

**Annexure-I**

**Outline of Scheme of M.Sc. (Mathematics) Semester System  
According to Choice Based Credit System (CBCS)  
For Department of Mathematics, CDLU, Sirsa**

The following types of courses shall be covered under choice based credit system:

- (a) Core Courses (CC)
- (b) Core Elective Courses (CEC)
- (c) Open Elective courses (OEC)

Outline of Scheme of M.Sc. (Mathematics) Semester System according to Choice Based Credit System (CBCS) is as under:

**1. For Core Courses and Core Elective Courses**

Courses Semester	Core Courses	Core Elective Courses	Total Credit (Sem. wise)
1 <sup>st</sup>	5 Theory Papers & 1 Comp. Practical (Each of Credit 4)	-----	24
2 <sup>nd</sup>	4 Theory Papers (Each of Credit 4)	2 Papers (Each of Credit 4)	24
3 <sup>rd</sup>	2 Theory Papers (Each of Credit 4)	3 Theory Papers (Each of Credit 4)	20
4 <sup>th</sup>	2 Theory Papers & 1 Comp. Practical (Each of Credit 4)	3 Theory Papers (Each of Credit 4)	24
<b>Total Credit (Course wise)</b>	60	32	92

**2. For Open Elective Courses**

**(a) For the students of Department of Mathematics:**

In addition of the above Core Courses and Core Elective Courses, students of this department have to opt open elective course(s) offered by University Teaching Departments (except Open Elective Courses offered by Mathematics Department) of total credit at least 10 and maximum 12 in all four semesters.

**(b) For the students of the Departments (other than Department of Mathematics) of the University:**

Department of Mathematics offers following open elective courses for the students of other teaching departments of the University.

Sr. No.	Paper Code	Title of the paper/ Subject	Remarks
01	MTHOE-1301	Basic mathematics	To be offered in odd semesters
02	MTHOE-2402	Descriptive Statistics	To be offered in even semesters

Detailed syllabi is attached as **Annexure-'A'**

**Note:** All the terms and conditions are strictly according to Ordinance of Choice Based Credit System of the University circulated vide letter no. AC-II/16/2525-52, Dated 25-07-2016.

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**Scheme/Structure of Examination**  
**M.Sc. (Mathematics) Semester System**  
**According to Choice Based Credit System (CBCS)**  
**For Department of Mathematics, CDLU, Sirsa**

**M. Sc. (Previous) Mathematics (with effect from session 2017-18)**

Paper Code No.	Title of the paper/ Subject	Hrs per week L+P	Marks (Theory)	Marks (Internal Assessment)	Marks (Practical)	Total Marks	Credit
<b>Semester-I</b> <b>(Core Courses)</b>							
MTHCC-2101	Abstract Algebra	4+0	70	30	00	100	4
MTHCC-2102	Real Analysis	4+0	70	30	00	100	4
MTHCC-2103	Mechanics	4+0	70	30	00	100	4
MTHCC-2104	Complex Analysis	4+0	70	30	00	100	4
MTHCC-2105	Ordinary Differential Equations	4+0	70	30	00	100	4
MTHCC-2106	Computer Programming in ANSI C	0+4	00	00	100	100	4
<b>Semester-II</b> <b>(Core Courses)</b>							
MTHCC-2201	Advanced Abstract Algebra	4+0	70	30	00	100	4
MTHCC-2202	Measure & Integration Theory	4+0	70	30	00	100	4
MTHCC-2203	Mechanics of Solids	4+0	70	30	00	100	4
MTHCC-2204	System of Differential Equations	4+0	70	30	00	100	4
<b>(Core Elective Courses)</b> <b>(Any two of the following)</b>							
MTHCE-2205	Computer Programming in FORTRAN 90 & 95	2+2	30	20	50	100	4
MTHCE-2206	Methods of Applied Mathematics	4+0	70	30	00	100	4
MTHCE-2207	Differential Geometry	4+0	70	30	00	100	4
MTHCE-2208	Mathematical Modeling	4+0	70	30	00	100	4

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**Scheme/Structure of Examination**  
**M.Sc. (Mathematics) Semester System**  
**According to Choice Based Credit System (CBCS)**  
**For Department of Mathematics, CDLU, Sirsa**

**M. Sc. (Final) Mathematics (with effect from session 2018-19)**

Paper Code No.	Title of the paper/ Subject	Hrs per week L+P	Marks (Theory)	Marks (Internal Assessment)	Marks (Practical)	Total Marks	Credit
<b>Semester-III</b>							
<b>(Core Courses)</b>							
MTHCC-2301	Topology	4+0	70	30	00	100	4
MTHCC-2302	Fluid Mechanics	4+0	70	30	00	100	4
<b>(Core Elective Courses)</b> <b>(Any three of the following)</b>							
MTHCE-2303	Integral Equations	4+0	70	30	00	100	4
MTHCE-2304	Mathematical Statistics	4+0	70	30	00	100	4
MTHCE-2305	Advanced Complex Analysis	4+0	70	30	00	100	4
MTHCE-2306	Advanced Mechanics of Solids	4+0	70	30	00	100	4
MTHCE-2307	Advanced Discrete Mathematics	4+0	70	30	00	100	4
MTHCE-2308	Fuzzy Sets and Fuzzy Logic	4+0	70	30	00	100	4
MTHCE-2309	Information Theory	4+0	70	30	00	100	4
MTHCE-2310	Difference Equations	4+0	70	30	00	100	4
MTHCE-2311	Financial Mathematics	4+0	70	30	00	100	4
MTHCE-2312	Number Theory	4+0	70	30	00	100	4
MTHCE-2313	Wavelet Analysis	4+0	70	30	00	100	4

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Paper Code No.	Title of the paper/ Subject	Hrs per week L+P	Marks (Theory)	Marks (Internal Assessment)	Marks (Practical)	Total Marks	Credit
<b>Semester-IV</b>							
<b>(Core Courses)</b>							
MTHCC-2401	Functional Analysis	4+0	70	30	00	100	4
MTHCC-2402	Partial Differential Equations	4+0	70	30	00	100	4
MTHCC-2403	Computer Programming in MATLAB	0+4	00	00	100	100	4
<b>(Core Elective Courses)</b>							
<b>(Any three of the following)</b>							
MTHCE-2404	Mathematical Aspect of Seismology	4+0	70	30	00	100	4
MTHCE-2405	Operation Research	4+0	70	30	00	100	4
MTHCE-2406	Advanced Fluid Mechanics	4+0	70	30	00	100	4
MTHCE-2407	Boundary Value Problem	4+0	70	30	00	100	4
MTHCE-2408	Algebraic Topology	4+0	70	30	00	100	4
MTHCE-2409	Analytic Number Theory	4+0	70	30	00	100	4
MTHCE-2410	Algebraic Coding Theory	4+0	70	30	00	100	4
MTHCE-2411	Control Theory	4+0	70	30	00	100	4
MTHCE-2412	Bio-Mechanics	4+0	70	30	00	100	4
MTHCE-2413	Algebraic Number Theory	4+0	70	30	00	100	4

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**MTHOE-1301: Basic Mathematics**

**Marks (Theory): 70**

**Marks (Internal Assessment): 30**

**Marks (Total): 100**

**Time: 03 Hours**

**Total Credit: 04**

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

**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.

**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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**MTHOE-2402: Descriptive Statistics****Marks (Theory): 70****Marks (Internal Assessment): 30****Marks (Total): 100****Time: 03 Hours****Total Credit: 04**

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

**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 ( $\sigma$ ), 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.

**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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MTHCC-2101: Abstract Algebra

Marks (Theory): 70  
Marks (Internal Assessment): 30

Marks (Total): 100  
Time: 03 Hours  
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.  
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.  
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

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 conjugacy classes. 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  $A_n$  ( $n \geq 5$ ). Zassenhaus's Lemma. 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 Abelian groups. Cauchy theorem for finite groups. p-groups. Finite Abelian groups. Sylow p-subgroups. Sylow's Ist, IInd and IIIrd theorems. Application of Sylow theory to groups of smaller orders.

Unit: 2.

Commutators identities. Commutator subgroups. Three subgroups Lemma of P.Hall. Central series of a group G. Nilpotent groups. Centre of a nilpotent group. Subgroups and factor 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. Non-solvability of the symmetric group  $S_n$  and the Alternating group  $A_n$  ( $n \geq 5$ ).

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 rings  $End_Z(M)$  and  $End_R(M)$  of a left R-module M. 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. Representation of linear mappings and their ranks.

Unit: 4.

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 change conditions (A.C.C. and D.C.C.). Noetherian modules and Noetherian rings. 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. Noether-laskar Theorem.

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**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. Vivek Sahai and Vikas Bist; Algebra (Narosa publication House)
5. Surjit Singh and Quazi Zameeruddin; Modern Algebra (Vikas Publishing House 1990)
6. W.R. Scott; Group Theory.

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**MTHCC-2102: Real Analysis**

**Marks (Theory): 70**

**Marks (Internal Assessment): 30**

**Marks (Total): 100**

**Time: 03 Hours**

**Total Credit: 04**

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

**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).

**Unit: 3.**

Functions of several variables : Linear transformations, the space of linear transformations on  $\mathbb{R}^n$  to  $\mathbb{R}^m$  as a metric space, open sets, continuity, derivative in an open subset of  $\mathbb{R}^n$ , 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

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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, 4<sup>th</sup> Edition 2010
9. D. Somasundaram and B. Choudhary : A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi, 1997.

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MTHCC-2103: Mechanics

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

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.

Hamilton's variables. Don kin'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 & Pramod Sharad 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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MTHCC-2104: Complex Analysis

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Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04


Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

**Unit: 1.**

Analytic functions, Harmonic functions, Uniquely determined analytic function Reflection *Principle*  function, Path in a region, Smooth path, p. w. smooth path, contour, Simply connected region, Multiply connected region, Complex integration, Cauchy-Goursat theorem, Cauchy theorem for simply connected and multiply connected domains.

**Unit: 2.**

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

**Unit: 3.**


Power series and its convergence, Radius of convergence, Sum and product, Differentiability of sum function of power series, Entire function, Radius of convergence of an entire function, Property of a differentiable function with derivative zero,  $\exp z$  and its properties,  $\log z$ , Power of a complex number  $z$ , their branches with analyticity, Zeros of an analytic function, Singularity and their classification, Pole of a function and its order.

**Unit: 4.**

Laurent series, Cassorati-Weierstrass theorem, Meromorphic functions, The Argument principle, Rouché's theorem, Inverse function theorem, Cauchy residue theorem, Evaluation of integrals, Bilinear transformation, their properties and classification, Definition and examples of conformal mapping.

**Books Recommended:**

1. H. A. Priestly; Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.
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. J. W. Brown and R. V. Churchill; Complex Variables and Applications, McGraw Hill, 1996.

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MTHCC-2105: Ordinary Differential Equations

Marks (Theory): 70  
Marks (Internal Assessment): 30

Marks (Total): 100  
Time: 03 Hours  
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.  
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.  
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Preliminaries: Initial value problem and equivalent integral equation,  $\epsilon$ -approximate solution, equicontinuous set of functions. Basic theorems: Ascoli- Arzela theorem, Cauchy -Peano existence theorem and its corollary. Gronwall's inequality.  
Lipschitz condition. Uniqueness of solutions. Successive approximations. Picard-Lindelöf theorem. Continuation of solution, Maximal interval of existence, Extension theorem.  
(Relevant portions from the book of 'Theory of Ordinary Differential Equations' by Coddington and Levinson.

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. More Wronskian theory. 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.  
(Relevant portions from the books of 'Theory of Ordinary Differential Equations' by Coddington and Levinson and the book 'Differential Equations' by S.L. Ross)

Unit: 3.

Linear second order equations: Preliminaries, self adjoint equation of second order, basic facts. Superposition Principle. Riccati's equation. Prüfer 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. Elementary linear oscillations.  
(Relevant portions from the book 'Differential Equations' by S.L. Ross and the book 'Textbook of Ordinary Differential Equations' by Deo et al.)

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.

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Green's function. Applications of Green's function for solving boundary value problems. Use of Implicit function theorem and Fixed point theorems for periodic solutions of linear and non-linear equations.

(Relevant portions from the book 'Textbook of Ordinary Differential Equations' by Deo et. al.)

**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. P. Hartman, Ordinary Differential Equations, John Wiley & Sons NY, 1971.
5. G. Birkhoff and G.C. Rota, Ordinary Differential Equations, John Wiley & Sons, 1978.
6. G.F. Simmons, Differential Equations, Tata McGraw-Hill, 1993.
7. I.G. Petrovski, Ordinary Differential Equations, Prentice-Hall, 1966.
8. D. Somasundaram, Ordinary Differential Equations, A first Course, Narosa Pub., 2001.
9. Mohan C Joshi, Ordinary Differential Equations, Modern Perspective, Narosa Publishing House, 2006

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MTHCC-2106: Computer Programming in ANSI C

Marks: 100  
Total Credit: 04

Implementation of the following programs in ANSI C.

1. Use of nested **if.. else** in finding the smallest of four numbers.
2. To find if a given 4-digit year is a leap year or not.
3. To compute AM, GM and HM of three given real values.
4. To invert the order of digits in a given positive integral value.
5. Use series sum to compute **sin(x)** and **cos(x)** for given angle **x** in degrees. Then, check error in verifying **sin<sup>2</sup>x+cos<sup>2</sup>(x)=1**.
6. Verify  $\sum n^3 = \{\sum n\}^2$ , (where  $n=1,2,\dots,m$ ) & check that prefix and postfix increment operator gives the same result.
7. Compute simple interest and compound interest for a given amount, time period, rate of interest and period of compounding.
8. Program to multiply two given matrices in a user defined function.
9. Calculate standard deviation for a set of values  $\{x(j), j=1,2,\dots,n\}$  having the corresponding frequencies  $\{f(j), j=1,2,\dots,n\}$ .
10. Write the user-defined function to compute GCD of two given values and use it to compute the LCM of three given integer values.
11. Compute GCD of 2 positive integer values using recursion / pointer to pointer.
12. Check a given square matrix for its positive definite form.
13. To find the inverse of a given non-singular square matrix.
14. To convert a decimal number to its binary representation.
15. Use array of pointers for alphabetic sorting of given list of English words

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**MTHCC-2201: Advanced Abstract Algebra**

**Marks (Theory): 70**

**Marks (Internal Assessment): 30**

**Marks (Total): 100**

**Time: 03 Hours**

**Total Credit: 4**

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

**Unit: 1.**

Characteristic of a ring with unity. Prime fields  $\mathbb{Z}/p\mathbb{Z}$  and  $\mathbb{Q}$ . Characterization of prime fields. Field extensions. 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. Frobenius automorphism of a finite field. Roots of unity, Cyclotomic polynomials and their irreducibility over  $\mathbb{Q}$ . Normal extensions. Finite normal extensions as Splitting fields. Separable elements, separable polynomials and separable extensions. Theorem of primitive element. Perfect fields.

(Scope of the course as given in the book at Sr. No. 2).

**Unit: 3.**

Galois extensions. Galois group of an extension. Dedekind lemma Fundamental theorem of Galois theory. Frobenius automorphism of a finite field. Klein's 4-group and Dihedral group. Galois groups of polynomials. Fundamental theorem of Algebra. Radicals extensions. Galois radical extensions. Cyclic extensions. Solvability of polynomials by radicals over  $\mathbb{Q}$ . Symmetric functions and elementary symmetric functions. 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. Rational Canonicals form of a linear transformation and its elementary divisor. Uniqueness of the elementary divisor. (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. Vivek Sahai and Vikas Bist; Algebra (Narosa publication House)
4. Surjit Singh and Quazi Zameeruddin; Modern Algebra (Vikas Publishing House 1990)
5. Patrick Morandi; Field and Galois Theory (Springer 1996).



MTHCC-2202: Measure and Integration theory

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 4

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

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,  $F_\sigma$  and  $G_\delta$  sets, existence of a non-measurable set.

Lebesgue measurable functions and their properties, the almost everywhere concept, characteristic functions, simple functions, approximation of measurable functions by sequences of simple functions, Borel measurability of a function.

Unit: 2.

Littlewood's three principles, 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.

The Lebesgue Integral : Shortcomings of Riemann integral, Lebesgue integral of a bounded function over a set of finite measure and its properties, Lebesgue integral as a generalization of the Riemann integral, Bounded convergence theorem, Lebesgue theorem regarding points of discontinuities of Riemann integrable functions.

Unit: 3.

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

Differentiation and Integration : Differentiation of monotone functions, Vitali's covering lemma, the four Dini derivatives, Lebesgue differentiation theorem, functions of bounded variation and their representation as difference of monotone functions.

Unit: 4.

Differentiation of an integral, absolutely continuous functions, convex functions, Jensen's inequality.

The  $L^p$  spaces, Minkowski and Holder inequalities, completeness of  $L^p$  spaces, Bounded linear functionals on the  $L^p$  spaces, Riesz representation theorem.

Recommended Books:

1. H.L.Royden; Real Analysis, 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.

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- 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

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MTHCC-2203: Mechanics of Solids

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 4

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Tensor Algebra: 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.

Tensor Analysis: Scalar, vector, tensor functions, Comma notation, Gradient, divergence and curl of a vector / tensor field.

Unit: 2.

Analysis of Strain: Affine transformation, Infinitesimal affine deformation, Geometrical Interpretation of the components of strain. Strain quadric of Cauchy. Principal strains and invariance, General infinitesimal deformation. Saint-Venant's equations of compatibility.

Analysis of Stress : Stress Vector, Stress tensor, Equations of equilibrium, Transformation of coordinates. Stress quadric of Cauchy, Principal stress and invariants. Maximum normal and shear stresses. Mohr's circles. Examples of stress.

Unit: 3.

Equations of Elasticity :Generalised Hooks Law, Anisotropic symmetries, Homogeneous isotropic medium. Elasticity moduli for Isotropic media. Equilibrium and dynamic equations for an isotropic elastic solid. Strain energy function and its connection with Hooke's Law.

Unit: 4.

Beltrami-Michell compatibility equations. Uniqueness of solution. Clapeyron's theorem. Saint-Venant's principle.

Variational Methods: Theorem of minimum potential energy. Theorem of minimum complementary energy. Reciprocal theorem of Betti and Rayleigh.

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 Tensor, S. Chand & Co., 1950.
6. S. Timoshenko 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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MTHCC-2204: System of Differential Equations

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 4

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Linear differential systems: Definitions and notations. Linear homogeneous systems; Existence and uniqueness theorem, Fundamental matrix, Adjoint systems, reduction to smaller homogeneous systems.

Non-homogeneous linear systems; variation of constants. Linear systems with constant coefficients. Linear systems with periodic coefficients; Floquet theory.

(Relevant portions from the book of 'Theory of Ordinary Differential Equations' by Coddington and Levinson)

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. Dependence of solutions on initial conditions and parameters: Preliminaries, continuity and differentiability.

(Relevant portions from the book of 'Theory of Ordinary Differential Equations' by Coddington and Levinson)

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. (Relevant portions from the book 'Differential Equations' by S.L. Ross)

Maximal and Minimal solutions. Upper and Lower solutions. Differential inequalities. (Relevant portions from the book 'Textbook of Ordinary Differential Equations' by Deo et al.)

Unit: 4.

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

(Relevant portions from the book 'Textbook of Ordinary Differential Equations' by Deo et al.)

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. (Relevant portions from the book 'Differential Equations' by S.L. Ross and the book 'Theory of Ordinary Differential Equations' by Coddington and Levinson)

Recommended books:

1. E.A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, Tata McGraw-Hill, 2000.

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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.

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**MTHCE-2205: Computer Programming in FORTRAN 90 & 95**

**Marks (Theory): 30**  
**Marks (Internal Assessment): 20**  
**Marks (Practical): 50**

**Marks (Total): 100**  
**Time: 03 Hours**  
**Total Credit: 2+2=4**

Note: -

The examiner is required to set nine questions in all.  
The first question will be compulsory consisting of six short questions (1 marks each) covering the whole syllabus.  
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

**Unit: 1.**

Numerical constants and variables; arithmetic expressions; input/output; conditional flow;

**Unit: 2.**

looping. Logical expressions and control flow; functions; subroutines; arrays.

**Unit: 3.**

Format specifications; strings; array arguments, derived data types.

**Unit: 4.**

Processing files; pointers; modules; FORTRAN 90 features; FORTRAN 95 features.

**Practical**

**Implementation of the following programs in FORTRAN-90 & 95**

1. Calculate the area of a triangle with given lengths of its sides.
2. Given the centre and a point on the boundary of a circle, find its perimeter and area.
3. To check an equation  $ax^2 + by^2 + 2cx + 2dy + e = 0$  in  $(x, y)$  plane with given coefficients for representing parabola/ hyperbola/ ellipse/ circle or else.
4. For two given values  $x$  and  $y$ , verify  $g * g = a * h$ , where  $a$ ,  $g$  and  $h$  denote the arithmetic, geometric and harmonic means respectively.
5. Use IF..THEN...ELSE to find the largest among three given real values.
6. To solve a quadratic equation with given coefficients, without using COMPLEX data type.
7. To find the location of a given point  $(x,y)$  i) at origin, ii) on x-axis or y-axis iii) in quadrant I, II, III or IV.
8. To find if a given 4-digit year is a leap year or not.
9. To find the greatest common divisor (gcd) of two given positive integers.
10. To verify that sum of cubes of first  $m$  positive integers is same as the square of the sum of these integers.
11. Find error in verifying  $\sin(x+y) = \sin(x) \cos(y) + \cos(x) \sin(y)$ , by approximating the  $\sin(x)$  and  $\cos(x)$  functions from the finite number of terms in their series expansions.
12. Use SELECT...CASE to calculate the income tax on a given income at the existing rates.

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**Books Recommended:**

1. V. Rajaraman; Computer Programming in FORTRAN 90 and 95; Printice-Hall of India Pvt. Ltd., New Delhi, 1997.
2. V. Rajaraman; Computer Programming in FORTRAN 77, Printice-Hall of India Pvt. Ltd., New Delhi, 1984.
3. J.F. Kerrigan; Migrating of FORTRAN 90, Orielly Associates, CA, USA, 1993.
4. M.Metcalf and J.Reid; FORTRAN 90/95 Explained, OUP, Oxford, UK, 1996.

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MTHCE-2206: Methods of Applied Mathematics

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Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 4

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

**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.**

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: 3.**

Mellin transforms, Definition, Elementary properties, Inversion theorem, Mellin transform of some elementary functions, derivatives and integrals. Convolution or Faulting theorem for the Mellin Transforms. Definition and properties of Hypergeometric functions, Properties of Confluent Hypergeometric function (Relevant portion of the Book by W. W. Bell).

**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.

**Books Recommended:**

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

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MTHCE-2207: Differential Geometry

Marks (Theory): 70  
Marks (Internal Assessment): 30

Marks (Total): 100  
Time: 03 Hours  
Total Credit: 4

Note: -

The examiner is required to set nine questions in all.  
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.  
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

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.

Unit: 3.

Curvilinear Coordinates, First order magnitudes, directions on a surface, the normal, second order magnitudes, derivatives of  $\mathbf{n}$ , curvature of normal section, Meunier's theorem.  
Curves on a surface : Principal directions and curvatures, first and second curvatures, Euler's theorem, Dupin's indicatrix, 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  $r_{11}, r_{12}, r_{22}$ , Gauss characteristic equation, Mainardi-Codazzi relations, alternative expression, Bonnet's theorem, derivatives of the angle  $\omega$ .  
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.

Recommended Book:

1. C.E. Weatherburn, Differential Geometry of Three Dimensions, Radha Publishing House, Calcutta.
2. J.A. Thorpe, Introduction to Differential Geometry, Springer-verlag.
3. B.O. Neill, Elementary Differential Geometry, Academic Press, 1966.
4. S. Sternberg, Lectures on Differential Geometry, Prentice- Hall , 1964.
5. R.S. Millman and G.D. Parker, Elements of Differential Geometry, Prentice-Hall, 1977.
6. W. Klingenberg, A course in Differential Geometry, Springer-verlag.

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MTHCE-2208: Mathematical Modeling

Marks (Theory): 70  
Marks (Internal Assessment): 30

Marks (Total): 100  
Time: 03 Hours  
Total Credit: 4

Note: -

The examiner is required to set nine questions in all.  
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.  
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

The process of Applied Mathematics; mathematical modeling: need, techniques, classification and illustrative; mathematical modeling through ordinary differential equation 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.

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.

Recommended Book:

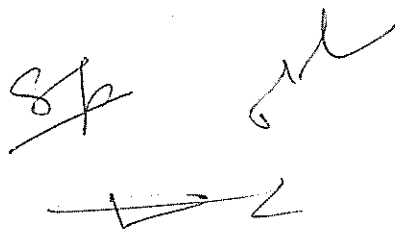
- 1. J.N. Kapur: Mathematical Modeling, Wiley Eastern Ltd., 1990 (Relevant portions; Chapters 1 to 6)

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**Scheme of Examination**  
**M.Sc. (Mathematics)**  
**Under Choice Based Credit System (CBCS)**  
**Department of Mathematics, CDLU, Sirsa**

M. Sc. (Final) Mathematics (with effect from session 2018-19)

Paper Code No.	Title of the paper/ Subject	Hrs per week L+P	Marks (Theory)	Marks (Internal Assessment)	Marks (Practical)	Total Marks	Credit
<b>Semester-III</b>							
<b>(Core Courses)</b>							
MTHCC-2301	Topology	4+0	70	30	00	100	4
MTHCC-2302	Fluid Mechanics	4+0	70	30	00	100	4
<b>(Core Elective Courses)</b> (Any three of the following)							
MTHCE-2303	Integral Equations	4+0	70	30	00	100	4
MTHCE-2304	Mathematical Statistics	4+0	70	30	00	100	4
MTHCE-2305	Advanced Complex Analysis	4+0	70	30	00	100	4
MTHCE-2306	Advanced Mechanics of Solids	4+0	70	30	00	100	4
MTHCE-2307	Advanced Discrete Mathematics	4+0	70	30	00	100	4
MTHCE-2308	Fuzzy Sets and Fuzzy Logic	4+0	70	30	00	100	4
MTHCE-2309	Information Theory	4+0	70	30	00	100	4
MTHCE-2310	Difference Equations	4+0	70	30	00	100	4
MTHCE-2311	Financial Mathematics	4+0	70	30	00	100	4
MTHCE-2312	Number Theory	4+0	70	30	00	100	4
MTHCE-2313	Wavelet Analysis	4+0	70	30	00	100	4

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Paper Code No.	Title of the paper/ Subject	Hrs per week L+P	Marks (Theory)	Marks (Internal Assessment)	Marks (Practical)	Total Marks	Credit
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**Semester-IV**

**(Core Courses)**

MTHCC-2401	Functional Analysis	4+0	70	30	00	100	4
MTHCC-2402	Partial Differential Equations	4+0	70	30	00	100	4
MTHCC-2403	Computer Programming in MATLAB	0+4	00	00	100	100	4

**(Core Elective Courses)  
(Any three of the following)**

MTHCE-2404	Mathematical Aspect of Seismology	4+0	70	30	00	100	4
MTHCE-2405	Operation Research	4+0	70	30	00	100	4
MTHCE-2406	Advanced Fluid Mechanics	4+0	70	30	00	100	4
MTHCE-2407	Boundary Value Problems	4+0	70	30	00	100	4
MTHCE-2408	Algebraic Topology	4+0	70	30	00	100	4
MTHCE-2409	Analytic Number Theory	4+0	70	30	00	100	4
MTHCE-2410	Algebraic Coding Theory	4+0	70	30	00	100	4
MTHCE-2411	Control Theory	4+0	70	30	00	100	4
MTHCE-2412	Bio-Mechanics	4+0	70	30	00	100	4
MTHCE-2413	Algebraic Number Theory	4+0	70	30	00	100	4

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## MTHCC-2301: Topology

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### 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.

### 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.

**Books Recommended:**

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.

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## MTHCC-2302: Fluid Mechanics

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Kinematics of fluid in motion: Real fluids and ideal fluids, Velocity at a point of a fluid, Lagrangian and Eulerian methods and the relation between them. Stream lines, path lines and streak lines, vorticity and circulation, Vortex lines, Acceleration and Material derivative.

Equation of continuity in vector form, Cartesian, cylindrical and spherical coordinates, Reynolds transport Theorem, Working rules for writing equation of continuity in some specific flows, General analysis of fluid motion, Properties of fluids- static and dynamic pressure, Boundary surfaces and boundary surface conditions, Irrotational and rotational motions, Velocity potential.

### Unit: 2.

Equation of Motion : Lagrange's and Euler's equations of Motion, Conservative field of force, Bernoulli's theorem, Applications of the Bernoulli Equation in one dimensional flow problems, Kelvin's circulation theorem, vorticity equation.

Energy equation for incompressible flow, Kinetic energy of irrotational flow, Kelvin's minimum energy theorem, Mean potential over a spherical surface, Kinetic energy of infinite liquid, Uniqueness theorems, Elementary fluid motion in two dimensions: stream function, irrotational motion, complex potential, sources, sinks and doublets.

### Unit: 3.

Real or Viscous fluids: Newton's Law of viscosity, Newtonian and non-Newtonian fluids, State of stress at a point, Nature of stresses, transformation of stress components, Nature of rate of strain, transformation of the rate of strain, Principal stress & strain rate, Relation between stress and rate of strain.

Navier - Stoke's equations of motion of a viscous fluid in vector form and in term of Cartesian, cylindrical and spherical coordinators, The energy equation, Diffusion of vorticity, vorticity equation; Energy dissipation due to viscosity.

### Unit: 4.

Laminar's flow: Steady flow between two parallel planes: plane Poiseuille flow, plane Couette flow, generalized plane Couette flow.

Steady flow in pipes: flow through a circular pipe (Hagen-Poiseuille flow), laminar steady flow between two coaxial circular cylinders, Laminar steady flow between concentric rotating cylinders, Uniqueness Theorem, Steady viscous flow in tubes of uniform elliptic, equilateral triangular and rectangular cross sections.

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v **Books Recommended:**

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, An Introduction to Fluid Mechanics, Foundation Books, New Delhi, 1994.
5. A.J. Chorin and A. Marsden, A Mathematical Introduction to Fluid Dynamics Springer-Verlag, New York, 1993.
6. L.D. Landau and E.M. Lifschitz, Fluid Mechanics Pergamon Press, London, 1985.
7. H. Schlichting, Boundary Layer Theory, McGraw Hill Book Company, New York, 1979.
8. R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.
9. A.D. Young, Boundary Layers, AIAA Education Series, Washington DC, 1989.
10. W.H. Besant and A.S. Ramsey, A Treatise on Hydromechanics, Part-II, CBS Publishers, Delhi, 1988.

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## MTHCE-2303: Integral Equations

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Definition of Integral Equations and their classifications. Eigen values and Eigen functions. Special kinds of Kernel Convolution Integral. The inner or scalar product of two functions. Reduction to a system of algebraic equations. Fredholm alternative, Fredholm theorem, Fredholm alternative theorem. An approximate method.

### Unit: 2.

Method of successive approximations, Iterative scheme for Fredholm and Volterra Integral equations of the second kind. Conditions of uniform convergence and uniqueness of series solution. Some results about the resolvent Kernel. Application of iterative scheme to Volterra integral equations of the second kind.

Classical Fredholm's theory, the method of solution of Fredholm equation, Fredholm's First theorem, Fredholm's second theorem, Fredholm's third theorem.

### Unit: 3.

Symmetric Kernels, Introduction, Complex Hilbert space. An orthonormal system of functions, Riesz-Fisher theorem. A complete two-Dimensional orthonormal set over the rectangle  $a \leq s \leq b, c \leq t \leq d$ . Fundamental properties of Eigenvalues and Eigenfunctions for symmetric Kernels, Expansion in eigen functions and Bilinear form, Hilbert-Schmidt theorem and some immediate consequences.

### Unit: 4.

Definite Kernel, and Mercer's theorem. Solution of a symmetric Integral Equation. Approximation of a general  $L_2$  Kernel (Not necessarily symmetric) by a separable Kernel. The operator method in the theory of integral equations. Rayleigh-Ritz method for finding the first eigenvalue.

The Abel Integral Equation - Inversion formula for singular integral equation with Kernel of the type  $h(s)-h(t)$ ,  $0 < \alpha < 1$ . Cauchy's principal value for integrals solution of the Cauchy-type singular integral equation, closed contour, unclosed contours and the Riemann-Hilbert problem. The Hilbert-Kernel, solution of the Hilbert-Type singular Integral equation.

Handwritten scribbles and symbols, possibly including the letters 'S', 'P', and 'A'.

**Books Recommended:**

1. R.P. Kanwal, Linear Integral Equations, Theory and Techniques, Academic Press, New York.
2. S.G. Mikhlin, Linear Integral Equations (translated from Russian) Hindustan Book Agency, 1960.
3. I.N. Sneddon, Mixed Boundary Value Problems in potential theory, North Holland, 1966.
4. I. Stakgold, Boundary Value Problems of Mathematical Physics Vol. I, II, Mac. Millan, 1969.
5. M.D. Raishinghamia, Integral Equations and Boundary value problems, S. Chand and Company Pvt. Ltd. 2007.

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MTHCE-2304: Mathematical Statistics

Marks (Theory): 70  
Marks (Internal Assessment): 30

Marks (Total): 100  
Time: 03 Hours  
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.  
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.  
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

**Unit: 1.**

Random distribution: preliminaries, Probability density function, Probability models, Mathematical Expectation, Chebyshev's Inequality; Conditional probability, Marginal and conditional distributions, Correlation coefficient, Stochastic independence.  
Frequency distributions: Binomial, Poisson, Gamma, Chi-square, Normal, Bivariate normal distributions.

**Unit: 2.**

Distributions of functions; Sampling, Transformations of variables: discrete and continuous;  $t$  &  $F$  distributions; Change of variable technique; Distribution of order; Moment-generating function technique; other distributions and expectations.

**Unit: 3.**


Limiting distributions: Stochastic convergence, Moment generating function, Related theorems.  
Intervals: Random intervals, Confidence intervals for mean, differences of means and variance; Bayesian estimation.

**Unit: 4.**

Estimation & sufficiency: Point estimation, sufficient statistics, Rao-Blackwell Theorem, Completeness, Uniqueness, Exponential PDF, Functions of parameters; Stochastic independence.

**Books Recommended:**

1. Baisnab and M. Das; Elements of Probability and Statistics, Tata McGraw Hill.
2. J. L. Freund; Mathematical Statistics, Prentice Hall of India.
3. R. V. Hogg and A. T. Criag; Introduction to Mathematical Statistics, Maxwell McMillan.
4. S. C. Gupta and V. K. Kapoor; Fundamentals of Mathematical Statistics.



## MTHCE-2305: Advanced Complex Analysis

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Convex functions and Hadamard's three circles theorem, The Phragmen-Lindelof Theorem  
The space of continuous functions  $C(G, \Omega)$ , Arzela-Ascoli theorem, Spaces of analytic functions, Hurwitz's theorem, Montel's theorem.

### Unit: 2.

Spaces of meromorphic functions, Riemann mapping theorem, infinite products, 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, Mittag-Leffler's theorem, Analytic continuation, uniqueness of direct analytic continuation, uniqueness of analytic continuation along a curve, Power series method of analytic continuation, Schwarz reflection principle, Monodromy theorem and its consequences.

Basic properties of harmonic functions, Harmonic function as a disk, Poisson's Kernel, Dirichlet problem for a unit disk, Harnack's inequality, Harnack's theorem, Dirichlet problem for a region, Green's function.

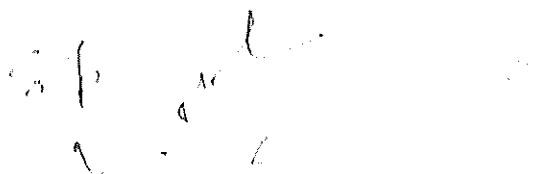
### Unit: 4.

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-Caratheodory theorem, Great Picard theorem

### Books Recommended:

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 Clarendon Press, Oxford, 1990.
5. Lang-schin Hain & Bernard Epstein, Classical Complex Analysis, Jones and Bartlett Publishers International, London, 1996.
6. D.Sarason, Complex Function Theory, Hindustan Book Agency, Delhi, 1994.



7. Mark J. Ablowitz and A.S. Fokas, Complex Variables : Introduction & Applications, Cambridge University Press, South Asian Edition, 1998.
8. E.C. Titchmarsh, The Theory of Functions, Oxford University Press, London.
9. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 1997.

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MTHCE-2306: Advanced Mechanics of Solids

Marks (Theory): 70  
Marks (Internal Assessment): 30

Marks (Total): 100  
Time: 03 Hours  
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.  
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.  
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

**Unit: 1.**

Extension : Extension of beams, bending of beams by own weight and terminal couples.  
Torsion : Torsion of cylindrical bars; Torsional rigidity, Torsion and stress functions. Lines of shearing stress. Simple problems related to equilateral triangle, grooves; Torsion of rectangular beam, Torsion of triangular prism.

**Unit: 2.**

Torsion problems through conformal mapping; Torsion-membrane analogy; Torsion of hollow beams, Torsion of anisotropic beams; Flexure/bending of circular/ elliptic/ rectangular beams; Deformation torsion of cylinders by lateral loads.

**Unit: 3.**

Two dimensional problems: Plane stress, Generalized plane stress, Airy stress function, General solution of biharmonic equation, Stresses and displacements in terms of complex potentials, The structure of functions of  $\phi(z)$  and  $\psi(z)$ , First and second boundary-value problems in plane elasticity, Existence and uniqueness of the solutions, Basic problem for circular finite/infinite region.

**Unit: 4.**

Three dimensional problems; general solutions; concentrated forces; deformation by normal loads; The problem of Boussinesq; Elastic sphere; pressures, harmonics, equilibrium; Integration method; Thermoelastic problems; Vibrations in elastic solids.

**Books Recommended:**

1. I.S. Sokolnikoff, Mathematical Theory of Elasticity, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1977.
2. A.E.H. Love, A Treatise on the Mathematical Theory of Elasticity Dover Publications, New York.
3. Y.C. Fung, Foundations of Solid Mechanics, Prentice Hall, New Delhi, 1965.
4. D.S. Chandrabhargava and T. Debnath, Continuum Mechanics, Academic Press, 1991.
5. S. Timoshenko and N. Goodier, Theory of Elasticity, McGraw Hill, New York, 1970.
6. I.H. Chamee, Introduction to Solid Mechanics, Prentice Hall, New Delhi, 1975.

## MTHCE-2307: Advanced Discrete Mathematics

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Partially ordered sets and lattices, Lattice as an algebraic system, sublattices, Isomorphism of lattices, Distributive and modular lattices, Lattices as intervals, Similar and projective intervals, Chains in lattices, Zassenhaus's Lemma and Schreier Theorem, Composition chain and Jordan Holder Theorem, Chain conditions, Fundamental dimensionality relation for modular lattices, Decomposition theory for lattices with ascending chain conditions, i.e. reducible and irreducible elements, Independent elements in lattices.

### Unit: 2.

Points (atoms) of a lattice, Complemented lattices, Chain conditions and complemented lattices, Boolean algebras, Conversion of a Boolean algebra into a Boolean ring with unity and vice-versa, Direct product of Boolean algebras, Uniqueness of finite Boolean algebras, Boolean functions and Boolean expressions, Application of Boolean algebra to switching circuit theory.

### Unit: 3.

Graphs, Konisberg seven bridges problem, Finite and infinite graphs, Incidence vertex, Degree of a vertex, Isolated and pendant vertices, Null graphs, Isomorphism of graphs, Subgraphs, walks, paths and circuits, Connected and disconnected graphs, Components of a graph, Euler graphs, Hamiltonian paths and circuits, The traveling salesman problem, Trees and their properties, Pendant vertices in a tree, Rooted and binary tree, Spanning tree and fundamental circuits, Spanning tree in a weighted graph.

### Unit: 4.

Cutsets and their properties, Fundamental circuits and cutsets, Connectivity and separability, Network flows, Planner graphs, Kuratowski's two graphs, Representation of planner graphs, Euler formula for planner graphs, Vector space associated with a graph, Basis vectors of a graph, Circuit and cutset subspaces, Intersection and joins of  $W_C$  and  $W_S$ , Incidence matrix  $A(G)$  of a graph  $G$ , Submatrices of  $A(G)$ , Circuit matrix, Fundamental circuit matrix, and its rank, Cutset matrix, path matrix and adjacency matrix of a graph.

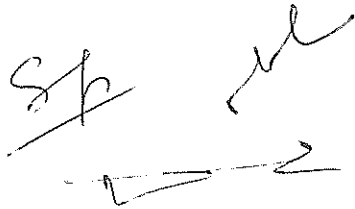
### Books Recommended:

1. Narsingh Deo, Graph Theory with application to Engineering and Computer Science, Prentice Hall of India.
2. Nathan Jacobson, Lectures in Abstract Algebra Vol.I, D. Van Nostrand Company, Inc.

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3. L.R. Vermani, A course in discrete Mathematical structures(Imperial College Shalini Press London 2011).
4. J. P. Tremblay & R. Manohar; Discrete Mathematical Structures with Applications to Computer Science. McGraw Hill Book Co., 1997.
5. Seymour Lipschutz; Finite Mathematics (International edition 1983), McGraw-Hill Book Company, New York.
6. C. L. Liu; Elements of Discrete Mathematics, McGraw-Hill Book Co.

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## MTHCE-2308: Fuzzy Sets and Fuzzy Logic

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Fuzzy Sets: Basic definitions,  $\alpha$ -cuts, strong  $\alpha$ -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

Additional properties of  $\alpha$ -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.

### Unit: 2.

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

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, conversion 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.

### Unit: 3.

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  $A \cdot X = B$ , equation  $A \cdot X = B$

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

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min transitive), non transitive, antitransitive fuzzy relations. Fuzzy equivalence relations, fuzzy compatibility relations,  $\alpha$ -compatibility class, maximal  $\alpha$ -compatibles, complete  $\alpha$ -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.

**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

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

**Books Recommended:**

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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## MTHCE-2309: Information Theory

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Measure of Information – Axioms for a measure of uncertainty, The Shannon entropy and its properties, Joint and conditional entropies, Transformation and its properties.

Noiseless coding – Ingredients of noiseless coding problem, Uniquely decipherable codes, Necessary and sufficient condition for the existence of instantaneous codes, Construction of optimal codes.

### Unit: 2.

Discrete memoryless Channel - Classification of channels, Information processed by a channel, Calculation of channel capacity, Decoding schemes, The ideal observer, The fundamental theorem of Information Theory and its strong and weak converses.

### Unit: 3.

Continuous Channels – The time-discrete Gaussian channel, Uncertainty of an absolutely continuous random variable, The converse to the coding theorem for time-discrete Gaussian channel, The time-continuous Gaussian channel, Band-limited channels.

### Unit: 4.

Some intuitive properties of a measure of entropy – Symmetry, normalization, expansibility, boundedness, recursivity, maximality, stability, additivity, subadditivity, nonnegativity, continuity, branching etc.

### Books Recommended:

1. R. Ash; Information Theory, Interscience Publishers, New York, 1965.
2. F. M. Reza; An introduction to Information Theory, MacGraw-Hill Book Company Inc., 1961.
3. J. Aczel and Z. daroczy; On measures of information and their characterization, Academic press, new York.

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## MTHCE-2310: Difference Equations

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Introduction, Difference Calculus- The Difference Operator, Summation, Generating functions and approximate summation.

### Unit: 2.

Linear Difference Equations - First order equations, General results for linear equations, Equations with constant coefficients, Applications, Equations with variable coefficients, Nonlinear equations that can be linearized, The z- Transform

### Unit: 3.

Stability Theory - Initial value problems for linear systems, Stability of linear systems, Stability of nonlinear systems, Chaotic behaviour.

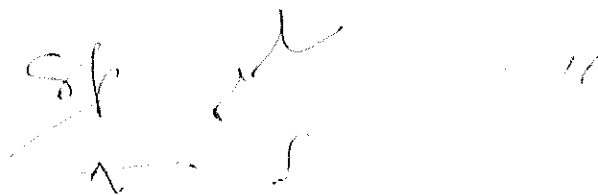
### Unit: 4.

Asymptotic methods Introduction, Asymptotic analysis of sums, Linear equations, Nonlinear equations.

The self-adjoint second order linear equation, Introduction, Sturmian Theory, Green's functions, Disconjugacy, The Riccati Equations, Oscillation.

### Books Recommended:

1. Walter G. Kelley and C. Allan Peterson-Difference Equations, An Introduction with Applications, Academic Press Inc., Harcourt Brace Jovanovich Publishers, 1991.
2. Calvin Ahlbrandt and C. Allan Peterson, Discrete Hamiltonian Systems, Difference Equations, Continued Fractions and Riccati Equations, Kluwer, Boston.



## MTHCE–2311: Financial Mathematics

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Fundamentals of Financial Mathematics.

Asset Price Model.

### Unit: 2.

Black-Scholes Analysis

Variations on Black-Scholes models.

### Unit: 3.

Numerical Methods

American Option

Exotic Options.

### Unit: 4.

Path-Dependent Options

Bonds and Interest Rate Derivatives

Stochastic calculus.

### Books Recommended:

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 E. and Pesonen M., Practical Risk Theory for Actuaries, Chapman & Hall.

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## MTHCE-2312: Number Theory

Marks (Theory): 70  
Marks (Internal Assessment): 30

Marks (Total): 100  
Time: 03 Hours  
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.  
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.  
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

The equation  $ax+by = c$ , simultaneous linear equations, Pythagorean triangles, assorted examples, ternary quadratic forms, rational points on curves.

### Unit: 2.

Farey sequences, rational approximations, Hurwitz theorem, irrational numbers, Geometry of Numbers, Blichfeldt's principle, Minkowski's Convex body theorem Lagrange's four square theorem.

### Unit: 3.

Euclidean algorithm, infinite continued fractions, irrational numbers, approximations to irrational numbers, Best possible approximations, Periodic continued fractions, Pell's equation.

### Unit: 4.

Partitions, Ferrers Graphs, Formal power series, generating functions and Euler's identity, Euler's formula, bounds on  $P(n)$ , Jacobi's formula, a divisibility property.

### Books Recommended:

1. An Introduction to the Theory of Numbers: Ivan Niven, Herbert S. Zuckerman, Hugh L. Montgomery, John Wiley & Sons(Asia)Pvt. Ltd. (Fifth Edition)

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## MTHCE-2313: Wavelet Analysis

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Fourier Transform: The finite Fourier transform, the circle group  $T$ , convolution on  $T$ ,  $(L^1(T), +, *)$  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  $\mathbb{R}$ , 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.

### 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  $L^1$ , Fourier Sine and Cosine transforms, Parseval's identities, the  $L^p$  theory, Parseval's identities for  $L^p$ , inversion theorem for  $L^2$  functions, the Plancherel theorem, A sampling theorem, the Mellin transform, variations.

### Unit: 3.

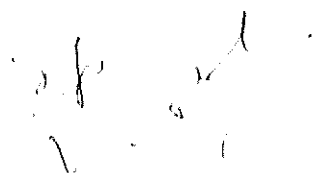
Discrete Fourier transform, the DFT in matrix form, inversion theorem for the DFT, DFT map as a linear bijection, Parseval's identities, cyclic convolution, Fast Fourier transform for  $\mathbb{N}^d$ , Cooley-Tukey Algorithm, FFT for  $\mathbb{N} \times \mathbb{R}$ , FFT factor form.

### 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.

### Books Recommended:

1. G. Bachelman, L. Narici and F. 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 NSF 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 Publish.

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## MTHCC-2401: Functional Analysis

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### 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 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 adjoint operator, 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.

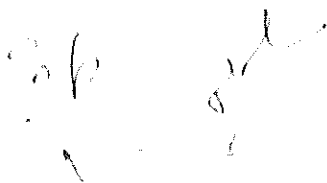
### Unit: 4.

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.

### Books Recommended:

1. F.Kreyszig: Introductory Functional Analysis with Applications, John Wiley and Sons, New York, 1978.
2. G.E.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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## MTHCC-2402: Partial Differential Equations

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Partial Differential Equations (PDE) of  $k^{\text{th}}$  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.

### Unit: 2.

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, Dirichlet'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: 3.

Wave equation- Physical interpretation, solution for one dimensional wave equation, D'Alembert's 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: 4.

Other ways to represent solutions: Method of Separation of variables for the Hamilton-Jacobi equations, Laplace, heat and wave equations, Similarity solutions (Plane and traveling waves, solitons, similarity under Scaling).

Fourier Transform, Laplace Transform, Convertible non-linear into linear PDE, Cole-Hopf Transform, Potential functions, Hodograph and Legendre transforms, Lagrange and Charpit methods.

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**Books Recommended:**

1. L.C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, American Mathematical Society, 2014.
2. I.N. Snedden, Elements of Partial Differential Equations, International Edition, McGraw-Hill, Singapore, 1986.
3. John F. Partial Differential Equations, Springer-Verlag, New York, 1971.
4. T. Amarnath, An Elementary Course in Partial Differential Equations, Jones & Bartlett Publishers, 2009.
5. P. Parsad and R. Ravindran, Partial Differential Equations, New Age / International Publishers, 2005.

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MTHCC-2403: Computer Programming in MATLAB

Marks (Total): 100

Total Credit: 04

Solution of the following problems based on following Numerical Methods through MATLAB :

1. Solutions of simultaneous linear equations: Gauss-elimination method; Gauss-Jordan method; Jacobi method; Gauss-Seidel method.
2. Solution of algebraic / transcendental equations: bisection method; regula-falsi method; secant method; Newton-Raphson method; Muller method; Chevyshev method.
3. Inversion of matrices: Adjoint matrix method; Jordan method.
4. Interpolation: Lagrange interpolation; Newton interpolation; Hermite interpolation.
5. Numerical differentiation: methods based on i) Interpolation, ii) finite difference operators, iii) undetermined coefficients.
6. Numerical integration: Composite methods based on trapezoidal rule, Simpson 1/3 rule and 3/8 rule; Romberg method.
7. Solution of ordinary differential equations: Euler methods; Runge-Kutta methods; predictor-corrector methods.
8. Statistical problems on central tendency (mean, mode, median) and dispersion (standard variation, standard error).
9. Least square method to fit polynomial (curve) of given degree to given function (data set).
10. Plotting of special functions.

**Books Recommended:**

1. Numerical methods for scientific and engineering computation, (MK Jain, SRK Iyengar, RK Jain), Wiley Eastern Ltd, N. Delhi (1984).
2. MATLAB Primer, Seventh Edition, (Timothy A. Davis, Kermit Sigmon), CHAPMAN & HALL/CRC

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## MTHCE-2404: Mathematical Aspect of Seismology

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### 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. Dispersion: Group velocity, relation between phase velocity and group velocity.

### Unit: 2.

Spherical waves. Expansion of a spherical wave into plane waves; Sommerfield's integral. Kirchoff's solution of the wave equation, Poissons's formula, Helmholtz's formula. 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. A normal force acts on the surface of a semi-infinite elastic solid, tangential forces acting on the surface of a semi-infinite elastic solid.

Three dimensional Lamb's problems in an isotropic elastic solid: Area or Volume sources and Point sources in an unlimited elastic solid, Area or Volume source and Point source on the surface of semi-infinite elastic solid. Surface waves: Rayleigh waves, Love waves and Stoneley waves.

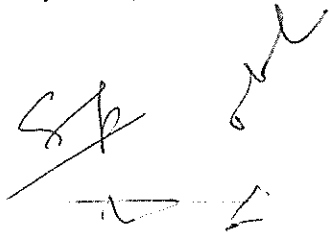
### Books Recommended:

1. C.A. Coulson and A. Jefferey, Waves, Longman, New York, 1977.
2. M. Bath, Mathematical Aspects of Seismology, Elsevier Publishing Company, 1968.

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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. Jose Pujol, Elastic Wave Propagation and Generation in Seismology, Cambridge University Press, 2003.
7. Seth Stein and Michael Wysession, An Introduction to Seismology, Earthquakes and Earth Structure, Blackwell Publishing Ltd., 2003.
8. Aki, K. and P.G. Richards, Quantitative Seismology: theory and methods, W.H. Freeman, 1980.
9. Bullen, K.E. and B.A. Bolt, An Introduction to the Theory of Seismology, Cambridge University Press, 1985.

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## MTHCE-2405: Operation Research

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### 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.

### 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, Constrained multivariables optimization, Language multiplier method, Nonlinear programming method, Kuhn Tucker conditions of optimality, Graphical method.

### Books Recommended:

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. Kanti Swarup, P. K. Gupta and Man Mohan; Operations Research, Sultan Chand & Sons, New Delhi.

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## MTHCE-2406: Advanced Fluid Mechanics

Marks (Theory): 70  
Marks (Internal Assessment): 30

Marks (Total): 100  
Time: 03 Hours  
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.  
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.  
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Two-dimensional inviscid incompressible flows: Stream function, Irrotational motion in two and three dimensions. Image system of a source, sink and doublet.  
Complex velocity potential. Thomson-circle theorem. Two-dimensional irrotational motion produced by motion of circular cylinder.

### Unit: 2.

Two dimensional motion produced by the motion of cylinder of arbitrary uniform cross section in an infinite mass of liquid at rest at infinity. Motion due to elliptic cylinder in an infinite mass of liquid. Kinetic energy of liquid contained in rotating elliptic cylinder, circulation about elliptic cylinder.  
Theorem of Blasius. Theorem of Kutta and Joukowski. Kinetic energy of a cyclic and acyclic irrotational motion. Axis-symmetric flows, Stoke's stream function, Stoke's stream functions of some basic flows.

### Unit: 3.

Three-dimensional motion: Motion of a sphere through a liquid at rest at infinity. Liquid streaming past a fixed sphere. Equation of motion a sphere. D'Alembert's paradox, impulsive motion, initial motion of liquid contained in the intervening space between two concentric spheres.

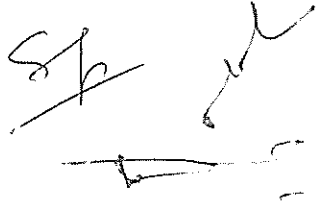
### Unit: 4.

Vortex motion and its elementary properties. Kelvin's proof of permanence. Motions due to circular and rectilinear vortices. Infinite rows of line vortices.  
Dynamical similarity. Buckingham pi-theorem, Reynolds number. Prandtl's boundary layer, boundary layer equations in two dimensions. Blasius solution Boundary layer thickness. Displacement thickness, Karman integral conditions, separation of boundary layer.

### Books Recommended:

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 F.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 Introduction to Fluid Mechanics, Foundation Books, New Delhi, 1994.
6. A.J. Chorin and A. Marsden, A Mathematical Introduction to Fluid Dynamics Springer-Verlag, New York, 1993.
7. L.D. Landau and E.M. Lifschitz, Fluid Mechanics Pergamon Press, London, 1985.
8. H. Schlichting, Boundary Layer Theory, McGraw Hill Book Company, New York, 1979.
9. R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.
10. A.D. Young, Boundary Layers, AIAA Education Series, Washington DC, 1989.

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## MTHCE-2407: Boundary Value Problems

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

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  $n^{\text{th}}$  order ordinary differential equation. Modified Green's function.

### Unit: 2.

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 bounded by a ground vessel. Integral equation formulation of boundary value problems 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: 3.

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

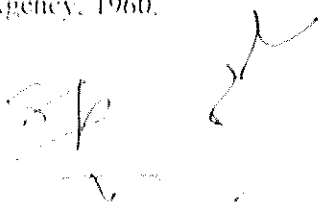
Applications to mixed Boundary Value Problems: Two-part Boundary Value problems. Three-part-Boundary Value Problems. Generalized Three-part Boundary Value problems.

### Unit: 4.

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.

### Books Recommended:

1. R.P.Kanwal, Linear Integral Equations, Theory and Techniques, Academic Press, New York.
2. S.G.Mikhlin, Linear Integral Equations (translated from Russian) Hindustan Book Agency, 1960.



3. I.N.Sneddon, Mixed Boundary Value Problems in potential theory, North Holland, 1966.
4. I. Stakgold, Boundary Value Problems of Mathematical Physics Vol.I, II, Mac. Millan, 1969.
5. M.D. Raishinghamia, Integral Equations and Boundary value problems, S. Chand and Company Pvt. Ltd. 2007

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## MTHCE-2408: Algebraic Topology

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Fundamental Groups functions, homotopy of maps between topological spaces, homotopy equivalence, contractible and simply connected spaces, fundamental groups of  $S^1$  and  $S^1 * S^2$  etc. calculation of fundamental group of  $S^n$ ,  $n > 1$  using Van Kampen's theorem, fundamental groups of a topological group.

### Unit: 2.

Brouwer's fixed point theorem, fundamental theorem of algebra, vector fields on planar sets, Frobenius theorem for  $3 \times 3$  matrices.

Covering Spaces, unique path lifting theorem, covering homotopy theorems, group of covering transformations,

### Unit: 3.

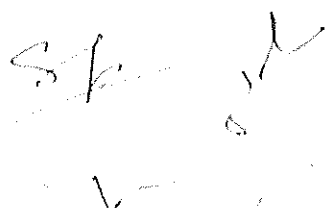
criterion of lifting of maps in terms of fundamental groups, universal covering, its existence, special cases of manifolds and topological groups, Singular homology, reduced homology, Eilenberg Steenrod axioms of homology (Statement only) and their application, relation between fundamental group and first homology.

### Unit: 4.

Calculation of homology of  $S^n$ , application spheres, vector fields, Mayer Victoris sequence and its application to calculation of homology of graphs, torus and compact surface of genus  $g$ , collared pairs, construction of spaces, by attaching of cells, spherical complexes with examples of  $S^n$ ,  $n$ -leaved rose, torus,  $RP^n$ ,  $CP^n$  etc.

### Books Recommended:

1. J. R. Munkers; Topology, Prentice Hall of India.
2. M. J. Greenberg and J. R. Harper; Algebraic Topology, Addison Wesley.
3. W. S. Messey; A basic course in Algebraic Topology, Springer.
4. A. Hatcher; Algebraic Topology, Cambridge University Press.



## MTHCE--2409: Analytic Number Theory

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Arithmetical functions, Mobius function, Euler totient function, relation connecting Mobius function and Euler totient function, Product formula for Euler totient function, Dirichlet product of arithmetical functions, Dirichlet inverses and Mobius inversion formula, Mangoldt function, multiplicative functions, Multiplicative functions and Dirichlet multiplication, Inverse of completely multiplicative function, Liouville's function, divisor function, generalized convolutions, Formal power-series, Bell series of an arithmetical function, Bell series and Dirichlet multiplication, Derivatives of arithmetical functions, Selberg identity, Asymptotic equality of functions, Euler's summation formula, some elementary asymptotic formulas, average order of divisor functions, average order of Euler totient function.

### Unit: 2.

Application to the distribution of lattice points visible from the origin, average order of Mobius function and Mangoldt function, Partial sums of a Dirichlet Product, applications to Mobius function and Mangoldt function, Legendre's identity, another identity for the partial sums of a Dirichlet product, Chebyshev's functions, Abel's identity, some equivalent forms of the prime number theorem, Inequalities for  $\pi(n)$  and  $P^n$ , Shapiro's Tauberian theorem.

Applications of Shapiro's theorem, An asymptotic formula for the partial sums  $\sum_{p \leq x} \binom{1}{p}$ , Partial sums of the Mobius function, Brief sketch of an elementary proof of the prime number theorem; Selberg's asymptotic formula.

### Unit: 3.

Elementary properties of groups, construction of subgroups, characters of finite abelian groups, the character group, orthogonality relations for characters, Dirichlet characters, Sums-involving Dirichlet characters, Nonvanishing of  $L(1, \chi)$  for real nonprincipal  $\chi$ , Dirichlet's theorem for primes of the form  $4n-1$  and  $4n+1$ , Dirichlet's theorem, Functions periodic modulo  $k$ , Existence of finite Fourier series for periodic arithmetical functions.

### Unit: 4.

Ramanujan's sum and generalizations, multiplicative properties of the sums  $S^{\lambda}(n)$ , Gauss sums associated with Dirichlet characters, Dirichlet characters with nonvanishing Gauss sums, Induced moduli and primitive characters, properties of induced moduli conductor of a character, Primitive characters and separable Gauss sums, Finite fourier series of the Dirichlet characters, Polya's inequality for the partial sums of primitive characters.

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**Books Recommended:**

1. Tom M. Apostol, Introduction to Analytic Number Theory.

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## MTHCE-2410: Algebraic Coding Theory

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Block Codes. Minimum distance of a code. Decoding principle of maximum likelihood. Binary error detecting and error correcting codes. Group codes. Minimum distance of a group code  $(m, m+1)$  parity check code. Double and triple repetition codes. Matrix codes. Generator and parity check matrices. Dual codes. Polynomial codes. Exponent of a polynomial over the binary field. Binary representation of a number. Hamming codes. Minimum distance of a Hamming code.

### Unit: 2.

Finite fields. Construction of finite fields. Primitive element of a finite field. Irreducibility of polynomials over finite fields. Irreducible polynomials over finite fields. Primitive polynomials over finite fields. Automorphism group of  $GF(q^n)$ . Normal basis of  $GF(q^n)$ . The number of irreducible polynomials over a finite field. The order of an irreducible polynomial. Generator polynomial of a Bose-Chaudhuri-Hocqquenghem codes (BCH codes) construction of BCH codes over finite fields.

### Unit: 3.

Linear codes. Generator matrices of linear codes. Equivalent codes and permutation matrices. Relation between generator and parity-check matrix of a linear codes over a finite field. Dual code of a linear code. Self dual codes. Weight distribution of a linear code. Weight enumerator of a linear code. Hadamard transform. Macwilliams identity for binary linear codes.

Maximum distance separable codes. (MDS codes). Examples of MDS codes. Characterization of MDS codes in terms of generator and parity check matrices. Dual code of a MDS code. Trivial MDS codes. Weight distribution of a MDS code. Number of code words of minimum distance  $d$  in a MDS code. Reed solomon codes.

### Unit: 4.

Hadamard matrices. Existence of a Hadamard matrix of order  $n$ . Hadamard codes from Hadamard matrices. Cyclic codes. Generator polynomial of a cyclic code. Check polynomial of a cyclic code. Equivalent code and dual code of a cyclic code. Idempotent generator of a cyclic code. Hamming and BCH codes as cyclic codes. Perfect codes. The Gilbert-varshamov and Plotkin bounds. Self dual binary cyclic codes.

### Books Recommended:

1. U.R. Vermani, Elements of Algebraic Coding Theory (Chapman and Hall Mathematics).
2. Steven Roman, Coding and Information Theory (Springer Verlag)





## MTHCE-2411: Control Theory

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Concept of control systems, definition and examples, open loop and closed loop systems, Continuous time systems and Laplace transformations, Discrete time systems and z-transforms, Transfer functions. Solution of uncontrolled systems (spectral form, exponential matrix, repeated roots).

### Unit: 2.

Solution of controlled systems, time varying systems, discrete time systems, relationship between state space and classical forms. Linear Control systems, controllability, observability, controllability and polynomials, linear feedback, state observers, realization of constant systems and time varying systems.

### Unit: 3.

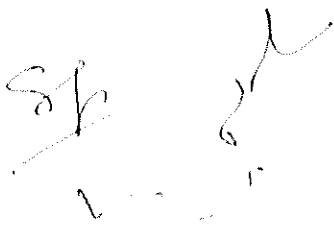
Stability, definitions, algebraic criterion for stability, Nyquist criterion, Lyapunov theory, application of Lyapunov theory to linear systems, construction of Lyapunov functions, Variable gradient method and Zubov method, stability and control.

### Unit: 4.

Optimal Control: definition, performance indices and constraints, variational approach to optimal control systems, linear quadratic optimal control systems: regulator and tracking problems, matrix differential Riccati equation, Pontryagin minimum principle, optimal control using dynamic programming, Hamilton Jacobi Bellman equation.

### Books Recommended:

1. S. Barnett; Introduction to mathematical control theory, Clarendon press.
2. D. S. Naidu; Optimal control systems, CRC press.



## MTHCE–2412: Bio-Mechanics

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Newton's equations of motion. Mathematical modeling. Continuum approach.

### Unit: 2.

Segmental Movement and Vibrations. External Flow: Fluid Dynamic Forces Acting on Moving Bodies.

### Unit: 3.

Flying and Swimming. Blood Flow in Heart, Lung, Arteries, and Veins. Micro and Macrocirculation. Respiratory Gas Flow.

### Unit: 4.

Description of Internal Deformation and Forces. Stress, Strain, and Stability of Organs.

### Books Recommended:

1. Y. C. Fung: Biomechanics, Springer-Verlag, New York Inc., 1990.

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## MTHCE-2413: Algebraic Number Theory

Marks (Theory): 70

Marks (Internal Assessment): 30

Marks (Total): 100

Time: 03 Hours

Total Credit: 04

Note: -

The examiner is required to set nine questions in all.

The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.

In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

### Unit: 1.

Algebraic numbers and algebraic integers. Transcendental Numbers. Liouville's Theorem for real Algebraic numbers. Thue Theorem and Roth's theorem (statement only). Algebraic numberfield  $K$ . Theorem of Primitive elements. Liouville's Theorem for complex algebraic numbers. Minimal polynomial of an algebraic integer. Primitive  $m$ -th roots of unity. Cyclotomic Polynomials. Norm and trace of algebraic numbers and algebraic integers. Bilinear form on algebraic number field  $K$ .

### Unit: 2.

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  $K$ . 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.

### Unit: 3.

Different of an algebraic number field  $K$ . Dedekind theorem. 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  $K$ .

### Unit: 4.

Diophantine equations Minkowski's bound. Quadratic reciprocity Legendre Symbol. Gauss sums. Law of quadratic reciprocity. Quadratic fields. Primes in special progression.

### Books Recommended:

1. Jody Esmonde and M.Ram Murty, Problems in Algebraic Number Theory (Springer Verlag, 1998).
2. Paulo Ribenboim, R. Narasimhan, S. Raghavan, Algebraic Numbers, Algebraic Number Theory and Mathematical Pamphlets-I, Tata Institute of Fundamental Research(1966).

