonical forms. Cyclic module relative to a linear transformation

Unit: 1.

Characteristic of a ring with unity.Prime fields Z/pZ and Q. Characterization of prime fields.Fieldextensions.Degree of an extension.Algebraic and transcendental elements.Simple field extensions.Minimal polynomial of an algebraic element. Conjugate elements. Algebraic extensions.Finitely generated algebraic extensions. Algebraic closure and algebraically closed fields. Splitting fields.

Unit: 2.

Finite fields.Roots of unity, Cyclotomic polynomials and their irreducibility over Q. Normal extensions.Finite normal extensions as Splitting fields.Separable elements, separable polynomials and separable extensions.Perfect fields.
(Scope of the course as given in the book at Sr. No. 2).

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Unit: 3.

Galois extensions. Galois theory, Automorphism of fields. Fundamental theorem of Galois theory. Klein's 4-group and Diheadral group. Galois groups of polynomials. Fundamental theorem of Algebra. Radicals extensions. Galois radical extensions. Cyclic extensions. Solvability of polynomials by radicals over Q. Construction with ruler and compass only. (Scope of the course as given in the book at Sr. No. 2).

Unit: 4.

Similar linear transformations. Invariant subspaces of vector spaces. Reduction of a linear transformation to triangular form.Nilpotent transformations.Index of nilpotency of a nilpotent transformation.Cyclic subspace with respect to a nilpotent transformation.Uniqueness of the invariants of a nilpotent transformation.Primary decomposition theorem.Jordan blocks and Jordan canonical forms.Cyclic module relative to a linear transformation.(Sections 6.4 to 6.7 of Topics in Algebra by I.N. Herstein).

Recommended Books:

1 I.N. Herstein; Topics in Algebra (Wiley Eastern Ltd.)
2 P.B. Bhattacharya S.R. Jain and S.R. Nagpal; Basic Abstract Algebra, (Cambridge University Press 1995)
3 VivekSahai and VikasBist; Algebra (Narosa publication House)
4 Surjit Singh and QuaziZameeruddin; Modern Algebra (Vikas Publishing House 1990)
5 Patrick Morandi; Field and Galois Theory (Springer 1996).

(Prof. Aseem Miglani)
Chairperson

(Prof. Neelam Kumari)
Associate Prof.

(Mr. Sandeep Kumar)
Assistant Prof.

MSc/Maths/2/CC7
Measure and Integration theory

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The main objective is to familiarize with Lebesgue outer measure, measurable sets, measurable functions, Lebesgue integration, fundamental integral convergence theorems, functions of bounded variation, differentiation of an integral and absolutely continuous functions.

Course Outcomes: This course will enable the students to:

1. Understand the concepts of measurable sets and Lebesgue measure,Borel sets and their measurability, construct a non-measurable set.
2. Know about Lebesgue measurable functions and their properties; and apply the knowledge to prove Egoroff's theorem, Lusin's theorem and F.Riesz theorem.
3. Understand the requirement and the concept of the Lebesgue integral (as a generalization of the Riemann integration) along its properties and demonstrate understanding of the statement and proofs of the fundamental integral convergence theorems.
4. Know about the concepts of differentiation of monotonic function, functions of bounded variations, differentiation of an integral and absolutely continuous functions.

Unit: 1.
Lebesgue outer measure, elementary properties of outer measure, Measurable sets and their properties, Lebesgue measure of sets of real numbers, algebra of measurable sets, Borel sets and their measurability, characterization of measurable sets in terms of open, closed, F_σ and G_δ sets, existence of a non-measurable set.

Unit: 2.
Lebesgue measurable functions and their properties, the almost everywhere concept , characteristic functions, simple functions, approximation of measurable functions by sequences of simple functions, measurable functions as nearly continuous functions. Lusin's theorem, almost uniform convergence, Egoroff's theorem, convergence in measure, F. Riesz theorem that every sequence which is convergent in measure has an almost everywhere convergent subsequence.

Unit: 3.
The Lebesgue Integral: Shortcomings of Riemann integral, Lebesgue integral of a bounded function over a set of finite measure and its properties, Lebsegue integral as a generalization

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Chairperson Associate Prof. Assistant Prof.

of the Riemann integral, Bounded convergence theorem, Lebesgue theorem regarding points of discontinuities of Riemann integrable functions.

Integral of a non negative function, Fatou's lemma, Monotone convergence theorem, the general Lebesgue integral, Lebesgue convergence theorem.

Unit: 4.

Differentiation and Integration: Differentiation of monotone functions, Vitali's covering lemma,Lebesgue differentiation theorem, functions of bounded variation and their representation as difference of monotone functions. Differentiation of an integral, absolutely continuous functions.

Recommended Books:

1. H. L. Royden , Real Analysis, 3rd Edition Prentice Hall of India, 1999.
2. G.de Barra, Measure theory and integration, Willey Eastern Ltd., 1981.
3. P.R. Halmos, Measure Theory, Van Nostrans, Princeton, 1950.
4. I.P. Natanson, Theory of functions of a real variable, Vol. I, Frederick Ungar Publishing Co., 1961.
5. R.G. Bartle, The elements of integration, John Wiley & Sons, Inc.New York, 1966.
6. K.R. Parthsarthy, Introduction to Probability and measure, Macmillan Company of India Ltd., Delhi, 1977.
7. P.K. Jain and V.P. Gupta, Lebesgue measure and integration, New age International (P) Ltd., Publishers, New Delhi, 1986.

(Prof. Aseem Miglani)
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Assistant Prof.

MSc/Maths/2/CC8
Mechanics of Solids

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: In this course, basic theory of mechanics of solids is introduced. First, the laws of transformations and tensors willbe introduced. Mathematical theory of deformations, analysis of strain and analysis of stress in elastic solids will be learnt next. A student will also learn basic equations of elasticity. In this course, the students will be exposed to the mathematical theory of elasticity and other techniques which find applications in areas of civil and mechanical engineering and Earth and material sciences. This course will expose a student to Applied Mathematics and will form a sound basis for doing research in the number of areas involving solid mechanics.

Course Outcomes: This course will enable the students to:

1. Understand the concept of tensors as a generalized form of directional entities and to explore their properties through the operations of algebra and calculus.
2. Understand the affine transformation, infinitesimal deformation, analysis of strain and stress tensors.
3. Learn about equations of equilibrium, examples of stress, about homogeneous isotropic elastic medium and anisotropic symmetries.
4. Learn about elastic constants, dynamical equations for an isotropic elastic media, Strain energy function and Saint-Venant's principle.

Unit: 1.
Coordinate-transformation, Cartesian Tensor of different order, Properties of tensors, Isotropic tensors of different orders and relation between them, Symmetric and skew symmetric tensors, Tensor invariants, Eigen-values and eigen-vectors of a tensor.
Scalar, vector, tensor functions, Comma notation, Gradient, divergence and curl of a vector/ tensor field.

Unit: 2.
Affine transformation, Infinitesimal affine deformation, Geometrical Interpretation of the components of strain, Strain quadric of Cauchy, Principal strains and invariants, General infinitesimal deformation, Saint-Venant's equations of compatibility, Stress, Stress Vector, Stress tensor.

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(Prof. Neelam Kumari) Associate Prof.

(Mr. Sandeep Kumar) Assistant Prof.

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Unit: 3.

Equations of equilibrium, Transformation of coordinates, Stress quadric of Cauchy, Principal stresses and invariants, Maximum normal and shear stresses, Mohr's circles, Examples of stress, Generalised Hooks Law, Anisotropic symmetries, Homogeneous isotropic elastic medium.

Unit: 4.

Elastic moduli for isotropic media, Equilibrium and dynamical equations for an isotropic elastic media, Strain energy function and its connection with Hooke's Law, Beltrami-Michell compatibility conditions and equations, Saint- Venant' s principle.

Recommended Books:

1. I.S. Sokolnikoff, Mathematical Theory of Elasticity, Tata-McGraw Hill Publishing Company Ltd., New Delhi, 1977.
2. D.S. Chandrasekharaiah and L. Debnath, Continuum Mechanics, Academic Press, 1994
3. A.E.H. Love, A Treatise on the Mathematical Theory of Elasticity, Dover Publications, New York.
4. Y.C. Fung. Foundations of Solid Mechanics, Prentice Hall, New Delhi, 1965.
5. Shanti Narayan, Text Book of Cartesian Tensors, S. Chand & Co., 1950.
6. S. Timeshenko and N. Goodier, Theory of Elasticity, McGraw Hill, New York, 1970.
7. I.H. Shames, Introduction to Solid Mechanics, Prentice Hall, New Delhi, 1975

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MSc/Maths/2/CC9
System of Differential Equations

Credits: 4 (Lectures: 60) | **Marks: 100**
Duration of exam: 3 Hrs. | **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The objectives of this course are to learn about Linear homogeneous and non-homogeneous differential systems, differential equation of order n and its equivalent system of differential equations, Dependence of solutions on initial conditions and parameters, autonomous systems, critical points, paths of linear and quasi linear systems, stability of linear and quasi linear systems, limit cycles and periodic solutions.

Course Outcomes: This course will enable the students to:

1. Understand linear homogeneous and non-homogeneous differential systems and theory
2. Have good understanding of System of differential equations, Existence theorem for solution of system of differential equations. Dependence of solutions on initial conditions and parameters, and Floquent theory.
3. Know critical points of linear and quasilinear system of differential equations, their types and stability. Apply the gained knowledge to determine type and stability of critical points and check for existence of limit cycles of given systems.
4. Understand stability of linear and quasi-linear systems. Learn to apply Liapunov direct method to determine stability of such systems, Understand about limit cycles, periodic solutions and half-path or semiorbit.

Unit: 1.

Linear differential systems: Definitions and notations. Linear homogeneous systems; Existence and uniqueness theorem. Fundamental set and fundamental matrix of a homogeneous system. Wronskian of a system. Abel-Liouville formula. Adjoint systems, Reduction to smaller homogeneous systems.

Unit: 2

System of differential equations. Differential equation of order n and its equivalent system of differential equations. Existence theorem for solution of system of differential equations. Systems with constant coefficients, method of variation of constants for a non-homogeneous system. Periodic system. Floquet theory for periodic systems.

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Associate Prof.

(Mr. Sandeep Kumar)
Assistant Prof.

Unit: 3.

Autonomous systems: the phase plane, paths and critical points, types of critical points; Node, Center, Saddle point, Spiral point. Stability of critical points. Critical points and paths of linear systems: basic theorems and their applications. Critical points and paths of quasilinear systems.

Unit: 4.

Stability of solution of system of equations with constant coefficients, linear equation with constant coefficients.Liapunov stability.Stability of quasi linear systems.

Limit cycles and periodic solutions: limit cycle, existence and non-existence of limit cycles, Benedixson’s non-existence theorem. Half-path or Semiorbit, Limit set, Poincare-Benedixson theorem (statement only).

Recommended books:

1. E.A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, Tata McGraw-Hill, 2000.
2. S.L. Ross, Differential Equations, John Wiley & Sons
3. S.G. Deo, V. Lakshmikantham and V. Raghavendra, Textbook of Ordinary Differential Equations, Tata McGraw-Hill , 2006.
4. Mohan C Joshi, Ordinary Differential Equations, Modern Perspective, Narosa Publishing House, 2006.
5. P. Hartman, Ordinary Differential Equations, John Wiley & Sons NY, 1971.
6. G. Birkhoff and G.C. Rota, Ordinary Differential Equations, John Wiley & Sons, 1978.
7. G.F. Simmons, Differential Equations, Tata McGraw-Hill , 1993.
8. I.G. Petrovski, Ordinary Differential Equations, Prentice-Hall, 1966.
9. D. Somasundaram, Ordinary Differential Equations, A first Course, Narosa Pub., 2001.

(Prof. Aseem Miglani)
Chairperson

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Assistant Prof.

MSc/Maths/2/DSC1
Methods of Applied Mathematics

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course objectives: The main objective of this course is to familiarize the students with Curvilinear Co-ordinates, areas, volumes and surface areas in Cartesian, Cylindrical and Spherical co-ordinates, Grad, div, Curl, Laplacian in orthogonal Co-ordinates,Hankel transforms and its properties, application of Hankel transform to Boundary Value Problem,Fourier Transform, motivating problems of calculus of variations.

Course Outcomes: This course will enable the students to:

1. Understand Curvilinear Co-ordinates, areas, volumes and surface areas in Cartesian, Cylindrical and spherical co-ordinates.
2. Know about Fourier Transform, its properties. Fourier transform of some elementary functions. Finite Fourier sine transform, finite Fourier cosine transform, Application of Fourier transform to solve ordinary and partial differential equation.
3. Know Hankel transforms and its properties, application of Hankel transform to Boundary Value Problem, relation between Fourier and Hankel transforms,
4. Know about Motivating problems of calculus of variations, fundamental lemma of calculus of variations.

Unit: 1.

Curvilinear Co-ordinates: Co-ordinate transformation, Orthogonal Co-ordinates, Change of Co-ordinates, Cartesian, Cylindrical and spherical co-ordinates, expressions for velocity and accelerations, ds, dv and ds^2 in orthogonal co-ordinates, Areas, Volumes & surface areas in Cartesian, Cylindrical & spherical co-ordinates in a few simple cases, Grad, Div, Curl, Laplacian in orthogonal Co-ordinates, Contravariant and Co-variant components of a vector, Metric coefficients & the volume element.

Unit: 2.

Fourier Transform: Definition and properties, Fourier transform of some elementary functions, Fourier transform of derivatives, Parseval's identity for Fourier transform, evaluation of integrals, convolution theorem, Finite Fourier sine transform, finite Fourier cosine transform, Application of Fourier transform to solve ordinary and partial differential equation.

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Unit: 3.

Hankel transforms, Definition, Elementary properties, Basic operational properties, Inversion theorem, Hankel transform of derivatives and some elementary functions, Relation between Fourier and Hankel transforms, Application of Hankel transform to Boundary Value Problem.

Unit: 4.

Motivating problems of calculus of variations, shortest distance, minimum surface of revolution, Branchistochrone problem, isoperimetric problem, geodesic. Fundamental lemma of calculus of variations, Euler's equation for one dependent function and its generalization to 'n' dependent functions and to higher order derivatives, conditional extremum under geometric constraints and under integral constraints. Ritz, Galerkin and Kantorovich methods.

RecommendedBooks:

1. I. N. Sneddon; The Use of lntegral Transforms.
2. W. W. Bell; Special Functions for Scientists and Engineers.
3. Schaum's Series; Vector Analysis.
4. LokenathDebnath; Integral Transforms and their Applications, CRC Press, Inc.
5. J. M. Gelfand and S. V. Fomin, Calculus of Variations, Prentice Hall, New Jersy, 1963.
6. Weinstock, Calculus of Variations, McGraw Hill.

(Prof. Aseem Miglani)
Chairperson

(Prof. Neelam Kumari)
Associate Prof.

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MSc/Maths/2/DSC2
Differential Geometry

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: Differential geometry is a discipline that uses the techniques of differential calculus, vector calculus and linear algebra to study problems in geometry and the mathematical analysis of curves and surfaces in space is studied in this course. The objective is to learn about curves in space and other related concepts; surfaces, envelopes, developable surfaces; curves on surfaces; and Geodesics.

Course Outcomes: This course will enable the students to:

1. Understand concepts of curves in space and other related concepts like tangent, principal normal, curvature, binormal, torsion, centre of curvature, spherical curvature, involutes, evolutes, Bertrand curves and to solve related problems
2. Understand and distinguish surfaces and their characteristics, developable surfaces, family of surfaces. Demonstrate knowledge to solve related problems of geometry.
3. Learn about curves on surfaces, conjugate systems, asymptotic lines, isometric lines, null lines etc. and minimal curves.
4. Derive equations of Gauss and Codazzi, Mainardi-Codazzi relations and Bonnet's theorem. Understand concepts of geodesics and curves in relation to geodesics and apply knowledge in problem solving.

Unit: 1.

Curves: Tangent, principal normal, curvature, binormal, torsion, Serret-Frenet formulae, locus of center of curvature, spherical curvature, locus of centre of spherical curvature, curve determined by its intrinsic equations, helices, spherical indicatrix of tangent, etc., involutes, evolutes, Bertrand curves.

Unit: 2.

Envelopes and Developable Surface: Surfaces, tangent plane, normal. One parameter family of surfaces; Envelope, characteristics, edge of regression, developable surfaces.Developables associated with a curve; Osculating developable, polar developable, rectifying developable. Two parameter family of surfaces; Envelope, characteristic points and examples.
Curvilinear Coordinates, First order magnitudes, directions on a surface, the normal, second order magnitudes, derivatives of **n**, curvature of normal section, Meunier's theorem.
(Relevant portions from the book '*Differential Geometry of Three Dimensions*' by C.E.Weatherburn)

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Assistant Prof.

Unit: 3.
Curves on a surface : Principal directions and curvatures, first and second curvatures, Euler's theorem, Dupin'sindicatrix, the surface z = f(x, y), surface of revolution. Conjugate systems; conjugate directions, conjugate systems. Asymptotic lines, curvature and torsion. Isometric lines; isometric parameters.Null lines, minimal curves.

Unit: 4.
The equations of Gauss and of Codazzi: Gauss's formulae for $\boldsymbol{r}_{11}, \boldsymbol{r}_{12}, \boldsymbol{r}_{22}$, Gauss characteristic equation, Mainardi-Codazzi relations, alternative expression, Bonnet's theorem, derivatives of the angle ω.
Geodesics: Geodesic property, equations of geodesics, surface of revolution, torsion of a geodesic. Curves in relation to Geodesics; Bonnet's theorem, Joachimsthal's theorems, vector curvature, geodesic curvature, Bonnet's formula.
(Relevant portions from the book '*Differential Geometry of Three Dimensions*' by C.E. Weatherburn)

Recommended Books:

1. C.E. Weatherburn, *Differential Geometry of Three Dimensions,* Radha Publishing House, Calcutta, 1988.
2. John A. Thorpe, *Elementary Topics in Differential Geometry*, Springer Science & Business Media, 1994.
3. B.O. Neill, *Elementary Differential Geometry*, Academic Press, 1997.
4. Erwin Kreyszig, *Differential Geometry*, Dover Publications, 2013.
5. S. Sternberg,*Lectures on Differential Geometry*, Reprinted by AMS, 2016.
6. NirmalaPrakash, *Differential Geometry*, Tata McGraw-Hill Publishing Company Limited, 1992.
7. R.S. Millman and G.D. Parker, Elements of Differential Geometry, Prentice-Hall, 1977.

(Prof. Aseem Miglani)
Chairperson

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Associate Prof.

(Mr. Sandeep Kumar)
Assistant Prof.

MSc/Maths/2/DSC3
Mathematical Modelling

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course objectives: A mathematical model is a description of a system (device or a phenomenon) using mathematical concepts and language. The process of developing a mathematical model is defined as mathematical modelling. A mathematical model may help to explain a system and to study the effects of different components, and to make predictions about the system. During this course, the students will learn basic concepts of mathematical modelling and to construct mathematical models for population dynamics, epidemic spreading, economics, medicine, arm-race, battle, genetics and other areas of physical/life/social sciences. The course also aims to let the students learn mathematical modelling through ordinary/partial differential equations and probability generating function.

Course outcomes: This course will enable the students to:

1. Understand the need/techniques/classification of mathematical modelling through the use of first order ODEs and their qualitative solutions through sketching.
2. Learn to develop mathematical models using systems of ODEs to analyse/predict population growth, epidemic spreading for their significance in economics, medicine, arm-race or battle/war.
3. Attain the skill to develop mathematical models involving linear ODEs of order two or more and difference equations, for their relevance in probability theory, economics, finance, population dynamics and genetics.
4. Develop mathematical models through PDEs for mass-balance, variational principles, probability generating function, traffic flow problems alongwith relevant initial & boundary conditions.

Unit: 1.
Mathematical modeling: need, techniques, classification and illustrative examples; Mathematical modeling through ordinary differential equations of first order; qualitative solutions through sketching.

Unit: 2.
Mathematical modeling in population dynamics, epidemic spreading and compartment models; mathematical modeling through systems of ordinary differential equations; mathematical modeling in economics, medicine, arm-race, battle.

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Unit: 3.

Mathematical modeling through ordinary differential equations of second order. Higher order (linear) models. Mathematical modeling through difference equations: Need, basic theory; mathematical modeling in probability theory, economics, finance, population dynamics and genetics.

Unit: 4.

Mathematical modeling through partial differential equations: simple models, mass-balance equations, variational principles, probability generating function, traffic flow problems, initial & boundary conditions.

(Scope of the syllabus is from relevant portions of Chapters 1 to 6 of the book recommended at Sr. No. 1)

Recommended Books:

1. J.N. Kapur: *Mathematical Modelling*, New Age International Ltd., 1988.
2. M. Adler, *An Introduction to Mathematical Modelling*, HeavenForBooks.Com, 2001.
3. S.M. Moghadas, M.J.-Douraki, *Mathematical Modelling: A Graduate Text Book*, Wiley, 2018.
4. E.A. Bender, *An Introduction to Mathematical Modeling*, Dover Publication, 2000.

(Prof. Aseem Miglani) Chairperson

(Prof. Neelam Kumari) Associate Prof.

(Mr. Sandeep Kumar) Assistant Prof.

MSc/Maths/2/SEC2
Computer Programming in FORTRAN 90 & 95 (Theory)

Credits: 2 (Lectures: 30) **Marks: 50**
Duration of exam: 2 Hrs. **Theory: 30; IA: 20**

Note for the paper setter: The question paper will consist of five questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.

Couse Objectives: The course comprises of theory as well as practical part is designed to train the students in the computer programming. The objective of this course is to develop a skill of writing codes in FORTRAN 90/95 for solving different types of mathematical problems which arise in the areas of Mathematics, Science and Engineering.

Theory Course Outcomes: This course will enable the students to:-

1. Get familiar with the importance and working of FORTRAN 90/95 as computation platform through the knowledge of constants and variables, expressions, implicit declaration, input/output and Format specifications
2. Get familiar with Logical expressions, control flow, conditional flow, Loops. Functions, subroutines, arrays, strings, array arguments.

Unit: 1.
Numerical constants and variables, arithmetic expressions, implicit declaration, named constants, input/output, Format specifications.

Unit: 2.
Logical expressions and control flow; conditional flow; IF structure, Block DO loop Counted controlled Loops. Functions, subroutines, arrays, strings, array arguments. Derived types Processing files.

Recommended Books:

1. V. Rajaraman; Computer Programming in FORTRAN 90 and 95; Printice-Hall of India Pvt. Ltd., New Delhi, 1997.
2. M.Metcalf and J.Reid; FORTRAN 90/95 Explained, OUP, Oxford, UK, 1996.

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MSc/Maths/2/SEC2
Computer Programming in FORTRAN 90 & 95 (Practical)

Credits: 2 (Hours: 60) **Marks: 50**
Duration of exam: 3 Hrs.

Note for the practical examiner: The examiner will set 4 questions at the time of practical examination. The examinee will be required to write two programs and execute one program successfully. The evaluation will be done on the basis of practical record, viva-voce, written exam and execution of the program.

Practical Course Outcomes: This course will enable the students to:

3. Know the syntax of expressions, statements, structures and to write source code for a program in FORTRAN 90 & 95.
4. Edit, compile and execute the source program for desired results.

Computing lab work will be based on programming in FORTRAN 90 & 95 for computing various mathematical problems. There will be 12-15 problems/ programmes during the semester.

Recommended Books:

1. V. Rajaraman; Computer Programming in FORTRAN 90 and 95; Printice-Hall of India Pvt. Ltd., New Delhi, 1997.
2. M. Metcalf and J. Reid; FORTRAN 90/95 Explained, OUP, Oxford, UK, 1996.

(Prof. Aseem Miglani)
Chairperson

(Prof. Neelam Kumari)
Associate Prof.

(Mr. Sandeep Kumar)
Assistant Prof.

MSc/Maths/3/CC10
Topology

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The main objective of this course is to introduce basic properties of topological spaces, basis and sub basis for a topology. Further, to study continuity, homeomorphisms, open and closed maps, product topologies, projections. To study T_0, T_1, T_2, T_3, T_4 and compactness of spaces.

Course Outcomes: This course will enable the students to:

1. Know about topological spaces, understand neighbourhood system of a point and its properties, interior, closure, boundary, limit points of subsets, and base and subbase of topological spaces, first and second countable spaces, separable and Lindelof spaces, continuous functions.
2. Learn about comparison of topologies on a set, characterization of continuous functions,Tychonoff product topology, projection maps.
3. Separation axioms and their properties Urysohn's Lemma, Tietze's extension theorem.
4. Know about connected spaces and their properties, compactness in topological spaces, regularity and normality of a compact Hausdorff space.

Unit: 1.

Definition and examples of topological spaces, Neighborhoods, closed sets, closure, Interior, exterior and boundary of a set, Adherent points and Accumulation points, closure of a set as a set of adherent points, derived sets, properties of closure operator, dense subsets.

Base and sub-base for a topology, Neighbourhood system of a point and its properties, Base for a neighbourhood system, Subspaces and relative topology. First countable, second countable and separable spaces, their relationships and hereditary properties, about countability of a collection of disjoint open sets in a separable and second countable space, Lindelof's theorems.

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Unit: 2.

Comparison of topologies on a set, about intersection, union, infimum and supremum of a collection of topologies on a set, Definition, examples and characterizations of continuous functions, composition of continuous functions, open and closed functions, homeomorphism.

Tychonoff product topology, defining base and sub-base for product topology, projection maps, characterization of product topology as smallest topology with continuous projections, continuity of a function from a space into a product of spaces, countability and product spaces.

Unit: 3.

Separation axioms, T_0 , T_1 , T_2 , Regular, T_3 spaces, their characterization and hereditary properties, productive properties of T_1 and T_2 spaces, completely regular and Tychonoff spaces, their hereditary and productive properties, Normal and T_4 spaces, normality of a regular Lindelof space, Urysohn's lemma, complete regularity of a regular normal space, T_4 implies Tychonoff, Tietze's extension theorem.

Unit: 4.

Connected spaces, separation of a topological space, definition of connectedness in terms of separation, characterization of connectedness, connected subsets and their properties, continuity and connectedness, connectedness and product spaces.

Compactness: definition and examples of compact spaces and subsets, compactness in terms of finite intersection property, continuity and compact sets, compactness and separation properties, closedness of compact subset and a continuous map from a compact space into a Hausdorff and its consequence, regularity and normality of a compact Hausdorff space.

Recommended Books:

1. J. L. Kelly; General Topology, Springer.
2. J. R. Munkers; Topology, Prentice Hall.
3. G. F. Simmons; Introduction to Topology and Modern Analysis, McGraw Hill.

(Prof. Aseem Miglani) Chairperson

(Prof. Neelam Kumari) Associate Prof.

(Mr. Sandeep Kumar) Assistant Prof.

Duly approved by staff council in its meeting held on 18-06-201 and PGBOS&R in its meeting held on 18-06-2021

MSc/Maths/3/CC11
Fluid Mechanics

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: Fluid mechanics is a branch of continuum mechanics which deals with mechanics of fluids (liquids and gases) of ideal and viscous types. Fluid mechanics has a wide range of applications in the areas of mechanical engineering, civil engineering, chemical engineering, geophysics, astrophysics and biology. This course aims to provide basic concepts, laws and theories of fluid dynamics and to prepare a foundation to understand the motion of fluid and develop concepts, models and techniques which enables to solve the two and three dimensional problems of fluid flow and help in advanced studies and research in the broad area of fluid motion.

Course Outcomes: This course will enable the students to:

1. Be familiar with continuum model of fluid flow, classify fluid/flows, Stream, path and streak lines, rotational and irrotational motion. Understand Eulerian and Lagrangian descriptions of fluid motion, law of conservation of mass and boundary surfaces. Attain ability to derive equation of continuity and problem solving.
2. Learn to derive equations of motion, Bernouli equation, vorticity equation corresponding to different problems of fluid dynamics and to solve those equations. Prove theorems on circulation and energy in fluid flow. Make strong foundation for doing research in the area of fluid mechanics and bio-mechanics.
3. Understand motion of sphere in a fluid and fluid flow past a sphere at rest; sources, sinks, doublets and their images. Learn to solve three dimensional flow problems of fluid dynamics.
4. Understand two dimensional flow problems, stream function, axi-symmetric flow, complex potential, source, sink and doublets in two dimensions, Milne-Thomson circle theorem, Blasius theorem. Attain skills to solve fluid flow problems in two dimensions. Get exposure to research problems in fluid dynamics.

Unit: 1

Kinematics - Velocity at a point of a fluid, Eulerian and Lagrangian methods, Stream lines, path lines and streak lines, Velocity potential, Irrotational and rotational motions, Vorticity and circulation, Equation of continuity, Boundary surfaces, Acceleration at a point of a fluid, Components of acceleration in cylindrical and spherical polar co-ordiantes.

Unit: 2

Pressure at a point of a moving fluid, Euler equation of motion, Equations of motion in cylindrical and spherical polar co-ordinates, Bernoulli equation, Impulsive motion, Kelvin circulation theorem, Vorticity equation, Energy equation for incompressible flow, Kinetic energy of irrotational flow, Kelvin minimum energy theorem, Kinetic energy of infinite fluid, Uniqueness theorems.

Unit: 3

Axially symmetric flows, Liquid streaming part a fixed sphere, Motion of a sphere through a liquid at rest at infinity, Equation of motion of a sphere, Kinetic energy generated by impulsive motion, Motion of two concentric spheres, Three-dimensional sources, sinks and doublets, Images of sources, sinks and doublets in rigid impermeable infinite plane and in impermeable spherical surface.

Unit: 4

Two dimensional motion, Use of cylindrical polar co-ordinates, Stream function. Axisymmetric flow, Stoke stream function, Stoke stream function of basic flows, Irrotational motion in two- dimensions, Complex velocity potential, Milne-Thomson circle theorem, Two-dimensional sources, sinks, doublets and their images, Blasius theorem.

Recommended Books:

1. F. Chorlton, Text-book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985.
2. Michael E.O. Neill and F. Chorlton, Ideal and Incompressible Fluid Dynamics, John Wiley & Sons, 1986.
3. S. W. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India Ltd., New Delhi, 1976.
4. G.K. Batchelor, AnIntroduciton to Fluid Mechanics, Foundation Books, New Delhi, 1994.
5. R.K. Rathy. An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi. 1976.
6. W.H. Besant and A.S. Ramsey, A Treatise on Hydromechanics, Part-II, CBS Publishers, Delhi, 1988.

(Prof. Aseem Miglani)
Chairperson

(Prof. Neelam Kumari)
Associate Prof.

(Mr. Sandeep Kumar)
Assistant Prof.

MSc/Maths/3/DSC4
Integral Equations

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The objectives of this course are to learn about integral equations, their classifications. Eigen values and eigen functions, method of successive approximations, resolvent kernel, iterated kernels and Neumann series in case of Fredholm and Volterra integral equations, solution of singular, Cauchy and Hilbert integral equation, Green function, reduction of a boundary value problem to a Fredholm integral equation with kernel as Green function.

Course outcomes: This course will enable the students to:

1. Understand the concept of integral equations, to classify them and to apply the eigen-system method for solving the Fredholm type with separable kernel. Eigen values and eigen functions, method of successive approximations, resolvent kernel, iterated kernels and Neumann series for Fredholm integral equations
2. Derive method of successive approximations, resolvent kernel, iterated kernels and Neumann series, Laplace transform method for Volterra integral equations.
3. Solve singular, Cauchy and Hilbert integral equation.
4. Design methods for reduction of a boundary value problem to a Fredholm integral equation with kernel as Green function. Apply the knowledge to solve problems.

Unit: 1.
Linear Integral equations, some basic identities, Initial value problems reduced to Volterra integral equations, Methods of successive substitution and successive approximation to solve Volterra integral equations of second kind, Iterated kernels and Neumann series for Volterra equations. Resolvent kernel as a series. Laplace transform method for a difference kernel. Solution of a Volterra integral equation of the first kind.

Unit: 2.
Boundary value problems reduced to Fredholm integral equations, Methods of successive approximation and successive substitution to solve Fredholm equations of second kind, Iterated kernels and Neumann series for Fredholm equations. Resolvent kernel as a sum of series.Fredholmresolvent kernel as a ratio of two series.Fredholm equations with separable kernels.Approximation of a kernel by a separable kernel, Fredholm Alternative, Non homogenous Fredholm equations with degenerate kernels.

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Unit: 3.

Singular integral equation, solution of Abel integral equation, solution of general form of Abel integral equation, Cauchy principal value for integrals: Cauchy's general and principal values, Holder condition, singular integrals, Plemelj formulas, Poincare-Bertrand transformation formula. Solution of Cauchy-Type singular integral equation, closed contour, unclosed contours and Riemann- Hilbert problem.Hilbert kernel, Hilbert formula, solution of Hilbert-type singular integral equation of first and second kind.

Unit: 4.

Green function, Use of method of variation of parameters to construct the Green function for a nonhomogeneous linear second order boundary value problem, Basic four properties of the Green function, Alternate procedure for construction of the Green function by using its basic four properties. Reduction of a boundary value problem to a Fredholm integral equation with kernel as Green function.

Recommended Books:

1. R.P. Kanwal, Linear Integral Equations, Theory and Techniques, Academic Press, New York.
2. M.D. Raishinghania, Integral Equations and Boundary value problems, S. Chand and Company Pvt. Ltd. 2007.
3. S.G. Mikhlin, Linear Integral Equations (translated from Russian) Hindustan Book Agency, 1960.
4. A.J. Jerri,Introduction to Integral Equations with Applications, AWiley-Interscience Publication, 1999.
5. W.V. Lovitt, Linear Integral Equations, McGraw Hill, NewYork.

(Prof. Aseem Miglani)
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(Mr. Sandeep Kumar)
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MSc/Maths/3/DSC5
Mathematical Statistics

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: Mathematical statistics is very useful in all branches of science as well as all branches of social sciences. The concept of mathematical statistics is surely one of the popular branches of mathematics. The main aim of this course is to introduce probability, random variable, mathematical expectation, correlation coefficient, discrete probability distributions, continuous probability distributions, testing of hypothesis, sampling distribution and standard error of estimate, large sample tests for single mean, Single proportion, difference between two means and two proportions.

Course Outcomes: This course will enable the students to:

1. Understand probability and various approaches of probability, addition theorem, Boole inequality, conditional probability , multiplication theorem, independent events, mutual and pairwise independence of events, Bayes theorem and its applications.
2. Understand random variable and probability functions, mathematical expectation, moment generating functions and their properties.
3. To learn about Uniform, Bernoulli, Binomial, Poisson and Geometric distributions with their properties, Uniform, Exponential and Normal distributions with their properties
4. To learn about parameter and statistic, sampling distribution and standard error of estimate, null and alternative hypotheses, simple and composite hypotheses, critical region, level of significance, one tailed and two tailed tests, two types of errors, large sample tests for single mean, single proportion, difference between two means and two proportions.

Unit: 1.
Probability: Definition and various approaches of probability, Addition theorem, Boole inequality, Conditional probability and multiplication theorem, Independent events, Mutual and pairwise independence of events, Bayes theorem and its applications.

Unit: 2.
Random variable and probability functions:Definition and properties of random variables, Discrete and continuous random variables, Probability mass and density functions, Distribution function. Concepts of bivariate random variable: joint, marginal and conditional distributions. Mathematical expectation: Definition and its properties. Variance, Covariance, Moment generating function- Definitions and their properties.

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(Mr. Sandeep Kumar)
Assistant Prof.

Unit: 3.

Discrete distributions:Uniform, Bernoulli, Binomial, Poisson and Geometric distributions with their properties.

Continuous distributions: Uniform, Exponential and Normal distributions with their properties.

Unit: 4.

Testing of hypothesis: Parameter and statistic, Sampling distribution and standard error of estimate, Null and alternative hypotheses, Simple and composite hypotheses, Critical region, Level of significance, One tailed and two tailed tests, Two types of errors. Tests of significance: Large sample tests for single mean, Single proportion, Difference between two means and two proportions.

Recommended Books:

1. V. Hogg and T. Craig, Introduction to Mathematical Statistics, 7th addition, Pearson Education Limited-2014
2. A.M. Mood, F.A. Graybill, andD.C. Boes, Introduction to the Theory of Statistics, McGraw Hill Book Company.
3. J.E. Freund, Mathematical Statistics, Prentice Hall of India.
4. M. Speigel, Probability and Statistics, Schaum Outline Series.
5. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, S. Chand Pub., New Delhi.

(Prof. Aseem Miglani) Chairperson	(Prof. Neelam Kumari) Associate Prof.	(Mr. Sandeep Kumar) Assistant Prof.

MSc/Maths/3/DSC6
Advanced Complex Analysis

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The main objective of this course is to understand the notion oflogarithmically convex function and its fusion with maximum modulus theorem, the spacesof continuous, analytic and meromorphic functions, Runge's theorem and topics related withit, introduce harmonic function theory leading to Dirichlet's problem, theory of range of anentire function leading to Picard and related theorems.

Course Outcomes: This course will enable the students to
1. Understand the basics of logarithmically convex functions that helps in extending maximum modulus theorem; learn about spaces of continuous, analytic and meromorphic functions.
2. Be familiar with Riemann mapping theorem, Weierstrass' factorization theorem, Gamma functions and its properties.
3. Understand Runge's theorem; know harmonic function theory on a disk; apply the knowledge in solving Dirichlet's problem; know about Green's function.
4. Know how big the range of an entire function is ; prove Picard and related theorems.

Unit: 1.
Convex functions and Hadamard's three circles theorem, Phragmen-Lindelöf theorem.
Spaces of continuous functions, Arzela-Ascoli theorem,Spaces of analytic functions, Hurwitz's theorem, Montel's theorem, Spaces of meromorphic functions.

Unit: 2.
Riemann mapping theorem, Weierstrass' factorization theorem, Factorization of sine function, Gamma function and its properties, functional equation for gamma function, Bohr-Mollerup theorem, Reimann-zeta function, Riemann's functional equation, Euler's theorem.

Unit: 3.
Runge's theorem, Simply connected regions, Mittag-Leffler's theorem. Analytic continuation, Power series method of analytic continuation , Schwarz reflection principle. Monodromy theorem and its consequences.
Harmonic functions, Maximum and minimum principles, Harmonic function on a disk, Harnack's theorem, Sub-harmonic and super-harmonic functions, Dirichlet's problems, Green's function.

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Chairperson Associate Prof. Assistant Prof.

Unit: 4.

Entire functions :Jensen's formula, Poisson–Jensen formula. The genus and order of an entire function, Hadamard's factorization theorem.

The range of an analytic function : Bloch's theorem, Little-Picard theorem, Schottky's theorem, Montel-Carathedory theorem, Great Picard theorem.

Recommended Books:

1. Conway, J.B., Functions of One complex variables Narosa Publishing, 2000.
2. Ahlfors, L.V., Complex Analysis. McGraw-Hill Book Company, 1979.
3. Churchill, R.V. and Brown, J.W., Complex Variables and Applications McGraw Hill Publishing Company, 1990.
4. Priestly, H.A., Introduction to Complex Analysis Claredon Press, Orford, 1990.
5. Mark J.Ablewitz and A.S.Fokas, Complex Variables: Introduction & Applications, Cambridge University Press, South Asian Edition, 1998.
6. E.C.Titchmarsh, The Theory of Functions, Oxford University Press, London.
7. S.Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 1997.

(Prof. Aseem Miglani) Chairperson | (Prof. Neelam Kumari) Associate Prof. | (Mr. Sandeep Kumar) Assistant Prof.

MSc/Maths/3/DSC7
Advanced Mechanics of Solids

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course objectives: This course is in continuation to the course Mechanics of Solids being taught as a core paper in second semester. This paper deals with elastostatic problems on extension and torsion of beams through the application of forces and couples, and with viscoelasticity. The techniques used to solve these problems involve the applications of complex analysis, variational methods. The boundary value problems arising in plane elasticity are solved for analytical solutions. Some techniques of solving the three-dimensional elastodynamics problems are also discussed.

Course outcomes: This course will enable the students to:

1. Understand the concepts of plane strain, plane stress, Airy stress function and general solution of two dimensional problems in terms of complex potentials.
2. Understand the concepts ofextension and torsion; and learn to solve different elastostatics problems of extension and torsion of beams.
3. Learn Variational methods, Deflection of elastic string and elastic membrane, Solution of Euler's equation by Ritz, Galerkin and Kantorovich methods.
4. Learn viscoelastic models, correspondence principle of viscoelasticity & its application to the Deformation of a viscoelastic Thick-walled tube in Plane strain.

Unit: 1.

Two dimensional problems: Plane strain deformation, State of Plane stress. Generalized plane stress, Airy stress function for plane strain problem, General solution of biharmonic equation, Stresses and displacements in terms of complex potentials, Deformation of a thick-walled elastic tube under external and internal pressures.

Unit: 2.

Extension: Extension of beams by longitudinal forces, beams stretched by its own weight.
Torsion: Torsion of a circular cylindrical beam, Torsional rigidity, Torsion and stress functions, Lines of shearing stress, Torsion of a beam of arbitrary cross-section and its special cases for circular, elliptic and equilateral triangular cross-sections, Circular grooves in a circular beam.

Unit: 3.

Variational methods: Theorems of minimum potential energy, Theorems of minimum complementary energy, Reciprocal theorem of Betti and Rayleigh, Deflection of elastic string and elastic membrane, Solution of Euler's equation by Ritz, Galerkin and Kantorovich methods.

Unit: 4.

Viscoelasticity: Spring & Dashpot, Maxwell & Kelvin Models, Three parameter solid, Correspondence principle & its application to the Deformation of a viscoelastic Thick-walled tube in Plane strain.

Recommended Books:

1. I.S. Sokolnikoff, Mathematical Theory of Elasticity, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1977.
2. Teodar M. Atanackovic and ArdeshivGuran, T*heory of Elasticity for Scientists and Engineers, B*irkhausev, Boston, 2000.
3. A.K. Mal & S.J. Singh, D*eformation of Elastic Solids*, Prentice Hall, New Jersey, 1991.
4. W. Flugge, Viscoelasticity, Springer Verlag.
5. A.S. Saada, E*lasticity-Theory and Applications*, Pergamon Press, New York, 1973.
6. Y.C. Fung. Foundations of Solid Mechanics, Prentice Hall, New Delhi, 1965.
7. D.S. Chandrasekharaiah and L. Debnath, Continuum Mechanics, Academic Press, 1994.

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MSc/Maths/3/DSC8
Advanced Discrete Mathematics

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The course consists of two sections. In the first section lattices are defined as algebraic structures. This section contains various types of lattices i.e. modular, distributive and complimented lattices.The notion of independent elements in modular lattices is introduced. Boolean algebra has been introduced as an algebraic system. Basic properties of finite Boolean algebra and application of Boolean algebra to switching circuit theory is also given.
Section two contains graph theory. In this section students will be taught connected graphs, Euler's theorem on connected graphs, trees and their basic properties. This section also contains fundamental circuits and fundamental cut-sets, planner graphs, vector space associated with a graph, and the matrices associated with graphs, paths, circuits and cut-sets. The contents of this paper find many applications in computer science and engineering science.

Course Outcomes: This course will enable the students to:
1. Understand concept of lattices, Boolean algebra.
2. Apply lattices to switching circuits.
3. Understand concept of graph, path, circuits, tree, fundamental circuits, cut-set and cut-vertices.
4. Understand concept of planer and dual graph, circuit and cut-set subspace, fundamental circuit matrix, cut- set matrix, path matrix and adjacency matrix.

Unit: 1.
Properties of lattice, modular and distributive lattices.Boolean algebra, basic properties, Boolean polynomial, ideals, minimal forms of Boolean polynomials. (Chapter 1 of recommended book at Sr. No. 1)

Unit: 2.
Switching circuits, application of lattice to switching circuits.
(Section 2.1 of chapter 2 of recommended book at Sr. No. 1)

Unit: 3.
Finite and infinite graphs, Incidence and degree, Isolated vertex, pendant vertex, Null graph, isomosphism, subgraphs, a puzzle with multicolored cubes, walks, paths and circuits. Connected and disconnected graphs, Components of a graph, Euler graphs, Hamiltonian

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Chairperson Associate Prof. Assistant Prof.

paths and circuits, The traveling salesman problem. Trees and their properties, pendant vertices in a tree, distance and centers in a tree, rooted and binary tree. Spanning tree, Fundamental circuits.Spanning tree in a weighted graph.Cut-sets and their properties.Fundamental circuits and cut-sets.Connectivity and separability. Network flows.
(Sections 1.1 to 1.5, 2.1 to 2.10, 3.1 to 3.10, 4.1 to 4.6 of recommended book at Sr. No. 2)

Unit: 4.

Planner graphs. Kuratowski's two graphs. Representation of planner graphs. Euler formula for planner graphs. Geometric dual, vector and vector spaces, Vector space associated with a graph. Basis vectors of a graph. Circuit and cut-set subspaces. Intersection and joins of W_C and W_S. Incidence matrix, submatrices of A(G), Circuit matrix, Fundamental circuit matrix, and its rank, Cut-set matrix, path matrix and adjacency matrix .
(Sections 5.1 to 5.6, 6.4 to 6.7, 6.9, 7.1 to 7.4, 7.6, 7.8 & 7.9 of recommended book at Sr. No. 2)

Recommended Books:

1. Rudolf Lidl& Gunter Pilz, Applied Abstract Algebra, Springer-Verlag, Second Edition, 1998.
2. NarsinghDeo, Graph Theory with application to Engineering and Computer Science, Prentice Hall of India.
3. Nathan Jacobson, Lectures in Abstract Algebra Vol.I, D.VanNostrand Company, Inc.
4. L.R. Vermani, A course in discrete Mathematical structures(Imperial College Shalini Press London 2011).
5. C. L. Liu; Elements of Discrete Mathematics, McGraw-Hili Book Co.

(Prof. Aseem Miglani) Chairperson

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(Mr. Sandeep Kumar) Assistant Prof.

MSc/Maths/3/DSC9
Fuzzy Sets and Applications

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: Fuzzy sets and fuzzy logic are powerful mathematical tools for modeling; and are facilitators for common-sense reasoning in decision making in the absence of complete and precise information. The main objective of this course is to familiarize the students with fuzzy sets, operations on fuzzy sets, fuzzy numbers, fuzzy relations, possibility theory and fuzzy logic.

Course Outcomes: This course will enable the students to:
1. Learn about fuzzy sets; understand fuzzy-set-related notions such as α level sets, convexity, normality, support, etc., their properties and various operations on fuzzy sets.
2. Understand the concepts of t-norms, t-conforms, fuzzy numbers; extend standard arithmetic operations on real numbers to fuzzy numbers.
3. Understand various type of fuzzy relations.
4. Apply fuzzy set theory to possibility theory and Fuzzy logic.

Unit: 1.
Fuzzy Sets: Basic definitions, α -cuts, strong α -cuts, level set of a fuzzy set, support of a fuzzy set, the core and height of a fuzzy set, normal and subnormal fuzzy sets, convex fuzzy sets, cutworthy property, strong cutworthy property, standard fuzzy set operations, standard complement, equilibrium points, standard intersection, standard union, fuzzy set inclusion, scalar cardinality of a fuzzy set, the degree of subsethood.
(Scope as in relevant parts of sections 1.3-1.4 of Chapter 1 of the book by Klir&Yuan)
Additional properties of α cuts involving the standard fuzzy set operators and the standard fuzzy set inclusion, Representation of fuzzy sets, three basic decomposition theorems of fuzzy sets Extension principle for fuzzy sets: the Zedah's extension principle, Images and inverse images of fuzzy sets, proof of the fact that the extension principle is strong cutworthy but not cutworthy.
(Scope as in relevant parts of Chapter 2 of the book by Klir& Yuan)
Operations on fuzzy sets: types of operations, fuzzy complements, equilibrium of a fuzzy complement, equilibrium of a continuous fuzzy complement, first and second characterization theorems of fuzzy complements.
(Scope as in relevant parts of sections 3.1 and 3.2 of Chapter 3 of the book by Klir& Yuan)

Unit: 2.

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Fuzzy intersections (t-norms), standard fuzzy intersection as the only idempotent t-norm, standard intersection, algebraic product, bounded difference and drastic intersection as examples of t-norms, decreasing generator, the Pseudo-inverse of a decreasing generator, increasing generators and their Pseudo-inverses, convertion of decreasing generators and increasing generators to each other, characterization theorem of t-norms(statement only). Fuzzy unions (t-conorms), standard union, algebraic sum, bounded sum and drastic union as examples of t-conorms, characterization theorem of t-conorms (Statement only), combination of operations, aggregation operations.

(Scope as in relevant parts of sections 3.3 to 3.6 of Chapter 3 of the book by Klir& Yuan)

Fuzzy numbers, relation between fuzzy number and a convex fuzzy set, characterization of fuzzy numbers in terms of its membership functions as piecewise defined functions, fuzzy cardinality of a fuzzy set using fuzzy numbers, arithmetic operations on fuzzy numbers, extension of standard arithmetic operations on real numbers to fuzzy numbers, lattice of fuzzy numbers, (R, MIN, MAX) as a distributive lattice, fuzzy equations, equation A+X = B, equation A.X = B.

(Scope as in relevant parts of Chapter 4 of the book by Klir& Yuan)

Unit: 3.

Fuzzy Relations: Crisp and fuzzy relations, projections and cylindrical extensions, binary fuzzy relations, domain, range and height of a fuzzy relation, membership matrices, sagittal diagram, inverse of a fuzzy relation, composition of fuzzy relations, standard composition, max-min composition, relational join, binary relations on a single set, directed graphs, reflexive irreflexive, antireflexive, symmetric, asymmetric, antisymmetric, transitive (max-min transitive), non transitive, antitransitive fuzzy relations. Fuzzy equivalence relations, fuzzy compatibility relations, α -compatibility class, maximal α -compatibles, complete α -cover, reflexive undirected graphs, fuzzy ordering relations, fuzzy upper bound, fuzzy pre ordering, fuzzy weak ordering, fuzzy strict ordering, fuzzy morphisms. Sup-i compositions of Fuzzy relations, Inf-i compositions of Fuzzy relations.

(Scope as in the relevant parts of Chapter 5 of the book by Klir& Yuan)

Unit: 4.

Possibility Theory : Fuzzy measures, continuity from below and above, semicontinuous fuzzy measures, examples and simple properties; Evidence Theory, belief measure, superadditivity, monotonicity, plausibility measure, subadditivity, basic assignment, its relation with belief measure and plausibility measure, focal element of basic assignment, body of evidence, total ignorance, Dempster`s rule of combination, examples; Possibility Theory, necessity measure, possibility measure, implications, possibility distribution function, lattice of possibility distributions, joint possibility distribution. Fuzzy sets and possibility theory, Possibility theory versus probability theory.

(Scope as in the relevant parts of Chapter 7 of the book by Klir& Yuan)

Fuzzy Logic: An overview of classical logic, about logic functions of two variables, Multivalued logics, Fuzzypropositions,FuzzyQuantifiers,Linguistic Hedges, Inference from conditional fuzzy propositions, inference from conditional and qualified propositions, inference from unqualified propositions.

(Scope as in the relevant parts of Chapter 8 of the book by Klir& Yuan)

(Prof. Aseem Miglani)
Chairperson

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Associate Prof.

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Assistant Prof.

Recommended Books:

1. G. J. Klir and B. Yuan: Fuzzy Sets and Fuzzy : Logic Theory and Applications, Prentice Hall of India, 2008.
2. Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer International Edition, 2005.
3. H.J. Zimmerman, Fuzzy Set Theory and its Applications, Allied Publishers Ltd., New Delhi, 1991.
4. John Yen, Reza Langari, Fuzzy Logic - Intelligence, Control and Information, Pearson Education, 1999.
5. A.K. Bhargava, Fuzzy Set Theory, Fuzzy Logic & their Applications, S. Chand & Company Pvt. Ltd., 2013.

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MSc/Maths/3/DSC10
Financial Mathematics

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course objectives: No one can deny the fact that financial markets play a fundamental role in economic growth of nations by helping efficient allocation of investment of individuals to the most productive sectors of the economy. Financial sector has seen enormous growth over the past thirty years in the developed world. This growth has been led by the innovations in products referred to as financial derivatives that require great deal of mathematical sophistication and ingenuity in pricing and in creating an insurance or hedge against associated risks. Hence, this course is for anyone who is interested in the applications of finance, particularly advanced /latest business techniques. Students are required to know elementary calculus (derivatives and partial derivatives, finding maxima or minima of differentiable functions of one or more variables, Lagrange multipliers, the Taylor formula and integrals), probability (random variables and probability (binomial & normal) distributions, expectation, variance and covariance, conditional probability and independence) and linear algebra (systems of linear equations, add, multiply, transpose and invert matrices, and compute determinants).

Course outcomes: This course will enable the students to:

1. Understand the fundamentals of financial mathematics through derivatives, payoff functions, options, trader types, asset price models, random walks/ motion, no-arbitrage and relevant formula/simulation /hypothesis.
2. Use the Black-Scholes analysis for European options, risk neutrality, delta hedging, trading strategy involving options, along with the variations on Black-Scholes models for options on dividend-paying assets, warrants and futures.
3. Solve Black-Scholes equation using Monte-Carlo method, binomial methods, finite difference methods including fast algorithms for solving linear systems and design free boundary value problem, linear complementary problem, fixed domain problem for American option to be solved with projective/implicit methods.
4. Work on exotic options, path-dependent options, derivatives through bond models and interest rate models, convertible bonds and to learn stochastic calculus for its use in Brownian motion, stochastic integrals, stochastic differential equations and diffusion process.

Unit: 1.

Fundamentals of Financial Mathematics: Financial Markets, derivatives; Payoff functions, Options, Types of traders Asset Price Models: Discrete/continuous models and their solutions; Random walks; The Brownian motion; Ito's formula; Simulation of asset price model; Hypothesis of no-arbitrage-opportunities; Basic properties of option prices.

Unit: 2.
Black-Scholes Analysis: The Black-Scholes Equation; Exact solution for European options; Risk Neutrality; The delta hedging; Trading strategy involving options.
Variations on Black-Scholes models: Options on dividend-paying assets; Warrants; Futures and futures options.

Unit: 3.
Numerical Methods (Solving B.S equation): Monte Carlo method; Binomial Methods; Finite difference methods; Fast algorithms for solving linear systems;
American Option: free boundary value problem; linear complementary problem; fixed domain problem; Projective/implicit method for American put/call.

Unit: 4.
Exotic Options: Binaries; Compounds; Chooser options; Barrier option; Asian/lookback options;
Path-Dependent Options: Average strike options; Lookback Option
Bonds and Interest Rate Derivatives: Bond Models; Interest models; Convertible Bonds
Stochastic calculus: Brownian motion; Stochastic integral; Stochastic differential equation; Diffusion process.

Recommended Books:

1. Financial Mathematics: I-Liang Chern Department of Mathematics, National Taiwan University
2. Sheldon M. Ross, An Introduction to Mathematical Finance, Cambridge Univ. Press.
3. Robert J. Elliott and P. Ekkehard Kopp. Mathematics of Financial Markets, Springer-Verlag, New York Inc.
4. Robert C. Marton, Continuous-Time Finance, Basil Blackwell Inc.
5. Daykin C.D., Pentikainen T. and Pesonen M., Practical Risk Theory for Actuaries, Chapman & Hall.

(Prof. Aseem Miglani)
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Assistant Prof.

MSc/Maths/3/DSC11
Number Theory

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The concept of number theory is surely one of the oldest ideas of Mathematics. The main aim of this course is to introduce arithmetic functions, Diophantine equations, Farey sequences, geometry of numbers, continued fractions. An attempt has been made in this course to strike a balance between different concepts of number theory.

Course Outcomes: This course will enable the students to:

1. Understand the concept of greatest integer function, arithmetic function, mobiusinversion formula, recurrence function, combinatorial number theory .
2. Find solution of Diophantine equations and rational points on curve.
3. Understand concept of Farey fractions, irrational numbers and geometry of numbers.
4. Have deep understanding of simple continued fractions, approximation to irrational number, Pell's equation.

Unit: 1.
Greatest integer function, Arithmetic function, multiplicative function, completely multiplicative function, mobius- inversion formula, recurrence function, combinational number theory.

Unit: 2.
Solution of the equation ax+by =c, simultaneous linear equations, Unimodular matrices, Pythagorean triangles, some assorted examples, ternary quadratic forms, rational points on curves.

Unit: 3.
Farey sequences, rational approximations, Hurwitz theorem, irrational numbers, Blichfeldt's principle, Minkowski'sConvex body theorem, Lagrange's four square theorem.

Unit: 4.
Euclidean algorithm, finite and infinite continued fractions, approximations to irrational numbers, Best possible approximations, Hurwitz theorem, Periodic continued fractions, Pell's equation.

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Recommended Books:

1. Ivan Niven, Herbert S. Zuckerman , Hugh L. Montgomery, An Introduction to the Theory of Numbers, John Wiley & Sons (Fifth Edition), 1991.
2. G.H. Hardy and E.M. Wright, An introduction to the theory of numbers, Oxford University Press, 6th Ed, 2008.

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MSc/Maths/3/DSC12
Fourier and Wavelet Analysis

Credits: 4 (Lectures: 60) | **Marks: 100**
Duration of exam: 3 Hrs. | **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: Wavelet analysis is a modern supplement to classical Fourier analysis. In some cases Wavelet analysis is much better than Fourier analysis in the sense that fewer terms suffice to approximate certain functions. The main objective of this course is to familiarize with the standard features of Fourier transforms along with more recent developments such as the discrete and fast Fourier transforms and wavelets. We consider the idea of a multiresolution analysis and the course we follow is to go from MRA to wavelet bases.

Course Outcomes: This course will enable the students to:

1. Have an idea of the finite Fourier transform, convolution on the circle group T, the Fourier transform and residues and know about continuous analogue of Dini’s theorem and Lipschitz’s test.
2. Know about (C,1) summability for integrals, understandthe Fejer-Lebesgue inversion theorem, Parseval’s identities, the L_2 theory, Plancherel theorem andMellin transform.
3. Have understanding of the Discrete and Fast Fourier transforms, and Buneman’s Algorithm.
4. UnderstandMultiresolution Analysis, Mother wavelets;construction of scaling function with compact support, Shannon wavelets,Franklin wavelets, frames, splines and the continuous wavelet transform.

Unit: 1.

Fourier Transform: The finite Fourier transform, the circle group T, convolution to T, (L (T),+,*) as a Banach algebra, convolutions to products, convolution on T, the exponential form of Lebesgue’s theorem, Fourier transform : trigonometric approach, exponential form, Basics/examples.

Fourier transform and residues, residue theorem for the upper and lower half planes, the Abel kernel, the Fourier map, convolution on R, inversion, exponential form, inversion, trigonometric form, criterion for convergence, continuous analogue of Dini’s theorem, continuous analogue of Lipschitz’s test, analogue of Jordan’s theorem.

(Scope as in relevant parts of Chapter 5 of the book “Fourier and Wavelet Analysis” by Bachman, Narici and Beckenstein)

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Unit: 2.

(C,1) summability for integrals, the Fejer-Lebesgue inversion theorem,the continuous Fejer Kernel, the Fourier map is not onto, a dominated inversion theorem, criterion for integrability of $\hat{f}$

Approximate identity for L_1(R), Fourier Sine and Cosine transforms, Parseval's identities, the L_2 theory, Parseval's identities for L_2, inversion theorem for L_2 functions, the Plancherel theorem, A sampling theorem, the Mellin transform, variations.

(Scope as in relevant parts of Chapter 5 of the book "Fourier and Wavelet Analysis" by Bachman, Narici and Beckenstein)

Unit: 3.

Discrete Fourier transform, the DFT in matrix form, inversion theorem for the DFT, DFT map as a linear bijection, Parseval's identities, cyclic convolution, Fast Fourier transform for N=2 , Buneman's Algorithm, FFT for N=RC, FFT factor form.

(Scope as in relevant parts of Chapter 6 of the book "Fourier and Wavelet Analysis" by Bachman, Narici and Beckenstein)

Unit: 4.

Wavelets : orthonormal basis from one function , Multiresolution Analysis, Mother wavelets yield Wavelet bases, Haar wavelets, from MRA to Mother wavelet, Mother wavelet theorem, construction of scaling function with compact support, Shannon wavelets, Riesz basis and MRAs, Franklin wavelets, frames, splines, the continuous wavelet transform.

(Scope as in relevant parts of Chapter 7 of the book "Fourier and Wavelet Analysis" by Bachman, Narici and Beckenstein)

Recommended Books:

1. G. Bachman, L. Narici and E. Beckenstein : Fourier and Wavelet Analysis, Springer, 2000
2. Hernandez and G. Weiss : A first course on wavelets, CRC Press, New York, 1996
3. C. K. Chui: An introduction to Wavelets, Academic Press,1992
4. I. Daubechies : Ten lectures on wavelets, CBMS_NFS Regional Conferences in Applied Mathematics, 61, SIAM, 1992
5. V. Meyer, Wavelets, algorithms and applications SIAM, 1993
6. M.V. Wickerhauser: Adapted wavelet analysis from theory to software, Wellesley,MA, A.K. Peters, 1994
7. D. F. Walnut: An Introduction to Wavelet Analysis, Birkhauser, 2002
8. K. Ahmad and F.A. Shah: Introduction to Wavelets with Applications, World Education Publishers, 2013

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MSc/Maths/3/SEC3
Computer Programming in MATLAB (Theory)

Credits: 2 (Lectures: 30) **Marks: 50**
Duration of exam: 2 Hrs. **Theory: 30; IA: 20**

Note for the paper setter: The question paper will consist of five questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.

Couse Objectives: The course, comprises of theory as well as practical part, aims to train the students in the computer programming. The objective of this course is to develop a skill of writing codes in MATLAB or equivalent Open Source software for solving different types of mathematical problems related to the areas of Mathematics, Science and Engineering.

Theory Course Outcomes: This course will enable the students to:-

1. Get familiar with the importance and working of MATLAB as computation platform through the knowledge of characters, variables, operators, functions and expressions as used for elementary operations in matrix algebra along with the editing, load/save data and compilation/execution/quitting of source programs.
2. Learn the process of writing a source program in MATLAB as high-level language making use of the statements for input/output, conditional/non-sequential processing involving functions, arrays and structures.

Unit: 1.

Introduction: Basics of programming; Anatomy of a program; Constants; Characters; Variables; Data types; Assignments; Operators; functions; Examples of expressions; Entering long statements; Command line editing. Good programming style.
Working with vectors: Defining a Vector, Accessing elements within a vector, Basic operations on vectors; Mathematical functions; Strings; String functions; Cell array; Creating cell array; Concatenation.
Working with Matrices: Generating matrices; Mathematical operations and functions;
Deleting rows /columns; Linear algebra; Arrays; Multivariate data; Scalar expansion; Logical subscripting;
Input and output: Save/Load functions, M-files, To find function; The format function; Suppressing output;

Unit: 2.

Flow Control: if and else, switch and case, for loop, while loop, continue, break, try – catch, return.
Data Structures: Multidimensional arrays; Cell arrays, Characters and text; Structures,
Scripts and Functions: Scripts; Functions; Types of functions; Global variables; Passing string arguments to functions; The eval function; Function handles; Function functions; Vectorization; Preallocation.

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PGBOS&R in its meeting held on 18-06-2021

Recommended Books:

1. *Learning MATLAB*, COPYRIGHT 1984 - 2005 by The MathWorks, Inc.
2. Amos Gilat, *MATLAB An Introduction With Applications* 5ed, Wiley, 2008.
3. C. F. Van Loan and K.-Y. D. Fan., *Insight through Computing: A Matlab Introduction to Computational Science and Engineering*, SIAM Publication, 2009.
4. T. A. Davis and K. Sigmon, *MATLAB Primer* 7th Edition, CHAPMAN & HALL/CRC, 2005.
5. B. R. Hunt, R. L. Lipsman, J. M. Rosenberg, K. R. Coombes, J. E. Osborn, and G. J. Stuck, *A Guide to MATLAB*, Second Edition, Cambridge University Press, 2006.
6. RudraPratap, *Getting Started with MATLAB*, Oxford University Press, 2010.
7. C. Gomez, C. Bunks and J.-P. Chancelier, *Engineering and Scientific Computing with SCILAB*, Birkhäuser, 2012.
8. A. Quarteroni, F. Saleri and P. Gervasio, *Scientific Computing with MATLAB and Octave*, Springer Nature, 2014.

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MSc/Maths/3/SEC3
Computer Programming in MATLAB (Practical)

Credits: 2 (Hours: 60) **Marks: 50**
Duration of exam: 3 Hrs.

Note for the practical examiner: The examiner will set 4 questions at the time of practical examination. The examinee will be required to write two programs and execute one program successfully. The evaluation will be done on the basis of practical record, viva-voce, written exam and execution of the program.

Practical Course Outcomes: This course will enable the students to:

3. Know syntax of expressions, statements, data types, structures, commands and to write source code for a program in MATLAB.
4. Edit, compile/interpret and execute the source program for desired results.

Computing lab work will be based on programming in MATLAB for computing various mathematical problems. There will be 12-15 problems/ programmes during the semester.

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MSc/Maths/4/CC12
Functional Analysis

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The main objective of this course is to study normed linear spaces, Banach spaces, inner product spaces and Hilbert spaces. Hahn-Banach Theorem, Uniform Boundedness Theorem, Open Mapping Theorem and Closed Graph Theorem. Hilbert spaces, introducing basic concepts and proving the theorems associated with the names of Riesz, Bessel and Parseval, along with classifying operators into self-adjoint, unitary and normal operators.

Course Outcomes: This course will enable the students to:

1. Know about the requirements of a norm; completeness with respect to a norm; understand relation between compactness and dimension of a space; check boundedness of a linear operator and its relation to continuity, convergence of operators by using a suitable norm, dual spaces.
2. Learn about Hahn Banach Theorem and its applications, Riesz-representation theorem for bounded linear functionals on C[a,b], know about adjoint of operators; understand reflexivity of a space, Uniform boundedness theorem.
3. Know about strong and weak convergence; understand open mapping theorem, bounded inverse theorem and closed graph theorem; distinguish between Banach spaces and Hilbert spaces; decompose a Hilbert space in terms of orthogonal complements, Projection theorem.
4. Learn about orthonormal sets and sequences, Bessel’s inequality, total or complete orthonormal sets, Parseval’s identity, Representation of functionals on Hilbert spaces, Riesz representation theorem for bounded linear functionals on a Hilbert space, sesquilinear form, Riesz representation theorem for bounded sesquilinear forms on a Hilbert space. Hilbert adjoint operator, its existence and uniqueness, properties of Hilbert adjoint operators, self adjoint, unitary, normal, positive and projection operators.

Unit: 1.

Normed linear spaces, Banach spaces, finite dimensional normed spaces and subspaces, equivalent norms, compactness and finite dimension, F.Riesz’s lemma. Bounded and continuous linear operators, differentiation operator, integral operator, bounded linear

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extension, linear functionals, bounded linear functionals, continuity and boundedness, normed spaces of operators, dual spaces with examples.

Unit: 2.

Hahn-Banach theorem for normed linear spaces, application to bounded linear functionals on C[a,b], Riesz-representation theorem for bounded linear functionals on C[a,b], adjoint operator, norm of the adjointoperator.Reflexive spaces, uniform boundedness theorem and some of its applications to the space of polynomials and fourier series.

Unit: 3.

Strong and weak convergence, Open mapping theorem, bounded inverse theorem, closed linear operators, closed graph theorem, differential operator, relation between closedness and boundedness of a linear operator.

Inner product spaces, Hilbert spaces and their examples, pythagorean theorem, Apolloniu's identity, Schwarz inequality, continuity of innerproduct, completion of an inner product space, subspace of a Hilbert space, orthogonal complements and direct sums, projection theorem, characterization of sets in Hilbert spaces whose space is dense.

Unit: 4.

Orthonormal sets and sequences, Bessel's inequality, series related to orthonormal sequences and sets, total(complete) orthonormal sets and sequences, Parseval's identity, separable Hilbert spaces.Representation of functionals on Hilbert spaces, Riesz representation theorem for bounded linear functionals on a Hilbert space, sesquilinear form, Riesz representation theorem for bounded sesquilinear forms on a Hilbert space.

Hilbert adjoint operator, its existence and uniqueness, properties of Hilbert adjoint operators, self adjoint, unitary, normal, positive and projection operators.

Recommended Books:

1. E.Kreyszig: Introductory Functional Analysis with Applications, John Wiley and Sons, New York, 1978.
2. G.F.Simmons: Introduction to Topology and Modern Analysis, McGraw Hill Book Co., New York, 1963.
3. C. Goffman and G. Pedrick: First Course in Functional Analysis, Prentice Hall of India, New Delhi, 1987.
4. G. Bachman and L. Narici, Functional Analysis, Academic Press, 1966.
5. L.A. Lustenik and V.J. Sobolev, Elements of Functional Analysis, Hindustan Publishing Corporation, New Delhi, 1971.
6. J.B. Conway: A Course in Functional Analysis, Springer-Verlag, 1990.
7. P.K. Jain, O.P. Ahuja and Khalil Ahmad: Functional Analysis, New Age International(P) Ltd. & Wiley Eastern Ltd., New Delhi, 1997.

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MSc/Maths/4/CC13
Partial Differential Equations

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course objectives: The learning objective of this paper is to study partial differential equations (PDE) which are used to describe a wide variety of phenomena such as sound, heat, electrostatics, electrodynamics, fluid dynamics, elasticity and mechanics. During this course, a student will learn about partial differential equations including definition, classifications, analytical theory and methods of solutions of IVP, transport equations, Laplace's equation, Poisson's equation and heat equations, Green's function and method of solving PDEs by Green's function approach. Other component of the learning objective is to study Wave equation, solutions of wave equation in different forms, Kirchhoff's and Poisson's formula, solution of non-homogeneous wave equation, solution of Laplace, heat and wave equations by method of separation of variables, similarity solutions and by using Fourier and Laplace transforms.

Course outcomes: This course will enable the students to:

1. Classify the PDE of different orders into elliptic/ parabolic/ hyperbolic types and work on the methods to solve homogeneous and non-homogeneous PDEs.
2. Understand the role of Green's function in solving PDE and work on the methods/principle used to derive formulas for solutions of homogeneous and non-homogeneous parabolic/heat equations.
3. Use various methods to solve the homogeneous and non–homogeneous wave equations in different coordinate systems. Capacity to apply those techniques/methods to numerous problems that arise in science, engineering and other disciplines.
4. Learn to solve non-linear first order PDEs through complete integrals, envelopes, characteristics and solve Laplace, heat and wave equations using method of separation of variables and using integral transforms.

Unit-I:

Partial Differential Equations (PDE) of k^{th} order: Definition, examples and classifications. Initial value problems. Transport equations homogeneous and non-homogeneous, Radial solution of Laplace's Equation: Fundamental solutions, harmonic functions and their properties, Mean value Formula.

Poisson's equation and its solution, strong maximum principle, uniqueness, local estimates for harmonic functions, Liouville's theorem, Harnack's inequality.

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Unit-II:
Green's function and its derivation, representation formula using Green's function, symmetry of Green's function, Green's function for a half space and for a unit ball. Energy methods: uniqueness, Drichlet's principle.
Heat Equations: Physical interpretation, fundamental solution.Integral of fundamental solution, solution of initial value problem, Duhamel's principle, non-homogeneous heat equation, Mean value formula for heat equation, strong maximum principle and uniqueness.Energy methods.

Unit-III:
Wave equation- Physical interpretation, solution for one dimentional wave equation, D'Alemberts formula and its applications, Reflection method, Solution by spherical means Euler-Poisson_Darboux equation. Kirchhoff's and Poisson's formula (for n=2, 3 only).
Solution of non –homogeneous wave equation for n=1,3. Energy method.Uniqueness of solution, finite propagation speed of wave equation.
Non-linear first order PDE- complete integrals, envelopes, Characteristics of (i) linear, (ii) quasilinear, (iii) fully non-linear first order partial differential equations.Hamilton Jacobi equations.

Unit-IV:
Other ways to represent solutions: Method of Separation of variables for the Hamilton Jacobi equations, Laplace, heat and wave equations. Similarity solutions (plane waves, traveling waves, solitons, similarity under scaling).
Fourier Transform, Laplace Transform, Convertible non-linear into linear PDE, Cole-Hop Transform, Potential functions, Hodograph and Legendre transforms.Lagrange and Charpit methods.

Recommended Books:

1. L.C. Evans, *Partial Differential Equations*, Graduate Studies in Mathematics, American Mathematical Society, 2014.
2. Ian N. Sneddon, *Elements of Partial Differential Equations*, Dover Publications, 2006.
3. T. Amarnath, *An Elementary Course in Partial Differential Equations*, Jones & Bartlett Publishers, 2009.
4. P. Parsad and R. Ravindran, *Partial Differential Equations*, New Age / International Publishers, 2005.
5. John F. *Partial Differential Equations*, Springer-Verlag, New York, 1971.

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MSc/Maths/4/CC14
Cardinal Principles of Academic Integrity and Publications Ethics

Credits: 2 (Lectures: 30) **Marks: 50**
Duration of exam: 2 Hrs. **Theory: 30; IA: 20**

Note for the paper setter: The question paper will consist of five questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.

Course outcomes: This course will enable the students to:

1. Know Academic Integrity, Plagiarism (prevention and detection) and UGC regulations.
2. Research and Publications ethics and best practices.

Unit: 1.
Academic Integrity: Introduction, Academic Integrity Values- Honesty and Trust, Fairness and Respect, Responsibility and Courage, Violations of Academic Integrity-types and consequences, Plagiarism -definition, Plagiarism arising out of misrepresentation-contract cheating, collusion, copying and pasting, recycling, Avoiding Plagiarism through referencing and writing skills, UGC Policy for Academic Integrity and prevention, Some Plagiarism detection tools.

Unit: 2.
Research and Publication ethics: Scientific misconducts- Falsifications, Fabrication and Plagiarism (FPP), Publication ethics- definition, introduction and importance, Best practices/standard setting initiatives and guidelines-COPE, WAME etc., Violation of publication ethics, authorship and contributor-ship, Identification of publications misconduct, complains and appeals, Conflicts of Interest, Predatory publisher and journals.

Recommended Books/ Papers:

1. MacIntyre A (1967) A short History of Ethics, London
2. Chaddah P (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized. ISBN: 978-9387480865.
3. National Academy of Sciences, National Academy of Engineering and Institute of Medicine (2009) On being a Scientist: A guide to Responsible Conduct in research: Third Edition. National Academics press.
4. Resnik D. B. (2011) What is ethics in research & why is it important. National Institute of Environmental Health Sciences, 1-10.
5. Beall J (2012). Predatory publishers are corrupting open access, Nature, 489 (7415), 179.
6. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019). ISBN: 978-81-939482-1-7.

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7. UGC regulations (2018) for Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutes.
8. Ulrike kestler, Academic Integrity, Kwantlen Polytechnic University.

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MSc/Maths/4/DSC13
Mathematical Aspects of Seismology

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: Seismology is the study of earthquakes and deals with the generation and propagation of seismic waves. This course has been designed to study applications of mathematics in the field of seismology and will introduce about the interior of the Earth and basic concepts related to earthquakes viz. causes, observation and location of earthquakes, magnitude and energy etc. The students will learn the mathematical representation of waves, solutions of wave equation in different forms and wave phenomena in detail; elastic waves, their reflection and refraction; mathematical models for the propagation of surface waves and source problems.

Course Outcomes: This course will enable the students to:

1. Know mathematical representation of progressive waves and wave characteristics. Have knowledge to solve wave equation in different coordinate systems.
2. Learn dispersion of waves, representation of spherical waves and their expansion in terms of plane waves. Learn techniques to solve wave equation in order to obtain Sommerfield's integralwhich find great importance in energy transport phenomenon in science and engineering. Understand introductory concepts of earthquakes, seismology and wave propagation.
3. Learn about seismic waves and understand reflection and refraction of seismic waves. Apply knowledge of mathematics and knowledge attained in first two COs to formulate mathematical models having application in seismology and to solve such problems.
4. Understand surface waves and seismic sources (area, line and point). Attain skills to formulate and solve Lamb's problems.

Unit: 1.

Waves, General form of progressive waves, Harmonic waves, Plane waves, the wave equation, Principle of superposition. Progressive types solutions of wave equation, Stationary type solutions of wave equation in Cartesian, Cylindrical and Spherical coordinates systems, Equation of telegraphy, Exponential form of harmonic waves. D' Alembert's formula, Inhomogeneous wave equation.

Unit: 2.

Spherical waves, Expansion of a spherical wave into plane waves, Sommerfield's integral, Dispersion, Group velocity, relation between phase velocity and group velocity.

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Introduction to Seismology: Earthquakes, Location of earthquakes, Causes of Earthquakes, Observation of Earthquakes, Aftershocks and Foreshocks, Earthquake magnitude, Seismic moment, Energy released by earthquakes, Interior structure of the Earth.

Unit: 3.

Reduction of equation of motion to wave equations, P and S waves and their characteristics, Polarization of plane P and S waves, Snell's law of reflection and refraction, Reflection of plane P and SV waves at a free surface, Partition of reflected energy, Reflection at critical angles, Reflection and refraction of plane P, SV and SH waves at an interface, Special cases of Liquid-Liquid interface, Liquid-Solid interface and Solid-Solid interface.

Unit: 4.

Two dimensional Lamb's problems in an isotropic elastic solid, Area sources and Line Sources in an unlimited elastic solid, normal force acts on the surface of a semi-infinite elastic solid, tangential forces acting on the surface of a semi-infinite elastic solid, Surface waves, Rayleigh waves, Love waves and Stoneley waves.

Recommended Books:

1. C.A. Coulson and A. Jefferey, Waves, Longman, New York, 1977.
2. M. Bath, Mathematical Aspects of Seismology, Elsevier Publishing Company, 1968.
3. W.M. Ewing, W.S. Jardetzky and F. Press, Elastic Waves in Layered Media, McGraw Hill Book Company, 1957.
4. C.M.R. Fowler, The Solid Earth, Cambridge University Press, 1990
5. P.M. Shearer, Introduction to Seismology, Cambridge University Press, (UK) 1999.
6. Seth Stein and Michael Wysession, An Introduction to Seismology, Earthquakes and Earth Structure, Blackwell Publishing Ltd., 2003.
7. Bullen, K.E. and B.A. Bolt, An Introduction to the Theory of Seismology, Cambridge Universty Press, 1985.

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MSc/Maths/4/DSC14
Operation Research

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The objectives of this course are to learn scope of operation research, formulation of linear programming problems and their solutions with graphical method and Simplex method, dual problem and its relation with primal problem, transportation problems, balanced and unbalanced transportation problems, assignment problems, game theory, job sequencing, nonlinear programming methods.

Course outcomes: This course will enable the students to:

1. Understand Operation Research and its scope, graphical method and Simplex method for finding solutions of linear programming problems.
2. Know about primal problem and its dual problem, dual simplex method.
3. Understand to find solutions of transportation problems, assignment problems, traveling salesman problem.
4. Understand game theory, rule of dominance, solution of game theory problems by simplex method, nonlinear programming.

Unit: 1.

Operation Research and its Scope.The linear programming (LP) Problem, General formulation of LP problem, Graphical solution of LP problems, Slack and Surplus variables. Theory and application of Simplex Method to LP problems, Charne's M-technique, Two phase method, degeneracy, alternative optima, unbounded solutions and infeasible solutions.

Unit: 2.

Duality – Definition of dual problem, relation between optimal primal and dual solutions, Dual simplex method. Basic duality theorem, Fundamental duality theorem, Existence Theorem, Complementary slackness theorem.

Unit: 3.

Transportation problems, feasible, basic feasible and optimum solutions, finding initial basic feasible solution: North West corner rule and Vogel approximation method (VAM), Optimum solution u-v method, Degeneracy, Balanced and Unbalanced problems. Assignment problem: Hungarian method, Traveling-salesman problem. Game Theory – Two-person zero sum games, Games with mixed strategies, Minimum and maximum principle, Game with saddle point, Rule of dominance, Graphical solution, Solution by linear programming.

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Unit: 4.

Job Sequencing: Terminology and Notations, Principle assumptions, Solution of sequencing problem, Processing of n jobs through two machines, Johnson's Algorithm for n jobs two machines, Processing of n jobs through m machines. Unconstraint optimization, Constrainedmultivariables optimization, Language multiplier method, Nonlinear programming method, Kuhn Tucker conditions of optimality, Graphical method.

Recommended Books:

1. F. S. Hiller and G. J. Lieberman; Introduction to Operations Research (Sixth Edition), McGraw Hill international Edition, Industrial Engineering Series, 1995.
2. G. Hadley; Linear Programming, Narosa Publishing House, 1995.
3. G. Hadly; Nonlinear and Dynamic Programming, Addison-Wesley, Reading Mass.
4. H. A. Taha; Operation Research – An introduction, Macmillan Publishing Co. Inc., New York.
5. KantiSwarup, P. K. Gupta and Man Mohan; Operations Research, Sultan Chand & Sons, New Delhi.

MSc/Maths/4/DSC15
Advanced Fluid Mechanics

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: This course deals with mechanics of real (viscous) fluids and objective of this course is to let the students have deep understanding of dynamics of viscous fluids and boundary layer theory. This is a strong foundation course to pursue research in the areas of Fluid Mechanics, Computational Fluid Dynamics, Bio-Mechanics, Mathematical Modeling and Mathematical Biology.

Course Outcomes: This course will enable the students to:

1. Have knowledge to understand Vorticity, vortices, Vortex doublet and Images; Newton's Law of viscosity and Stresses in a fluid.
2. Have knowledge of strain rate, relations between stresses and strain rate and equations of motion for viscous fluids.
3. Understand different kinds of flows; Steady and unsteady flow through different channels.
4. Recognize the concepts of dynamical similarity, dimensional analysis and Buckingham π-theorem with its applications; the concept of boundary layer and the associated theory.

Unit: 1

Vorticity in two dimensions, Circular and rectilinear vortices, Vortex doublet, Images, Motion due to vortices, Single and double infinite rows of vortices, Karman vortex sheet.
Newton's Law of viscosity, Newtonian and non-Newtonian fluids, Stress components in a real fluid, State of stress at a point, Nature of stresses, transformation of stress components, Relation between Cartesian components of stress.

Unit: 2

Translational motion of fluid element, Rates of strain. Transformation of rates of strain, Principal stress & strain rate, Relation between stresses and rates of strain.The co-efficient of viscosity and laminar flow.
Navier-Stoke equations of motion.Equations of motion in cylindrical and spherical polar co-ordinates.Diffusion of vorticity.Energy dissipation due to viscosity.

Unit: 3

Plane Poiseuille and Couette flows between two parallel plates. Theory of lubrication.Hagen Poiseuille flow. Steady flow between co-axial circular cylinders and concentric rotating

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cylinders. Flow through tubes of uniform elliptic and equilateral triangular cross-section. Unsteady flow over a flat plate. Steady flow past a fixed sphere. Flow in convergent and divergent channels.

Unit: 4

Dynamical similarity, Inspection analysis, Non-dimensional numbers, Dimensional analysis.Buckingham pi-theorem and its application, Physical importance of non-dimensional parameters.

Prandtl boundary layer, Boundary layer equation in two-dimensions, The boundary layer on a flat plate (Blasius solution), Characteristic boundary layer parameters, Karman integral conditions, Karman-Pohlhausen method.

Recommended Books:

1. W.H. Besant and A.S. Ramsey, A Treatise on Hydromechanics, Part-II, CBS Publishers, Delhi, 1988.
2. F. Chorlton, Text-book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985.
3. Michael E.O. Neill and F. Chorlton, Ideal and Incompressible Fluid Dynamics, John Wiley & Sons, 1986.
4. S. W. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India Ltd., New Delhi, 1976.
5. G.K. Batchelor, An Introduciton to Fluid Mechanics, Foundation Books, New Delhi, 1994.
6. H. Schlichting, Boundary Layer Theory, McGraw Hill Book Company, New York, 1979.
7. R.K. Rathy. An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi. 1976.
8. A.D. Young, Boundary Layers, AIAA Education Series, Washington DC, 1989.

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MSc/Maths/4/DSC16
Boundary Value Problems

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The objective of this course is to learn to solve the boundary value problems. Boundary value problems find applications in all area of science and engineering. The different techniques to solve boundary value problems and mixed boundary value problems are studied in this course. Such problems can be solved with Green's function approach, Integral transform methods and by using Perturbation techniques. One of the objectives to study this course is to expose a student to real world problems that are formulated as boundary value problems.

Course Outcomes: This course will enable the students to:

1. Reduce boundary value problems involving ODEs to the equivalent integral and to solve such problems with Green's function and Modified Green's function approaches. Apply these techniques in problem solving.
2. Learn to find solutions of boundary value problems involving Laplace's equation, Poisson's equation and Helmholtz's equation by using theory of integral equations and Green's function. Attain skill to solve such BVP which arise frequently in different branches of engineering and sciences.
3. Learn to solve the integral equations by integral transform methods. Apply the gained knowledge in solving mixed boundary problems.
4. Understand Perturbation methods and attain capability to apply perturbation techniques in solving different listed boundary value problems of Electrostatics, Hydrodynamics and Elasticity.

Unit-I:
Applications to Ordinary Differential Equations; Initial value problems, Boundary Value Problems. Dirac Delta functions. Green's function approach to reduce boundary value problems of a self-adjoint-differential equation with homogeneous boundary conditions to integral equation forms. Green's function for N^{th}-order ordinary differential equation.Modified Green's function.

Unit-II:
Applications to partial differential equations: Integral representation formulas for the solution of the Laplace and Poisson Equations. The Newtonian, single-layer and double-layer potentials, Interior and Exterior Dirichlet problems, Interior and Exterior Neumann problems.Green's function for Laplace's equation in a free space as well as in a space

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bounded by a ground vessel.Integral equation formulation of boundary value prolems for Laplace's equation.Poisson's Integral formula. Green's function for the space bounded by grounded two parallel plates or an infinite circular cylinder. The Helmholtz equation.

Unit-III:

Integral Transform methods: Introduction, Fourier transform. Laplace transform. Convolution Integral.Application to Volterra Integral Equations with convolution-type Kernels. Hilbert transform.

Applications to mixed Boundary Value Problems: Two-part Boundary Value problems, Three-part-Boundary Value Problems, Generalized Three-part Boundary Value problems.

Unit-IV:

Integral equation perturbation methods: Basic procedure, Applications to Electrostatics, Low-Reynolds-Number Hydrodynamics: Steady stokes Flow, Boundary effects on Stokes flow, Longitudinal oscillations of solids in stokes Flow, Steady Rotary Stokes Flow, Rotary Oscillations in Stokes Flow, Rotary Oscillation in Stokes Flow, Oseen Flow-Translation Motion, Oseen Flow-Rotary motion Elasticity, Boundary effects, Rotation, Torsion and Rotary Oscillation problems in elasticity, crack problems in elasticity, Theory of Diffraction.

Recommended Books:

1. Ram P. Kanwal, *Linear Integral Equations: Theory & Techniques*, Springer Science & Business Media, 2012.
2. S.G. Mikhlin, *Linear Integral Equations* (translated from Russian) ,Hindustan Book Agency, 1960.
3. F.G Tricomi, *Integral Equations,* Courier Corporation, 1985.
4. Abdul J. Jerri, *Introduction to Integral Equations with Applications*, Wiley-Interscience, 1999.
5. Ian N. Sneddon, *Mixed Boundary Value Problems in potential theory*, North Holland Publishing Co., 1966.
6. IvarStakgold, *Boundary Value Problems of Mathematical Physics*Vol.I, II, Society for Industrial and Applied Mathematics, 2000.

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MSc/Maths/4/DSC17
Advanced Topology

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The main objective of this course is to familiarize with some advanced topics in topology. Starting from the convergence of sequences in topological spaces and in first axiom topological spaces, we move on to the introduction and convergence of nets in topological spaces followed by canonical way of converting nets to filters and vice versa. The concepts of metrisable spaces and paracompactness also form a part of the course along with some topics from algebraic topology including the fundamental group, Euclidean simplexes, singular simplexes etc.

Course Outcomes: This course will enable the students to:

1. Know about nets in topological spaces; learn canonical way of converting nets to filters and vice versa; understand the concepts of connectedness and local connectedness.
2. Have understanding of metrisable spaces and Urysohn'smetrisation theorem; know about locally finite family and its equivalent forms, paracompactness of a metrisable space; apply knowledge to prove Nagata-Smirnov metrisation theorem and Smirnov metrisation theorem.
3. Understand homotopy classes, fundamental group, Euclidean simplexes and related concepts.
4. Learn about singular simplexes homology and relative homology groups; demonstrate understanding of the statement and proof of the excision theorem.

Unit: 1.
Convergence of sequences in topological spaces and in first axiom topological spaces, Nets in topological spaces, convergence of nets, Hausdorffness and convergence of nets, Subnets and cluster points, canonical way of converting nets to filters and vice versa, their convergence relations.
(Scope as in theorems 2-3,5-8 of Chapter 2 of Kelley's book recommended at Sr. No.1)
Connected spaces, connected subspaces of the real line, components and local connectedness.
(Scope as in relevant portions of sections 23-26 of Chapter 3 of the book by 'Munkres' recommended at Sr. No. 2)

Unit: 2.
Definition and examples of metrisable spaces,Urysohn'smetrisation theorem. Locally finite family, its equivalent forms, countably locally finite family, refinement, open refinement,

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closed refinement of a family, existence of countably locally finite open covering of a metrisable space, Nagata-Smirnov metrisation theorem, Paracompactness, normality of a paracompactHausdorff space, paracompactness of a metrisable space and of regular Lindelof space, Smirnov metrisation theorem.
(Scope as in theorems 34.1, 39.1-39.2. 40.3, 41.1-41.5 and 42.1 of Chapter 6 of the book by 'Munkres' recommended at Sr. No. 2)

Unit: 3.
Relation of homotopy of paths based at a point and homotopy classes, product of homotopy classes, Fundamental group, change of base point topological invariance of fundamental group.
(scope as in relevant parts of Chapter IV of the book by 'Wallace' recommended at Sr. No.3)
Euclidean simplex, its convexity and its relation with its faces, standard Euclidean simplex, linear mapping between Euclidean simplexes of same dimension.
(scope as in relevant parts of Chapter V of the book by 'Wallace' recommended at Sr. No.3)

Unit: 4.
Singular simplexes and group of p-chains on a space, special singular simplex on and its boundary, induced homomorphism between groups of chains, boundary of a singular simplex and a chain, cycles and boundaries on a space, homologous cycles, homology and relative homology groups, induced homomorphism on relative homology groups, induced homomorphism on relative homology groups, topological invariance of relative homology groups, Prisms, homotopic maps and homology groups.
(Scope as in relevant parts of Chapter VI of the book by 'Wallace' recommended at Sr. No.3)
Join of a point and a chain, Barycentric subdivision operator B, diameter of a Euclidean simplex and a singular simplex, operator H and its relation with B, representation of an element of a relative cycle made up of singular simplexes into members of a given open cover of the space, the excision theorem
(Scope as in relevant parts of Chapter VII of the book by 'Wallace' recommended at Sr. No.3)

Recommended Books:

1. J.L.Kelley, General Topology, Springer Verlag, New York, 2012.
2. J.R.Munkres, Topology, Pearson Education Asia, 2002.
3. A.H.Wallace, Introduction to Algebraic Topology, Dover Publications, 2007
4. K. ChandrasekharaRao, Topology, Narosa Publishing House Delhi,2009.
5. Fred H. Croom, Principles of Topology, Cengage Learning, 2009.
6. K.D. Joshi, Introduction to General Topology, Wiley Eastern Ltd, 2006.
7. C.W.Patty, Foundation of Topology, Jones &Bertlett, 2009.
8. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1983.

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MSc/Maths/4/DSC18
Algebraic Coding Theory

Credits: 4 (Lectures: 60) | **Marks: 100**
Duration of exam: 3 Hrs. | **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The course contains systematic study of coding and communication of messages. This course is concerned with devising efficient encoding and decoding procedures using modern algebraic techniques. The course begins with basic results of error detection and error correction of codes, thereafter codes defined by generator and parity check matrices are given. The course also contains polynomial codes, Hamming codes, construction of finite fields and thereafter the construction of BCH codes. Linear codes, MDS codes, Reed-Solomon codes, Perfect codes, Hadamard matrices and Hadamard codes are also the part of the course.

Course Outcomes: This course will enable the students to:

1. Understand group codes, matrix encoding techniques, polynomial codes and Hamming codes.
2. Have deep understanding of finite fields, BCH codes.
3. Learn about linear codes, cyclic codes, self dual binary cyclic codes.
4. Learn about MDS codes, Hadamard matrices and Hadamard codes.

Unit: 1.
Group codes, elementary properties, matrix encoding techniques. Generator and parity check matrices, polynomial codes. Vector space and polynomial ring, binary representation of numbers, Hamming codes.
(Chapter 1, 2 & 3 of recommended book at Sr. No. 1)

Unit: 2.
Basic properties of finite fields, irreducible polynomial over finite field, roots of unity.
(Sections 7.1 to 7.3 of recommended book at Sr. No. 2)
Some examples of primitive polynomials, BCH codes.
(Chapter 4 of recommended book at Sr. No. 1)

Unit: 3.
Linear codes, generator and parity check matrices, dual code of a linear code, Weight distribution of the dual code of a binary linear code, new codes obtained from given codes, cyclic codes, check polynomials, BCH and Hamming codes as cyclic codes, Non-binary Hamming codes, Idempotent , solved examples and invariance property, cyclic codes and group algebras, self dual binary cyclic codes.

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(Chapter 5, 6 of recommended book at Sr. No. 1)

Unit: 4.

Necessary and sufficient condition for MDS codes, the weight distribution of MDS codes, an existence problem, Read Solomon codes. Hadamardmatrices andHadamard codes.
(Chapter 9 and 11 of recommended book at Sr. No. 1)

Recommended Books:

1. L.R. Vermani, Elements of Algebraic Coding Theory, CRC Press, 1996.
2. Steven Roman, Coding and Information Theory, Springer-Verlag, 1992.

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MSc/Maths/4/DSC19
Bio-Mathematics

Credits: 4 (Lectures: 60) | **Marks: 100**
Duration of exam: 3 Hrs. | **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course objectives: This paper deals with a widely acceptable fact that many phenomena in life sciences and environment sciences can be modelled mathematically. Biology offers a rich variety of topics that are amenable to mathematical modeling, but some of the genuinely interesting are touched in this paper. It is assumed that students have no knowledge of biology, but they are expected to learn a substantial amount during the course. The ability to model problems using mathematics may not require much of the memorization, but it does require a deep understanding of basic principles and a wide range of mathematical techniques. Students are required to know differential equations and linear algebra. Topics in stochastic modeling are also touched, which requires some knowledge of probability.

Course outcomes: This course will enable the students to:

1. Derive population growth laws/models regulated through logistic equation, involving species competition, Lotka-Volterra predator-prey equations to develop the theory of age-structured populations using both discrete- and continuous-time models for their applications in life cycle of a hermaphroditic worm.
2. Model smaller populations those exhibit stochastic effects so as to analyze births rates in finite populations for their role in mathematical models of infectious disease epidemics and endemics so as to predict the future spread of a disease and to develop strategies for containment and eradication.
3. Learn the mathematical modeling of the evolution/maintenance of polymorphism to understand population genetics, influence of natural selection, genetic drift, mutation, and migration (i.e., evolutionary forces) in changing the Allele frequencies.
4. Derive mathematical models for biochemical reactions, including catalyzed by enzymes, based on the law of mass action, enzyme kinetics, fundamental enzymatic properties (i.e., competitive inhibition, allosteric inhibition, cooperativity) so as to know about DNA chemistry and the genetic code for alignment of DNA/RNA sequences by brute force, dynamic programming or gaps.

Unit: 1.

Population Dynamics: The Malthusian growth; The Logistic equation; A model of species competition; The Lotka-Volterra predator-prey model;
Age-structured Populations: Fibonacci's rabbits; The golden ratio Φ; The Fibonacci numbers in a sunflower; Rabbits are an age-structured population; Discrete age-structured populations; Continuous age-structured populations; The brood size of a hermaphroditic worm.

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Unit: 2.

Stochastic Population Growth : A stochastic model of population growth; Asymptotics of large initial populations; Derivation of the deterministic model; Derivation of the normal probability distribution; Simulation of population growth.

Infectious Disease Modeling: The SI model; The SIS model; The SIR epidemic disease model; Vaccination ; The SIR endemic disease model ; Evolution of virulence.

Unit: 3.

Population Genetics: Haploid genetics; Spread of a favored allele; Mutation-selection balance; Diploid genetics; Sexual reproduction; Spread of a favored allele; Mutation-selection balance; Heterosis; Frequency-dependent selection; Linkage equilibrium; Random genetic drift.

Unit: 4.

Biochemical Reactions: The law of mass action; Enzyme kinetics; Competitive inhibition; Allosteric inhibition; Cooperativity. Sequence Alignment: DNA ; Brute force alignment; Dynamic programming; Gaps; Local alignments; Software.

Recommended Books:

1. Mathematical Biology, Lecture notes for MATH 4333, (Jeffrey R. Chasnov)
2. Mathematical Biology I. An Introduction, Third Edition, (J.D. Murray)

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MSc/Maths/4/DSC20
Algebraic Number Theory

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course Objectives: The concept of ALGEBRAIC NUMBER THEORY is surely one of the recent ideas of mathematics. The main aim of this course is to introduce Norm and trace, Ideals in the ring of algebraic number field, Dedekind domains, Fractional ideals, Chinese Remainder theorem, Different of an algebraic number field, Hurwitz constant, Ideal class group, Minkowski's bound and Quadratic reciprocity.

Course Outcomes: This course will enable the students to:

1. Understand concept of integral bases and discriminant of algebraic number field, ring of algebraic integers and ideal in the ring of algebraic integers
2. Learn about integrally closed domains, Dedekind domain, fractional ideals and unique factorization , different of an algebraic number field, Dedekind theorem
3. Learn about Hurwitz's lemma, Hurwitz constant, finiteness of the ideal class group, class number of an algebraic number field, Diophantine equations, minkowski's bound
4. Understand Legendre symbol, gauss sums, law of quadratic reciprocity, quadratic field, primes in special progression, class number of quadratic fields

Unit: 1.
Norm and trace of algebraic numbers and algebraic integers, Bilinear map on algebraic number field K. Integral basis and discriminant of an algebraic number field, Index of an element of K, Ring O_k of algebraic integers of an algebraic number field K. Ideals in the ring of algebraic number field K.

Unit: 2.
Integrally closed domains.Dedekind domains. Fractional ideals of K. Factorization of ideals as a product of prime ideals in the ring of algebraic integers of an algebraic number field K. G.C.D. and L.C.M. of ideals in O_k.Chinese Remainder theorem, order of ideal in prime ideal, ramification degree of prime ideals, different of an algebraic number field K, Dedekind theorem.

Unit: 3.
Euclidean rings.Hurwitz Lemma and Hurwitz constant.Equivalent fractional ideals.Ideal class group.Finiteness of the ideal class group. Class number of the algebraic number field K. Diophantine equations, Minkowski's bound.

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Chairperson Associate Prof. Assistant Prof.

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PGBOS&R in its meeting held on 18-06-2021

Unit: 4.

Legendre Symbol, Jacobi symbol, Gauss sums, Law of quadratic reciprocity, Quadratic fields, Primes in special progression, class number of quadratic fields.
(Chapter 4, 5, 6 & 7 of recommended book no. 1)

Recommended Books:

1. Jody Esmonde and M.RamMurty, Problems in Algebraic Number Theory, Springer Verlag, 1998.
2. Paulo Ribenboim: Algebraic Numbers, Wiley-Interscience, 1972.
3. R. Narasimhan and S. Raghavan: Algebraic Number Theory, Mathematical Pamphlets-4,Tata Institute of Fundamental Research,1966.

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MSc/Maths/4/DSC21
Advanced Numerical Analysis

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Note for the paper setter: The question paper will consist of nine questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each selecting at least one question from each unit.

Course objectives: This course considers the high-end numerical methods, which are often required to get the numerical results from research studies in applied sciences and engineering. The objective of the course is to equip learners with specialized tools for solving transcendental and polynomial equations, system of linear equations, eigen-value problems, numerical differentiation, numerical integration, ordinary/partial differential equations so as to enable them to draw the algorithm of these numerical methods that form the basis to write source programs in any programming language.

Course outcomes: This course will enable the students to:

1. Learn about errors which arise during computation due to roundoff or truncation or number representation and the high-end numerical methods for solving transcendental and polynomial equations.
2. Attain the skills of solving system of linear equations using direct and iterative schemes and analysis of such schemes. Know to apply finite difference schemes/operators for numerical differentiation.
3. Learn advanced numerical methods to evaluate integrals for solving linear/non-linear first/second order IVP/BVP involving ODEs .
4. Understand the finite difference methods for solving parabolic, elliptic and hyperbolic PDEs and attain capability to use such methods in scientific problem solving.

Unit: 1.
Error Analysis: Errors, Absolute, relative and percentage errors; Significant digits and numerical instability, Propagation of errors in arithmetic operations, Significant errors, Representation of numbers in computer, Normalized floating point representation and its effects.
Solution of Polynomial and Transcendental Equations: Iteration methods; First order, second order and higher order methods, Accelaration of the convergence, Efficiency of a method, Newton-Raphson method for multiple roots, Modified Newton-Raphson method, Muller method and Chebyshev method, Birge-Vieta method, Bairstow method, Graeffe's root squaring method, Solutions of systems of non-linear equations.

Unit: 2.
Systems of Linear Equations: Matrix inverse methods, Triangularization method, Cholesky Method, Matrix partition method, Operation count, Ill-conditioned linear systems, Moore-

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Penrose inverse method, Least square solutions for inconsistent systems. Iteration methods Successive over relaxation (SOR) method, Convergence analysis. Eigen values and eigenvectors, bounds on eigen values, Given's method, Rutishauser method, Householder's method for symmetric matrices, Power method.
Numerical Differentiation based on difference formulae, Richardson's extrapolation method, Cubic spline method, Method of undetermined coefficients.

Unit: 3.
Numerical Integration: Weddle's rule, Newton-Cotes method, Gauss-Legendre, Gauss-Chebyshev, Gauss-Laguerre, and Gauss-Hermite integration methods. Composite integration method, Euler-Maclaurin's formula, Romberg Integration, Double integration.
Numerical Solution of Ordinary Differential Equations: Estimation of local truncation error of Euler and single step methods. Bounds of local truncation error and convergence analysis of multistep methods, Predictor-Corrector methods; Adams-Bashforth methods, Adams-Moulton formula, Milne-Simpson method, System of Differential Equations.Finite difference method for solving second order IVPs and BVPs, Shooting method for boundary value problems.

Unit: 4.
Solving Partial Differential Equations: Finite difference approximations to partial derivatives, solving parabolic equations using implicit and explicit formulae, C-N scheme and ADI methods; solving elliptic equations using Gauss-elimination, Gauss-Seidel method, SOR method, and ADI method, solving hyperbolic equations using method of characteristics, explicit and implicit methods, Lax-Wendroff's method.

Recommended Books:

1. Gupta, R. S., *Elements of Numerical Analysis*, Cambridge Univ. Press, 2015.
2. Jain, M. K., Iyengar, S.R.K. and Jain, R.K., *Numerical Methods for Scientific and Engineering Computation*, 6th Edition, New Age International Publishers, 2012.
3. Pal, M., *Numerical Analysis for Scientists and Engineers*, Narosa Publishing House Pvt. Ltd., 2008.
4. Mathews, John H. and Fink Kurtis D., *Numerical Methods Using Matlab*, Fourth edition; PHI Learning Private Ltd., 2009.
5. Gourdin, A. and Boumahrat, M., *Applied Numerical Methods*, PHI Learning Private Ltd., 2004.

(Prof. Aseem Miglani) Chairperson | (Prof. Neelam Kumari) Associate Prof. | (Mr. Sandeep Kumar) Assistant Prof.

MSc/Maths/4/SEC4
Computer Programming in LATEX

Credits: 2 (Hours: 60) **Marks: 50**
Duration of exam: 3 Hrs.

Note for the practical examiner: The examiner will set 4 questions at the time of practical examination. The examinee will be required to write two programs and execute one program successfully. The evaluation will be done on the basis of practical record, viva-voce, written exam and execution of the program.

Course Objectives: This is a laboratory course and objective of this course is to make students aware about preparing presentations and maintain course notes. This will also train them to write letters, books, thesis and scientific papers.

Practical Course Outcomes: This course will enable the students to:

1. Know the mathematical notations, consistent handling of intra-document references and bibliography and to write typesetting code for a program in LATEX.
2. Collaborative editing, interpret and execute the source program for desired results.

Computing lab work will be based on programming in LATEX. There will be 12-15 problems/ programmes during the semester.

Recommended Books:

1. LATEX tutorials; A PRIMER Indian TEX users group, Trivandrum, INDIA, 2003.
2. Kottwitz, Stefan; LaTeX beginner's guide, Packt Publishing, BIRMINGHAM-MUMBAI.

(Prof. Aseem Miglani)
Chairperson

(Prof. Neelam Kumari)
Associate Prof.

(Mr. Sandeep Kumar)
Assistant Prof.