Detailed Syllabus for M.Sc Mathematics

PROGRAMME STRUCTURE & Syllabus FOR M.SC MATHEMATICS

Programme Structure

S.No	Course Code	Course Title	Type of Course	Teaching hours/week	Credits	Marks		Total Marks
						CIA	ESE	
	SEMESTER-I							
1	**MMT-101**	**Advanced Algebra – I**	C	4	4	40	60	100
2	**MMT-102**	**Real Analysis**	C	4	4	40	60	100
3	**MMT-103**	**Complex Analysis**	C	4	4	40	60	100
4	**MMT-104**	**Topology**	C	4	4	40	60	100
5	**SS**	**Soft Skill Elective**	SS	4	4	40	60	100
	SEMESTER-II							
6	**MMT-201**	**Advanced Algebra – II**	C	4	4	40	60	100
7	**MMT-202**	**Advanced Real Analysis**	C	4	4	40	60	100
8	**MMT-203**	**Functional Analysis**	C	4	4	40	60	100
9	**MMT-204**	**Ordinary & Partial Differential Equations**	C	4	4	40	60	100
10	**SO**	**Social Orientation Elective**	SO	4	4	40	60	100
	SEMESTER-III							
11	**MMT-301**	**Analytic Theory of Functions**	C	4	4	40	60	100
12	**MMT-302**	**Theory of Numbers-I**	C	4	4	40	60	100
13	**MMT-303**	**Methods of Applied Mathematics**	C	4	4	40	60	100
14 15	**Elective** **Elective**	**Elective Course I** **Elective Course II**	E E	4 4	4 4	40 40	60 60	100 100
	SEMESTER-IV							
16	**MMT-401**	**Differential Geometry**	C	4	4	40	60	100
17	**MMT-402**	**Theory of Numbers II**	C	4	4	40	60	100
18	**MMT-403**	**Graphy Theory**	C	4	4	40	60	100
19	**Elective**	**Elective Course III**	E	4	4	40	60	100
20	**MMT-405**	**Project on any of the topics taught (except the electivecourse) in Semester IV**	C	4	4	40	60	100
	Grand Total							**2000**

Detailed Syllabus for M.Sc Mathematics

Notes:

C: Core **E: Elective** **SS: Soft Skill** **SO: Social Orientation**

1. **Soft Skill Electives:**
   SS 01 - I T Skills (Not available to MSc. I.T students.)
   SS 02 - Communication Skills (Not available to MA English students.)
   SS 03- Management Skills (Not available to MBA students.)
2. **Social Orientation Electives:**
   SO 01 - Human Rights
   SO 02 - Disaster Management
   SO 03 - Environment and sustainable Development
3. **List of Electives for Elective Course I and Elective Course II.**
   MMT E01: Operations Research
   MMT E02: Commutative Algebra
   MMT E03: Coding Theory
   MMT E04: Probability & Statistics-I
   MMT E05: Fuzzy Logic
4. **List of Electives for Elective Course III.**
   MMT E06: Probability & Statistics-II
   MMT E07: Theory of Semi-rings
   MMT E08: Advanced Topics in Analytic Theory of Polynomials
   MMT E09: Wavelet Analysis
   MMT E10: Fluid Dynamics

ELECTIVES WILL BE OFFERED SUBJECT TO THE AVAILABILITY OF FACULTY

Detailed Syllabus

SEMESTER – I

MMT-101 : **Advanced Algebra – I**

Unit – I

Review of elementary concepts of groups and subgroups, semi-groups, criteria for a semi-group to be a group and normal sub-groups. Cyclic groups. Automorphisms of groups and structure of cyclic groups. Generator of acyclic groups. Endomorphism and Inner Automorphism of groups. Center of a group. Cauchy's theorem and Sylow's theorem for alelian groups. Cayley's theorem, Permutation groups, Symmetric groups, Alternating groups, simple groups and simplicity of an alternating group A_n, for $n \geq 5$

Unit – II

Normalizer, conjugate classes, class equation of a finite group and its applications, Cauchy's theorem, Sylow's theorem, Double cosets, second and third parts of Sylow's theorem. Direct product of groups, finite abelian groups, sub-normal and normal series of a group. Length of the sub-normal series. Solvable groups, maximal normal sub-groups and composition series of a group. Zassenhaus theorem and Scherier's refinement theorem. Jordan Holder theorem for finite groups.

Unit – III

Review of Rings, integral domains and Division rings and fields with examples. Sub-rings and ideals. Prime and maximal ideals of a ring. Principal ideals. Power of an ideal. Nilpotent ideal and nil ideal. Field of quotients and Embedding Theorems. Ring of Polynomials F[x] over a field F. F[x] is an integral domain. The Division Algorithm F[x]. Factorization Theory in integral domains. Divisibility, associates, prime and irreducible elements in a commutative ring with examples. Principal ideal domains with related results.

Unit IV

Relation and ordering, partially ordered sets and Lattices. Properties of lattices, sub-lattice and complete lattice. Distributive lattice, modular lattice and complemented lattice. Boolean Algebra, definition and properties. Duality and principle of duality, Boolean Algebras and Lattices. Sum-of-Products form for Boolean Algebras, Boolean expressions, complete Sum-of-Products. Minimal Boolean Expressions, Prime implicants. Logic gates and circuits

Text Books

1. I.N. Herstein, "**Topics in Algebra**" , 2nd Edition, John Wiley and Sons, 2006.
2. Surjeet Singh and qazi Zameeruddin, "**Modern Algebra**", Vikas, 1999.
3. N. Jacobson, Basic Algebra, Vol. 1, W.H. Freeman & Company, 1985

Reference Books
1. S. Warner, "**Classical Modern Algebra**", Prentice Hall, 1971
2. G. Birkhoff and S. Maclane, "**Algebra**", Macmillan, 1979
3. J.R. Durbin, "**Modern Algebra**", John Wiley, 1979
4. N. Jacobson, "**Basic Algebra- I**", Hemisphere Publishing Corporation, 1984
5. S. Lang, "**Algebra**", Springer, 2002
6. M. Artin, "**Algerba**", Prentice Hall, 1991.
7. J.B. Fraieigh, "**A First Course in Abstract Algebra**", Addison-Wesley, 2002.
8. G. Birkhoff, "**Lattice Theory**", American Mathematical Society, Colloqium Publications, Vol. 25, New York, 1948
9. J.J. Rotman, "**An Introduction to the Theory of Groups**", Graduate Texts in Mathematics, 148, Springer-Verlag, 1995
10. S. Lang, "**Algebra Graduate Texts in Mathematics**, **211**", Springer-Verlag, 2002
11. N.S. Gopalakrishnan, "**University Algebra"**, Wiley Eastern Ltd., 1986
12. N.S. Gopalakrishnan, "**Commutative Algebra**", Oxonian Press Pvt. Ltd. 1984

MMT-102 : <u>Real Analysis</u>

Unit –I

A review of basic set theory, finite, countable and un-countable sets, real number system as complete order field, Archimedean property, Bounded and un-bounded sets, Supremum and Infimum, Dedekind's form of completeness property

Inequalities: Arithmetic Mean- Geometric mean inequality, Cauchy-Schwarz inequality, Chebyshev's inequality, Holder's and Minkowski inequalities, Convex and concave functions, Jensen's inequality, Bernoulli's inequality, some applications involving inequalities

Unit-II

Definition and existence of the Riemann-Stieltjes integral,, upper and lower sums and integrals. Refinement of partitions. Necessary and sufficient conditions for R-S integrability. Some properties of the Riemann- Stieltjes integrals. The integral as a limit of a sum. R-S integrability of continuous and monotonic functions, reduction of the R-S integral to a Riemann integral. First and second Mean Value Theorems. Change of variables

Unit-III

Improper Integrals: integration of un-bounded functions with finite limit of integration. Comparison of tests for convergence of improper integrals. Cauchy's test for convergence. Absolute convergence. Infinite range of integration of bounded functions . convergence of integrals of unbounded functions with infinite limits of integration. Integrated as a product of functions. Abel's and Dirchlet's tests of convergence.

Unit-IV

Uniform convergence of sequences and series of functions : Point wise convergence, uniform convergence on an interval, Caucy's criterion for uniform convergence, M_n-test for uniform convergence of sequences, Weirestrass's M-Test, Abel's and Dichelt's tests for uniform convergence of series. Uniform convergences and continuity, uniform convergence and integration and uniform convergence and differentiation, Weirestrass Approximation Theorem

Text Books

1. Walter Rudin, "**Principles of Mathematical Analysis**", 3rd Edition. Mc-Graw Hill, 1976.
2. S.C. Malik, "**Mathematical Analysis**" Wiley Eastern Limited Urvashi, Press, 1983, Meeut
3. B.J. Venkatachala, "**Inequalities- An Approach Through Problems**, Hindustan Book Ageny (India), 2009

Reference Books

1. A.J. White, "**Real Analysis- An Introduction**", Addison, Wesley, 1968
2. S. Lang, "**Real Analysis**", Addison, Wesley, 1969
3. R. Goldberg, "**Methods of Real Analysis**", John Wiley & Sons, 1976
4. T.M. Apostol, "**Mathematical Analysis**", Narosa, 2004
5. H.L. Royden, "Real Analysis", MacMillan, 1988
6. G.B. Folland, "**Real Analysis**", Brooks/Cole, 1992

MMT-103: Complex Analysis

Unit –I

Continuity and differentiability of complex functions, analytic functions, Cauchy-Riemann equations, necessary and sufficient condition for analyticity, complex integration, Gourset's Lemma and Cauchy theorem. The index of a point with respect to a closed curve, Cauchy's integral formula, Cauchy integral formula for the derivative, Higher order derivatives, Morera's theorem and Cauchy's inequality

Unit – II

Moebius (Bi-linear) transformations, their properties and classification. Fixed points and critical points of a bi-linear transformation. Cross ration, conformal mapping and perseverance of cross ratio. Bi-linear transformations carrying circles into circles, Bi-linear transformations carrying $l_m(Z) \geq 0$ into $|W| \leq 1$, $Re(Z) \geq 0$ into $|W| \leq 1$, $|Z| \leq 1$ into $|W| \leq 1$ and $|Z| \leq R$. The transformations

$W = \sqrt{z}$, $w = z^2$ and $w = \frac{1}{2}(z + \frac{1}{z})$

Unit – III

Power series, absolute convergence, radius of convergence of power series and Cauchy-Hadamard Formula, Taylor's Theorem, Taylor's series and expansion of an analytic function in a power series, Laurent's Theorem and uniqueness of Laurent expansion, classification of singularities, isolated singularities, poles and essential singular points, behaviour at an essential singular point, Casorati-Weirstrauss Theorem

Unit-IV

Calculus of Residues : Residue at a pole and Residue at infinity, Cauchy Residues Theorem, Jordan's Lemma and Evaluation of integrals by the method of residues. Pasevals Identity, infinite products, if $a_n \geq 0$ then $\sum a_n$ and $\prod (1+a_n)$ converge or diverge together, if $0 \leq b_n \leq 1$, then $\sum b$ and $\prod (1+b_n)$ converge or diverge together. Absolute convergence of $\prod (1+a_n)$, necessary and sufficient condition for absolute convergence, if $\sum a_n$ and $\sum a_n^2$ are convergent, then so is $\prod (1+a_n)$

Text Books

1. L.V. Ahlfors, "**Complex Analysis**", 3rd Edition, MC Graw Hill, New York, 1979
2. J.B. Conway, "**Functions of One Complex Variable**", II, Graduate Text in Mathematics, 159, Springer-Verlag, 1995
3. Richard A Silverman, "**Introductory Complex Analysis**", Prentice Hall, Inc., 1967

Reference Books

1. E.C. Tichmarsh, "**Theory of Functions**", Oxford University Press
2. W.H.J. Fuchs, "**Topics in Theory of Functions on One Complex Variable**"
3. E.Hille, "**Analytic Function Theory**", Vol. 1, Ginn, 1959
4. R. Nevanlinna, "**Analytic Functions**", Springer 1970
5. M.R. Spiegel, "**Theory & Problems of Complex Variables**", Schaum's Outine Series, Mc Graw Hill, New York , 1985
6. R.V. Churchill, J.W. Brown and R.F. Verkey, "**Complex Variables and Applications**", 5, Ed. MC-Graw Hill, New York, 1989.

MMT-104: Topology

Unit-I

Definition and examples of metric spaces, open and closed spheres and sets, convergence and completeness in metric spaces, Cantor's Intersection Theorem, topological spaces, closet set, closure, dense sub-sets, neighbourhoods, interior, exterior, and boundary of a set, accumulation points and derived sets, bases and sub-bases, sub-spaces and relative topology, the product topology on two spaces, the metric topology, continuous functions and Homeomorphism

Unit – II

First and second countable spaces, separable spaces, second countability and separability, separation axioms , T_i (i =0, 1,2) spaces and their characterizations and basic properties, regular and completely regular, normal and completely normal spaces, Urysohn's Lemma, Tietze Extension Theorem

Unit-III

Open Covering and compact spaces, continuous functions and compact sets, finite intersections property, locally compact spaces, countable compactness and sequential compactness, Bolzano Weierstrass Property, Lebesgue Covering Lemma, Total boundedness, equivalence of compactness

Unit – IV

Separation of a space, connected space, connected sets in the real line, totally dis-connected spaces, intermediate value theorem, path connected, components, local connectedness, locally path connected spaces, continuous and connected sets.

Text Books

1. J.R Munkres, "**Topology** (*Relevant Portions Only*)" Pearson Education, 2004
2. Benjamin T. Sims, "**Fundamentals of Topology** (*Relevant Portions Only*)" Macmillan Publishing Co., Inc. New York
3. Colin Adams & Robert Franzosa, "**Introduction to Topology : Pure & Applied**"

Reference Books

1. Sions G.F., "**Introduction to Topology & Modern Analysis**", Tata MC-Graw Hill, 1963
2. J.R. Munkres, "**Topology**", 2^{nd} Edition, Prentice Hall of India, 2007
3. Dugundji J, **Topology",** Prentice Hall of India, 1966
4. Willard, "**General Topology**", Addison-Wesley 1970
5. Crump, W. Baker, **"Introduction to Topology"**, Krieger Publishing Company, 1997
6. I.M. Singer & J.A. Thorpe, "**Lecture Notes on Elementary Topology & Geometry**", Undergraduate Texts in Mathematics, Srpinger-Verlag, 1976

SEMESTER – II

MMT-201 : <u>Advanced Algebra –II</u>

Unit – I

Euclidean rings with examples such as Z [√ - 1] and Z [√ - 2]. Principal ideal rings. Divisibility, greatest common division, unit, associates and prime elements with their properties in Euclidean rings. Relatively prime elements, factorization and unique factorization theorems, maximal ideals in Euclidean rings, polynomials over the rational field. Irreducible and primitive polynomials, the product of two primitive polynomials is a primitive polynomial, the content of a polynomial, Gauss's Lemma, integer monic polynomials, Eisenstein's irreducibility criteria for irreducibility over the rationals

Unit-II

Review of basis concept of vector spaces, sub-spaces, linear dependence and independence, bases and dimensions, inner product spaces, definition with examples, properties of an inner product space and Cauchy-Schwarz inequality. Modules, definition with examples, sub-modules, quotient modules, cyclic and finitely generated modules, direct sum of modules, fundamental theorem on finitely generated modules, modules homonmorphism and module isomorphisms.

Unit-III

Fields, sub-fields, prime fields and their structure, extension of fields, roots of polynomials, algebraic numbers and algebraic extensions of a field, minimal polynomials of algebraic elements, remainder and factor theorems, splitting field of a polynomials, simple extension of a field

Unit –IV

Separable and inseparable extensions of fields with related results, finite and perfect fields, the elements of Galois theory, Automorphism of a field and group of Automorphisms , normal extensions and fundamental theorem of Galois theory, construction with straight edge and compass

Text Books

1. I.N. Herestein, "**Topics in Algebra**", 2nd Edition, John Wiley and Sons, 2006
2. Surjeet Singh & Qazi Zameeruddin, "**Modern Algera**", Vikas, 1999
3. N. Jacobson, "Basic Algebra", Vol. 1, W.H., Freeman & Company, 1985

Reference Books

1. S. Warner, "**Classical Modern Algebra**", Prentice Hall, 1971
2. G. Birkhoff and S. Maciane, "**Algebra**", Macmillan, 1979
3. J.R. Durbin, "**Modern Algebra**", John Wiley, 1979
4. S.Lang, "**Algebra**", Springer, 2002
5. M. Artin, "**Algebra**" , Prentice Hall, 1991
6. J.B. Fraleigh, "**A First Course in Algebra**", Addison-Wesely, 2002
7. G. Birkhoff, "**Lattice Theory**", American Mathematical Society, Coloquium Publications, Vol. 25, New York 1995
8. J.J. Rotman, "**An Introduction to the Theory of Groups**", Graduate Texts in Mathematics, 148, Springer-Verlga, 1995
9. S. Lang, "Algebra", Graduate Texts in Mathematics, 211, Springer-Verlag, 2002
10. N.S. Gopalakrishnan, "**University Algebra"**, Wiley Eastern Ltd., 1986
11. N.S. Gopalakrishnan, "**Commutative Algebra**", Oxonian Press Pvt. Ltd. 1984

MMT-202 : <u>Advanced Real Analysis</u>

Unit – I

Measurable sets : Definitions of outer and inner measure of a set, some basic properties, outer measure of an interval as its length, measurability of the union of two measurable sets, measurability of the countable union of pair wise dis-joint bounded measurable sets, inequality concerning countable addditivity of an outer measure, Borel measurable sets, sets of measure zero and non-measurable sets. Measurable of the outer and inner limiting sets, measurable functions & their structures

Unit-II

Riemann integral and its deficiency, Lebesgue integral of bounded function, comparison of Riemann 7 Lebesgue integrals, properties of Lebesgue integral for bounded measurable function, the Lebesgue integral for unbounded functions, integral of non-negative measurable functions, general Lebesgue integral, improper integral

Unit-III

Real valued functions of several variables : spheres and neighbourhoods of a point in the Euclidean space R^n. Limit point of a set R^n. limit, continuity, uniform continuity and inter-mediate value theorem in R^n. limit and continuity of vector valued functions, partial derivatives and directional derivative, existence of directional derivatives, composite functions (linear case), mean value theorem in R^n, differentiability at a point and sufficient condition for differentiability in R^n. Partial derivatives of higher order and generalized reversal theorem, second and higher order derivatives

Unit – IV

Taylor's theorem in R^n, extreme values and a necessary condition for an extreme value of a real valued function in variables, Lagrange's multipliers, invertible functions, locally invertible transformations and Jacobian of a transformation, linear valued functions and the Jacobian of a linear transformation, linear vector valued functions and the Jacobian of a linear transformation. Inverse Function Theorem, implicitly defined functions and implicit function theorem

Text Books

1. Walter Rudin, "**Principles of Mathematical Analysis**", 3rd Edition, MC-Graw Hill, 1976
2. S.C. Malik, "**Mathematical Analysis**", Wiley Eastern Limited Urvashi Press, 1983, Meerus
3. Barra, De. G, "**Measure Theory and Integration**(Narosa)"
4. Shanti Narayan, "**Mathematical Analysis**", S. Chand & Co., 1986, New Delhi

Reference Books

1. D.V. Widder, "**Advanced Calculus**". 2/e, Prentice Hall of India, New Delhi
2. R. Goldberg, "**Methods of Real Analysis**", John Wiley & Sons, 1976
3. T.M. Apostol, "**Mathematical Analysis**", Narosa, 2004
4. H.L. Royden, "**Real Analysis**", Macmillan, 1988
5. G.B. Folland, "**Real Analysis**", Brooks/ Cole, 1992
6. T.M. Apostol, "**Mathematical Analysis**"

MMT-203 : <u>Functional Analysis</u>

Unit- I

Normed linear spaces and Branch Spaces : Definition & examples, continuous linear transformations and their characterization, completeness of the space B (X,Y) of bounded linear operators, isometric isomorphism, dual of a normed linear space, computing the dual of well known banach spaces, equivalence of norms of finite dimensional space, Hahn Banach theorem and its applications.

Unit- II

The natural imbedding of a normal linear space N in N**, Reflexive normed linear spaces, weak and weak * topologies, characterization of Reflexive Banach spaces, open mapping theorem, projection on a banach space, closed graph theorem and Banach Steinhaus theorem (Uniform boundedness Principle), conjugate of a continuous linear operator and its properties

Unit-III

Definition and examples of Hilbert spaces, Cauchy's Schwartz inequality and Parallelogram Law, Orhtogonal complements, orthogonal decomposition of Hilbert Space, orthonormal systems, Bessel's inequality, Gram Schmidst process, application of G-S process to certain linearly independent sequences in L2 [0, 2Λ], orthonormal basis in separable Hilbert spaces

Unit – IV

The conjugate space, the adjoint of an operator on Hilbert space and its properties, self adjoint operators, normal and unitary operators, and their properties, projections on a Hilbert space and their characterization, reflexivity of Hilbert space, Riesz representation theorem and finite spectral theorem for normal operators

Text Books

1. G.F. Simmons, "**Introduction to Topology and Modern Analysis**", MCGraw Hill, 1963
2. B.V. Llmaya, "**Functional Analysis**"

Reference Books

1. W. Wudin, "**Functional Analysis**", MCGraw Hill, Inc., 1991
2. J.B. Conway, **"A Course in Functional Analysis**", Graduate Texts in Mathematics, 96, Springer
3. Kosaku Yoshida, "**Functional Analysis**", Springer 1974
4. E.Kreysizig, "**Introductory Functional Analysis with Applications**", John Wiley, 1978
5. C.Goffmab, G. Pedrick, "**A First course in Functional Analysis**"
6. L.A. Lusternick & V.J. Sobolv, "**Elements of Functional Analysis**"

MMT-204 : **<u>Ordinary & Partial Differential Equations</u>**

Unit-I

First order ODE, singular solutions, p-discriminate and c-discriminate, initial value problems of first order ODE, general theory of homogenous and non-homogenous linear ODE, Picard's theorem of the existence and uniqueness of solutions to an initial value problem, factorization of operator, variation of parameters, numerical approximation to the solution of differential equations

Unit-II

Solution in series : Methods of Frobenius (i) Roots of an indicial equation, un-equal and differing by quantity not an integer (ii) Roots of an indicial equation, which are equal (iii) Roots of an indicial equation differing by an integer making coefficient infinite (iv) Roots of an indicial equation differing by an integer making a coefficient indeterminate.

Simultaneous equations dx/P = dx/Q = dz/R and its solutions by use of multipliers and a second integral found by the help of the first. Total differential equation Pdx + Qdy + Rdz = 0. Necessary and sufficient condition than an equation may be integrable. Geometric interpretation of the Pdx + Qdy + Rdz = 0

Partial differential equation : Partial differential equation of the first order, Lagrange's linear equation Pp + Qq = R, Charpits Method

Unit-III

Geometry of Partial Differential Equations : Cauchy Problem : Formulation and geometrical aspects, Cauchy Kowalewska theorem, reduction to a first order system, the proof of convergence by major ants, the generalized Cauchy problem

The Characteristic Surface : characteristic equation, examples, Lap Lace equation, Wave equation, Heat Equation, first order linear equation, first order linear system and general non-linear system.

Unit –IV

Classification of Partial Differential Equations : Linear equations of the second order in ne unknown function, elliptic, hyperbolic, ultra hyperbolic, parabolic, non-linear equations of the second order –Petoskey's type classification, systems of linear partial differential equations of the first order, Cauchy problem in non-analytic case, Holmgren's theorem, survey on general hyperbolic systems

The Basic Equations : The wave equation, one dimensional case, D Alembert's solution, Fourier method for a vibrating string, vibration of a membrane, the initials value problem in three space, Poisson's method of spherical averages, Huygen's principle, the method of descent, the in-homogenous wave equation, the initial value problem f heat conduction, investigation of harmonic functions, mean value principle and maximum principle, Dirchlet problem, Poisson integral formulas, Neumann problem, interpretation by means of the Brownian motion

Text Books

1. H.P.H. Tiago, "Theory of Differential Equations"
2. E.A. Coddington & N. Levinson, "**Theory of Ordinary Differential Equations**"

Reference Books

1. P. Hartmen, "**Ordinary Differential Equations**"
2. W.T. Reid, "**Ordinary Differential Equations**"
3. R. Courant, "**Partial Differential Equations**"
4. Tyn Myint, "**Partial Differential Equations of Mathematical Physics**", Elsevier, 1973
5. G. Petrosky, "**Lectures on Partial Differential Equations**"
6. Fritz John, "**Lectures on Partial Differential Equations**"
7. I.C. Evans, "**Lectures on Partial Differential Equations**"
8. I.N. Sheddon, "**Lectures on Partial Differential Equations**"
9. I.N. Sheddon, "Elements of **Partial Differential Equations**", 3rd Edition, Tata MCgraw Hill Company, 1998
10. T. Amarnath, "**An Elementary Course in Partial Differential Equations",** 2nd Edition, Narosa Publising House