Syllabus for the course of study in
M.A/M.Sc. Mathematics (I to IV Semester)
For 2010-2013

SEMESTER-I
(Courses of Study for 2010 – 2013)

Course No. Title of the Course
MM-CP-101:--------------------- Abstract Algebra -I
MM-CP-102:--------------------- Real Analysis-I
MM-CP-103:---------------------Complex Analysis-I
MM-CP-104:---------------------Methods of Applied Mathematics-I
MM-CP-105:---------------------Topology

SEMESTER-II
(Courses of Study for 2010 – 2013)

Course No. Title of the Course
MM-CP-201:---------------------Abstract Algebra-II
MM-CP-202:---------------------Real Analysis-II
MM-CP-203:---------------------Complex Analysis-II
MM-CP-204:---------------------Methods of Applied Mathematics-II
MM-CP-205:---------------------Functional Analysis - I

SEMESTER-III
(Courses of Study for the Year2011-2014)

Core Courses

Course No. Title of the Course
MM-CP-301:--------------------- Ordinary Differential Equations
MM-CP-302:--------------------- Functional Analysis-II

SEMESTER-IV
(Courses of Study for the Year 2011-2014)

Core Courses

Course No. Title of the Course
MM-CP-401:--------------------- Partial Differential Equations
MM-CP-402:--------------------- Differential Geometry
Optional Courses

Besides two core courses in 3rd and 4th Semesters as indicated above, three Optional papers out of the following will have to be chosen by a student in the 3rd Semester and the corresponding three optional papers in the 4th Semester keeping in view the suitability of the combinations.

**SEMESTER: 3**

*(Courses of Study for 2011-2014)*

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<td>MM-OP-303:</td>
<td>Advanced topics in Topology &amp; Modern Analysis</td>
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**SEMESTER: 4**

*(Courses of Study for the Year 2011-2014)*

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<td>MM-OP-408:</td>
<td>Wavelet Analysis</td>
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<td>MM-OP-409:</td>
<td>Banach Algebras and Spectral Theory</td>
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**Note:**
The student shall have the option of choosing only those optional papers in the third & fourth semesters in which the facilities in terms of resource personnel & related infrastructure are available in the Department.
SEMESTER-I
ADVANCED ABSTRACT ALGEBRA-I

Course No. MM-CP-101
Duration of Examination: 3 hrs
Maximum Marks: 100
(a) External Exam: 80
(b) Internal Exam: 20

Unit I
Definitions and Examples of Semi-groups and Monoids, Criteria for the semi-groups to be a group. Cyclic groups. Structure theorem for cyclic groups. Endomorphism, Automorphism, Inner Automorphism and Outer Automorphism, Center of a group, Cauchy’s and Sylow’s theorem for abelian groups. Applications of Sylow theory, Groups of order 2n, n as odd prime, groups of order \( p^2 \), \( pq \), \( p^3 \). Permutation groups, Symmetric groups, Alternating groups, Simple groups, Simplicity of the 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, normal and subnormal series, Composition series. Jordan Holder theorem for finite groups. Zassenhaus Lemma, Schreir’s Refinement theorem, Solvable groups and Nilpotent groups.

Unit III
Brief review of Rings, Integral domain, Ideals. The field of quotients of an Integral domain. Euclidean rings with examples such as \( \mathbb{Z}[\sqrt{-1}] \), \( \mathbb{Z}[\sqrt{2}] \), Principal ideal rings(PIR) Unique factorization domains(UFD), Relationships between Euclidean rings, P.I.R.’s and U.F.D. The Division algorithm for polynomials, Irreducible polynomials, Polynomials and the rational field, Primitive polynomials, Contract of a polynomials, Gauss Lemma, Integer monic polynomial, Eisenstein’s irreducibility criterion, Polynomial rings and Commutative rings.

Unit IV

Recommended Books:
1. I.N.Heristein : Topics in Algebra.
REAL ANALYSIS-I

Course No. MM-CP-102

Duration of Examination: 3 hrs

Maximum Marks: 100

(a) External Exam: 80
(b) Internal Exam: 20

Unit I
Infinite series: Carleman’s theorem. Conditional and absolute convergence, multiplication of series, Merten’s theorem, Riemann’s rearrangement theorem. Sequence and series of functions: Pointwise and uniform convergence, Cauchy criterion for uniform convergence, Weirstrauss M-test, uniform convergence and continuity, Riemann integration and differentiation, Weirstrass’s Approximation Theorem, Example of a continuous nowhere differentiable function on R.

Unit II
Integration: Definition and existence of Riemann – Stieltjes integral, behavior of upper and lower sums under refinement, Necessary and sufficient conditions for RS-integrability of continuous and monotonic functions, Reduction of an RS-integral to a Riemann integral, Basic properties of RS-integrals, Differentiability of an indefinite integral of a continuous function, Fundamental theorem of calculus for Riemann integrals.

Unit III

Unit IV
Functions of several variables, directional derivative and continuity, total derivative, Matrix of a linear function, Jacobian matrix, chain rule, mean value theorem for differentiable functions. Sufficient conditions for differentiability and for the equality of mixed partials, Taylor’s theorem for functions from \( \mathbb{R}^n \) and \( \mathbb{R} \). Inverse and Implicit function theorems in \( \mathbb{R}^n \). Extremum problems for functions on \( \mathbb{R}^n \). Langrange’s multipliers, Multiple Riemann Integral and change of variable formula for multiple Riemann integrals.

Recommended Books:
1. R. Goldberg: Methods of Real Analysis
2. W. Rudin: Principles of Mathematical Analysis
3. J.M. Apostol: Mathematical Analysis
4. S.M. Shah and Saxena: Real Analysis
5. A.J. White: Real Analysis, An Introduction
6. L. Royden: Real Analysis
COMPLEX ANALYSIS-I

Course No. MM-CP-103
Duration of Examination: 3 hrs

Maximum Marks: 100
(a) External Exam: 80
(b) Internal Exam: 20

Unit I
Review of C-R equations and analytic functions. Complex integration, Cauchy Goursat theorem, the index of a point w.r.t. of a closed curve. Cauchy’s integral formula, higher order derivatives. Morera’s theorem, Cauchy’s inequality and Liounillis Theorem.

Unit II

Unit III
Bilinear(Moebus) transformations. Their properties and classification. Fixed Points, Cross Ratio, Inverse points and Critical Points. Conformal Mapping. Mappings of (i) upper half plane on to the unit disc, (ii) unit disc on to the unit disc, (iii) left half plane on to the unit disc and (iv) circle on to a circle. The Transformations $w = \sqrt{z}$, $w = z^2$ and $w = \frac{1}{2} \left( z + \frac{1}{z} \right)$.

Unit IV

Recommended Books:

1. L.Ahlfors, Complex Analysis.
METHODS OF APPLIED MATHEMATICS-I

Course No. MM-CP-104
Duration of Examination: 3 hrs

Maximum Marks: 100
(a) External Exam: 80
(b) Internal Exam: 20

UNIT-I (Matrix Theory)
Eigen values and eigen vectors of a matrix and their determination. Similarity of matrices. Two similar matrices have the same eigen values. Algebraic and geometric multiplicity of a characteristic root. Necessary and sufficient condition for a square matrix of order n to be similar to a diagonal matrix. Orthogonal reduction of real matrices, Schur’s theorem. Normal matrices, Necessary and sufficient condition for a square matrix to be unitarily similar to a diagonal matrix.

Quadratic forms: The Kronecker’s and Lagrange’s reduction. Reduction by orthogonal transformation of real quadratic forms. Necessary and sufficient condition for a quadratic form to be positive definite. Rank, Index and signature of a quadratic form. If $A = [a_{ij}]$ is a positive definite matrix of order n, then $|A| \leq a_{11}a_{22}\cdots a_{nn}$. Gram matrices. The Gram matrix $B'B$ is always positive definite or positive semi-definite. Hadamard’s inequality. If $B = [b_{ij}]$ is an arbitrary non-singular real square matrix of order n, then

$$|B| \leq \prod_{i=1}^{n} \left( \sum_{k=1}^{n} |b_{ik}| \right).$$

UNIT-II
(Numerical Analysis)

(Topic of Probability)
UNIT-III
The probability set functions, its properties, probability density function, the distribution function and its properties. Mathematical Expectations, some special mathematical expectations, Inequalities of Markov, Chebyshev and Jensen.

UNIT-IV
Conditional probability, independent events, Baye’s theorem, Distribution of two and more random variables, Marginal and conditional distributions, conditional means and variances, Correlation coefficient, stochastic independence and its various criteria.

Recommended Books:

2. Introduction to Numerical Analysis by K.E. Atkinson
3. Hogg and Craig: An Introduction to the Mathematical Statistics
Suggested Readings:

2. A Text Book of Matrices by Shanti Narayan, S. Chand and company Ltd.
4. Mood and Grayball : An Introduction to the Mathematical Statistics
**TOPOLOGY**

*Course No. MM-CP-105*

*Maximum Marks: 100*

*Duration of Examination: 3 hrs*

(a) External Exam: 80

(b) Internal Exam: 20

Unit I
Review of countable and uncountable sets, Schroeder-Bernstein theorem, Axiom of Choice and its various equivalent forms, Definition and examples of metric spaces, Open and Closed sets, Nets in topological spaces, convergence of nets, completeness in metric spaces, Baire’s Category theorem, and applications to the (1) Non-existence of a function which is continuous precisely at irrationals (ii) Impossibility of approximating the characteristic of rationals on [0, 1] by a sequence of continuous functions.

Unit II
Completion of a metric space, Cantor’s intersection theorem, with examples to demonstrate that each of the conditions in the theorem is essential, Uniformly continuous mappings with examples and counter examples, Extending Uniformity continuous maps, Banach’s contraction principle with applications to the inverse function theorem in R.

Unit III
Topological spaces; Definition and examples, elementary properties, Kuratowski’s axioms, continuous mappings and their characterizations, pasting Lemma, convergence of nets and continuity in terms of nets, Bases and sub bases for a topology, Lower limit topology, concepts of first countability, second countability, separability and their relationships, counter examples and behavior under subspaces, product topology and weak topology, compactness and its various characterizations.

Unit IV
Heine-Borel theorem, Tychnoff’s theorem, compactness, sequential compactness and total bounded ness in metric spaces. Lebesgue’s covering lemma, continuous maps on a compact space. Separation axioms T_i (i=1,2,3,3\frac{1}{2},4) and their permanence properties, connectedness, local connectedness, their relationship and basic properties, Connected sets in R. Urysohn’s lemma. Urysohn’s metrization theorem. Tietze’s extension theorem, one point compactification.

**Recommended Books:**

1. G.F. Simmons: Introduction to topology and Modern Analysis
2. J. Munkres: Topology
3. K.D. Joshi: Introduction to General topology
4. J.L. Kelley: General topology
5. Murdeshwar: General topology
6. S.T. Hu: Introduction to General topology
SEMESTER: 2

ADVANCED ABSTRACT ALGEBRA—II

Course No. MM-CP-201
Duration of Examination: 2-1/2 hrs

Maximum Marks: 100
(a) External Exam: 80
(b) Internal Exam: 20

Unit I

Unit-II

Unit-III
Fields: Prime fields and their structure, Extensions of fields, Algebraic numbers and Algebraic extensions of a field, Roots of polynomials, Remainder and Factor theorems, Splitting field of a polynomial, Existence and uniqueness of splitting fields of polynomials, Simple extension of a field.

Unit IV
Separable and In-separable extensions, The primitive element theorem, Finite fields, Perfect fields, The elements of Galois theory. Automorphisms of fields, Normal extensions, Fundamental theorem of Galois theory, Construction with straight edge and compass, \( R^n \) is a field iff \( n = 1, 2 \).

Recommended Books:

7. I.N.Heristein : Topics in Algebra.
REAL ANALYSIS-II

Course No. MM-CP-202  
Duration of Examination:3 hrs  
Maximum Marks: 100  
(a) External Exam: 80  
(b) Internal Exam: 202

Unit I
Measure theory: Definition of outer measure and its basic properties, Outer measure of an interval as its length. Countable additivity of the outer measure, Borel measurable sets and Lebesgue measurability of Borel sets, Cantor set, existence of non-measurable sets and of measurable sets which are not Borel, Outer measure of monotonic sequences of sets.

UNIT-II
Measurable functions and their characterization. Algebra of measurable functions, Stienhauss theorem on sets of positive measure, Ostrovisk’s theorem on measurable solution of \( f(x+y) = f(x) + f(y) \), \( x, y \in \mathbb{R} \). Convergence a.e., convergence in measure and almost uniform convergenc, their relationship on sets of finite measure, Egoroff’s theorem.

UNIT-III

UNIT-IV
Absolute continuity and bounded variation, their relationships and counter examples. Indefinite integral of a L-integrable functions and its absolute continuity. Necessary and sufficient condition for bounded variation. Vitali’s covering lemma and a.e. differentiability of a monotone function \( f \) and \( \int f' \leq f(b)-f(a) \).

Recommended Books:

1. Royden, L. :Real Analysis (PHI)
2. Goldberg, R. : Methods of Real Analysis
3. Barra, De. G. : Measure theory and Integration (Narosa)
7. T.M.Apostol : Mathematical Analysis
Unit I
Maximum Modulus Principle, Schwarz Lemma and its generalization, Meromorphic function, Argument Principle, Rouche’s theorem with application, Inverse function Theorem, Poisson integral formula for a circle and half plane, Poisson Jenson formula, Carleman’s theorem, Hadmard three-circle theorem and the theorem of Borel and Caratheodory.

Unit II

Unit III

Unit IV
Canonical products, order of an entire functions, Exponential convergence, Borel theorem, Hadmards factorization theorem, the range of analytic function, Bloch’s theorem, Schottkys theorems, the little Picard’s theorem, Landau’s theorem, Montel Carathéodory theorem and the Great Picard theorem. Univalent function. Bieberbach’s conjecture (statement only) and the 1/4 – theorem.

Recommended Books:

1. L.Ahlfors: Complex Analysis
2. E.C. Titchmarsh : Theory of Functions
3. J.B.Conway : Functions of a complex variable –I
4. Richard’s Silverman : Complex Analysis
5. A.I.Markushevish :Theory of Functions of a Complex variable
8. S.Lang : Complex Analysis.
11. D.Sarason: Complex Function Theory
UNIT I
Graphs, Basic terminology, Incidence and Degree, Isomorphism, Sub graphs, adjacency matrix, Walks, Paths, Cycles, Connected graphs, Components, Eulerian graphs, Euler’s theorem, Konigsberg Bridge Problem, Unicursal graphs, Operations on graphs, connected graphs and circuits, Hamiltonian paths and cycles, Dirac’s theorem, Degree sequences. Planar graphs, Kuratowski’s two graphs, Embedding on a sphere, Euler’s formula.

UNIT II
Trees, properties of trees, Pendant vertices in trees, Degree sequences in trees, Necessary and sufficient conditions for a sequence to be a degree sequence of a tree, Distance and Centers in a tree, spanning tree of a graph, The minimum spanning tree problem, Rooted and Binary trees, Cayley’s theorem on the number of trees on a given set of vertices, Fundamental cycles, Generation of trees, Ramsey’s theorem and Ramsey numbers.

UNIT III

UNIT IV

Recommended Books:
1. F. Harary, Graph Theory, Addison-Wesley.
2. Narsingh Deo : Graph Theory with Applications to Engineering and Computer Sciences, Prentice Hall, India Ltd.
3. D.B. West Introduction to Graph Theory Prentice, Hall, India.
5. O. Ore: Theory of Grpahs, AMS.
10. M. R. Cullen, Linear Models in Biology, Ellis Horwood Ltd.

**FUNCTIONAL ANALYSIS**

Course No. MM-CP-205
Duration of Examination: 3 hrs
Maximum Marks: 100
(a) External Exam: 80
(b) Internal Exam: 20

**BANACH SPACE:**

Unit I
Banach Spaces: Definition and examples, subspaces, quotient spaces, Continuous Linear Operators and their Characterization, Completeness of the space $L(X,Y)$ of bounded linear operators (and its converse), incompleteness of $C[a, b]$, under the integral norm, Finite dimensional Banach spaces, Equivalence of norms on finite dimensional space and its consequences, Dual of a normed linear space, Hahn Banach theorem (extension form) and its applications, Complemented subspaces, Duals of $l^n_p$, $C_0$, $l_p$ ($p \geq 1$), $C[a, b]$.

Unit II
Uniform boundedness Principle and weak boundedness, Dimension of an infinite-dimensional Banach space, Conjugate of a continuous linear operator and its properties, Banach-Steinhauss theorem, open Mapping and closed graph theorems, counterexamples to Banach-Steinhauss, open mapping theorem and closed graph theorems for incomplete domain and range spaces, separable Banach spaces and the separability of some concrete Banach spaces ($C_0$, $C[0,1]$, $l_p$, $p \geq 1$), Reflexive Banach Spaces, closed subspace and the dual of a reflexive Banach space, Examples of reflexive and non-reflexive Banach spaces.

**HILBERT SPACE:**

Unit III
Hilbert spaces: Definition and examples, Cauchy’s Schwartz inequality, Parallelogram law, orthonormal (o.n) systems, Bessel’s inequality and Parseval’s Identity for complete orthonormal systems, Riesz-Fischer theorem, Gram Schmidt process, o.n basis in separable Hilbert spaces.

Fourier Series: Fourier series with respect to an o.n. base in Hilbert space, Applications to classical Fourier analysis, Examples of special o.n. bases in $L_2[-\pi, \pi]$. Convergence of Fourier series: Fejer’s theorem on $(C,1)$ convergence of Fourier series of a continuous function on $(-\pi, \pi)$, Existence of a continuous function with a divergent Fourier series at a point, Riemann-Lebesgue Lemma, Convergence of Fourier series of
a function which is continuous and has left and right hand derivatives, Term by term integration of Fourier series, Uniform convergence of a Fourier series

**UNIT-IV**

**Recommended Books:**

3. L.A. Lusternick & V.J. Sobolov. : Elements of Functional Analysis

**SEMESTER 3**

**ORDINARY DIFFERENTIAL EQUATIONS**

**Course No. MM-CP-301**
**Maximum Marks: 100**
**Duration of Examination: 3 hrs**

(a) External Exam: 80
(b) Internal Exam: 20

**Unit I**

**Unit II**
Solution in Series: (i) Roots of an Indicial equation, un-equal and differing by a quantity not an integer. (ii) Roots of an Indicial equation, which are equal. (iii) Roots of an Indicial equation differing by an integer making a coefficient infinite. (iv) Roots of an Indicial equation differing by an integer making a coefficient indeterminate. Simultaneous equation \(dx/P = dx/Q = dz/R\) and its solutions by use of multipliers and a second integral found by the help of first. Total differential equations \(Pdx + Qdy + Rdz = 0\). Necessary and sufficient condition that an equation may be integrable. Geometric interpretation of the \(Pdx + Qdy + Rdz = 0\).

**Unit III**
Existence of Solutions, Initial value problem, Ascoli-lema, Cauchy Piano existence theorem, Uniqueness of solutions with examples, Lipschitz condition and Gronwall inequality, Method of successive approximation, Picard-Lindlof theorem, Continuation
of solutions, System of Differential equations, Dependence of solutions on initial
conditions and parameters.

**Unit IV**
Maximal and Minimal solutions of the system of Ordinary Differential equations,
Cartheodary theorem, Linear differential equations, Linear Homogeneous equations,
Linear system with constant coefficients, Linear systems with periodic coefficients,
Fundamental matrix and its properties, Non-homogeneous linear systems, Variation of
constant formula. Wronskian and its properties.

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**Recommended Books:**

1. H.T.H. Piaggio, Differential Equations, CBS Publishers and Distributors, New Delhi
2. P.Hartmen : Ordinary Differential Equations
3. W.T.Reid : Ordinary Differential Equations
FUNCTIONAL ANALYSIS-II

Course No. MM-CP-302  Maximum Marks: 100
Duration of Examination: 3 hrs  (a) External Exam: 80
                          (b) Internal Exam: 20

Unit I
Relationship between analytic and geometric forms of Hahn-Banach Theorem, Applications of Hahn-Banach Theorem: Banach limits, Markov-Kakutani theorem for a commuting family of maps, Complemented subspaces of Banach spaces, Complementability of dual of a Banach space in its bidual, uncomplementability of co, Dual of Subspace, Quotient space of a normed space.

Unit II
Banach’s closed range theorem, injective and surjective bounded linear mappings between Banach spaces $\ell_\infty$ and $C[0,1]$ as universal separable Banach spaces, $l_1$ as a quotient universal separable Banach space, Weak and weak* topologies on a Banach space, Goldstine’s theorem, Banach-Alaoglu theorem and its simple consequences.

Unit III
Reflexivity of Banach spaces and weak compactness, Completeness of $Lp[a,b]$. Duals of $\ell_\infty$, $C(X)$ and $Lp$ spaces, Banach Stone Theorem, Applications of fundamental theorems to Radon-Nikodym Theorem, Laplace transform.

Unit IV
Extreme points, Krein-Milman theorem and its simple consequences, Mazur-Ulam theorem on isometries between real normed spaces, Muntz theorem on $C[a,b]$ and $L2 [a,b]$. Bases in Banach spaces, Schauder basis for $C[0,1]$. 
Recommended Books:

1. Ballobas, B; Lineart Analysis (Camb. Univ. Pres)
2. Goffman, C and Pedrick, G; A first course in functional Analysis (Prentice Hall.)
3. Beauzamy, B; Introduction to Banach Spaces and their geometry (North Holland).

ADVANCED TOPICS IN TOPOLOGY AND MODERN ANALYSIS

Course No. MM-CP-303
Duration of Examination: 3 hrs
Maximum Marks: 100
(a) External Exam: 80
(b) Internal Exam: 20

Unit I
Uniform spaces. Definition and examples, uniform topology, and metrizability complete regularity of uniform spaces, pre-compactness and compactness in uniform spaces, uniform continuity.

Unit II
Uniform continuity, uniform continuous maps on compact spaces Cauchy convergence and completeness in uniform spaces, initial uniformity, simple applications to function spaces, Arzela-Ascoli theorem.

Unit III
Abstract Harmonic Analysis, Definition of a topological group and its basic properties. Subgroups and quotient groups. Product groups and projective limits. Properties of topological groups involving connectedness. Invariant metrics and Kakutani theorem, Structure theory for compact and locally compact Abelian groups.

Unit IV
Some special theory for compact and locally compact Abelian groups, Haar integral and Haar measure, invariant means defined for all bounded functions, convolution of functions and measures. Elements of representation theory, Unitary representations of locally compact groups.
1. I.M. James Uniform Spaces, Springer Verlag.

**Suggested Readings:**
1. G. Murdeshwar, General Topology,

**ABSTRACT MEASURE THEORY**

**Course No. MM-CP-304**
**Maximum Marks:** 100

**Duration of Examination:** 3 hrs

(a) External Exam: 80
(b) Internal Exam: 20

**Unit-I**
Semiring, algebra and $\sigma$-algebra of sets, Borel sets, measures on semirings, outer measure associated with a set function and basic properties, measurable sets associated with an outer measure as a $\sigma$-algebra, construction of the Lebesgue measure on $\mathbb{R}^n$.

**Unit-II**
For $f \in L_1[ a, b ]$, $F'=f$ a.e. on $[a, b]$. If $f$ is absolutely continuous on $(a, b)$ with $f(x)=0$ a.e. then $f = \text{constant}$. Characterization of an absolutely continuous function as an indefinite Lebesgue integral. Non-Lebesgue integrability of $f$ where $f(x) = x^2 \sin(1/x^2)$, $f(0) = 0$ on $[0, 1]$. Fundamental theorem of calculus for the Lebesgue integral. A brief introduction to $L^p$ spaces. Holder’s and Minkowki’s inequalities.

**Unit-III**
Improper Riemann integral as a Lebesgue integral, calculation of some improper Riemann integrable functions, space of Lebesgue integrable functions as completion of Riemann integrable functions on $[a,b]$, change of variables formula and simple consequences, Riemann Lebesgue lemma.

**Unit-IV**
Product measures and iterated integrals, example of non-integrable functions whose iterated integrals exist (and are equal), Fubini theorem, expressing a
double integral as an iterated integral, Tonelli-Hobson theorem as a converse to Fubini theorem, differentiation under the integral sign.

**Recommended Books:**
1. C.D. Aliprantis and O. Burkinshaw, Principles of Real Analysis
2. Goldberg, R.: Methods of Real Analysis
3. T.M. Apostol: Mathematical Analysis

**Suggested Readings:**
1. Royden, L: Real Analysis (PHI)
2. Chae, S.B. Lebesgue Integration (Springer Verlag).
4. Barra, De. G.: Measure theory and Integration (Narosa)

**THEORY OF NUMBERS-I**

**Course No. MM-CP-305**

**Maximum Marks: 100**

**Duration of Examination: 3 hrs**

(a) External Exam: 80

(b) Internal Exam: 20

**Unit I**

**Unit II**
Sequence of primes, Euclid’s Second theorem, Infinitude of primes of the form 4n+3 and of the form 6n+5. No polynomial f(x) with integer coefficients can represent primes for all integral values of x or for all sufficiently large x. Fermat Numbers and their properties. Fermat Numbers are relatively prime. There are arbitrary large gaps in the sequence of primes. Congruences, Complete Residue System (CRS), Reduced Residue System (RRS) and their properties. Fermat and Euler’s theorems with applications.

**Unit III**
Euler’s \( \phi \)-function, \( \phi (mn) = \phi (m) \phi (n) \) where \((m, n) = 1\), \( \sum_{d|m} \phi(d) = n \) and \( \phi(m) = m \prod_p \left(1 - \frac{1}{p}\right) \) for \( m > 1 \). Wilson’s theorem and its application to the solution the congruence of \( x^2 \equiv -1 (mod \ p) \), Solutions of linear Congruence’s. The necessary and sufficient condition for the solution of \( a_1x_1 + a_2x_2 + \ldots + a_nx_n \equiv c (mod \ m) \). Chinese Remainder Theorem. Congruences of higher degree \( F(x) \equiv 0 (mod \ m) \), where \( F(x) \) is a Polynomials. Congruence’s with prime power, Congruences with prime modulus and
related results. Lagrange’s theorem, viz., the polynomial congruence \( F(x) \equiv 0 \pmod{p} \) of degree \( n \) has at most \( n \) roots.

**Unit IV**
Factor theorem and its generalization. Polynomial congruences \( F(x_1, x_2, \ldots, x_n) \equiv 0 \pmod{p} \) in several variables. Equivalence of polynomials. Theorem on the number of solutions of congruences: Chevalley’s theorem, Warning’s theorem. Quadratic forms over a field of characteristic \( \neq 2 \) Equivalence of Quadratic forms. Witt’s theorem. Representation of Field Elements. Hermite’s theorem on the minima of a positive definite quadratic form and its application to the sum of two squares.

**Recommended Books:**

**Suggested Readings:**
2. An introduction to the theory of Numbers by G.H Hardy and Wright.
4. An elementary Number theory of E. Landau.
MATHEMATICAL BIOLOGY

Course No. MM-CP-306  
Duration of Examination: 3 hrs  
Maximum Marks: 100  
(a) External Exam: 80  
(b) Internal Exam: 20

Unit-I  

Unit-II  
Epidemic Models and Dynamics of Infectious Diseases: Simple Epidemic Models; SIS, SIR and SRS Epidemic Models. Modelling Venereal Diseases, Modelling Transmission Dynamics of HIV.
Unit-III
Cell Growth, Exponential Growth or Decay, Determination of Growth or Decay Rates, The method of Least Squares, Nutrient Uptake by a Cell, Growth of Microbial Colony and Growth of Chemostat.

Enzyme kinetics, The Michaelis-Menten Theory, Early time behaviour of Enzymatic reactions, Cooperative properties of Enzymes, Allosteric Enzymes, Haemoglobin,

Unit-IV
Introduction to compartment models, Discrete and Continuous transfers, Introduction to tracer method in Physiology, Bath-tub models, Continuous Infusion into a Compartment, Elementary pharmacokinetics, Parameter estimation in two Compartment models.

**Recommended Books:**

4. M. R. Cullen, Linear Models in Biology, Ellis Horwood Ltd.

**OPERATIONS RESEARCH**

*Course No. MM-CP-307*

*Duration of Examination: 3 hrs*

*Maximum Marks: 100*

(a) *External Exam: 80*

(b) *Internal Exam: 20*

**Unit I**

Definition of Operational Research, main phases of OR study, Linear programming problems (LPP), applications to industrial problems – optimal product links and activity levels, convex sets and convex functions, simplex method and extreme point theorems. Big M and two phase methods of solving LPP.

**Unit II**
Revised simplex method, Assignment problem, Hungarian method, Transportation problem, and Mathematical formulation of transportation problem, methods of solving (North-West Corner rule, Vogel’s method and U.V. method.) Concept and applications of duality, formulation of dual problem, duality theorems (weak duality and strong duality theorems), dual simplex method, primal-dual relations, complementary slackness theorems and conditions.

Unit III
Sensitivity Analysis: changes in the coefficients of the objective function and right hand side constants of constraints, adding a new constraint and a new variable. Project management: PERT and CIM: probability of completing a project.

Unit IV
Game theory: Two person zero sum Games, games with pure strategies, Games with mixed strategies, Min. Max. principle, Dominance rule, finding solution of 2 x 2, 2 x m, 2 x m games. Equivalence between game theory and linear programming problem(LPP). Simplex method for game problem. Queues: Empirical models (M/M/1): (GD/∞/∞) (M/M/C : (GD/∞/∞ ) model and ( M/M/! ): (GD/N/ ∞) model.

Recommended Books:


Suggested Readings:

COMPUTER PROGRAMMING

Course No. MM-CP-308
Duration of Examination: 3 hrs

Maximum Marks: 100
(a) External Exam: 80
(b) Internal Exam: 20

Unit I


Introduction to C Language – Character set, Variables and Identifiers, Built-in Data Types, Variable Definition, Arithmetic Operators and Expressions, Constants and Literals, Simple Assignment Statement, Basic Input/Output statements, Simple C Programs.

Unit II
Arrays – One Dimensional Arrays: Array Manipulation; Searching, Insertion, Deletion of an element from an Array, Finding the largest/smallest element in an array, Two Dimensional Arrays: Addition/Multiplication of two matrices, Transpose of a square Matrix, Null Terminated Strings as Array of Characters, Representation of Sparse Matrices.
Pointers - Address operators, Pointer type declaration, Pointer assignment, Pointer Initialization, Pointer arithmetic, Function and pointers, Arrays and pointers, Pointer Arrays.

Unit III
Functions - Top Down approach of problem solving, Modular Programming and functions, Standard library of C functions, Prototype of a function, Formal parameter list, return type, Function call, Block Structure, Passing Arguments to a function: call by value; call by reference, Recursive functions, Arrays as function arguments.
File Processing - Concept of files, File opening in various modes and closing of a file, Reading from a file and writing into a file.

Unit IV
Writing C Programs for Binomial, Trinomial, and Multinomial Distributions.

Recommended Books:
1. Bryon Gottfried, “Programming with C”
2. E. Balaguruswamy, “Programming with ANSI C”
3. A. Kamthane, “Programming with ANSI & Turbo C”
ADVANCED TOPICS IN LINEAR ALGEBRA

Course No. MM-CP-309
Duration of Examination: 3 hrs
Maximum Marks: 100
(a) External Exam: 80
(b) Internal Exam: 20

UNIT-I
Tensor product of vector spaces, isomorphism of Hom(V,W) with V* tensor W, tensor algebra, symmetric algebra,

UNIT-II
Exterior algebra of a vector space with their universal properties, structure of bilinear forms, symmetric and alternating forms, orthogonal transformations, reflections.
UNIT-III
Hermitian forms, classical groups associated to Symmetric and Alternating bilinear forms as isometry groups (namely, SO(V,Q), O(V,Q), Sp(V,Q))

UNIT-IV

**Recommended Books:**

**SEMESTER: 4**

**PARTIAL DIFFERENTIAL EQUATIONS**

- **Course No. MM-CP-401**
- **Maximum Marks: 100**
- **Duration of Examination: 3 hrs**
  - (a) External Exam: 80
  - (b) Internal Exam: 20

**UNIT I**
Partial Differential Equations of first order PDEs, origins of first order PDEs, Cauchy Problem for first order equations, Linear, equations of the first order, Nonlinear PDEs of the first order, Lagrange and Charpits methods for solving first order PDEs.

**Unit II**
Classification of Second order PDEs, General solution of higher order PDEs with constant coefficients, Method of separation of variables for Laplace, Heat and Wave equations.

**Unit III**
Three Basic Equations, the Wave equation---one dimensional case, D’Alembert’s solution, the initial value problem in three space, Poisson’s method of spherical averages, Hadamard’s method of descent, Duhamel’s Principle, the inhomogeneous wave equation.

**Unit IV**

**Recommended Books**
Partial Differential Equations by Fritz John, Springer Verlag
Partial Differential Equations by Ian Sneddon, McGraw Hill
Partial Differential Equations by L.C. Evans, GTM, AMS, 1998
Partial Differential Equations by P. Prasad and R. Ravindaran,
Partial Differential Equations by Amarnath.

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**DIFFERENTIAL GEOMETRY**

**Course No. MM-CP-402**  
**Maximum Marks: 100**
**Duration of Examination: 3 hrs**

(a) External Exam: 80  
(b) Internal Exam: 20

**Unit I**
Curves : Differentiable curves, Regular point, Parameterization of curves, arc-length, and arc-length is independent of parameterization, unit speed curves. Plane curves: Curvature of plane curves, osculating circle, centre of curvature. Computation of curvature of plane curves. Directed curvature, fundamental theorem for plane curves. Examples: Straight line, circle, ellipse, tractrix, evolutes and involutes. Space curves: Tangent vector, unit normal vector and unit binormal vector to a space curve.

Unit II

Surfaces; Regular surfaces with examples, coordinate charts or curvilinear coordinates, change of coordinates, tangent plane at a regular point, normal to the surface, orient able surface, differentiable mapping between regular surfaces and their differential. Fundamental form or a metric of a surface, line element, invariance of a line element under change of coordinates, angle between two curves, condition of orthogonality of coordinate curves. Area of bounded region, invariance of area under change of coordinates.

Unit III

Curvature of a Surface: Normal curvature, Euler’s work on principal curvature, Qualitative behavior of a surface near a point with prescribed principal curvatures. The Gauss map and its differential. The differential of Gauss is self-adjoint. Second fundamental form. Normal curvature in terms of second fundamental form. Meunier theorem. Gaussian curvature, Weingarten equation. Gaussian curvature \( K(p)= \frac{(eg-f^2)}{EG-F^2} \). Surface of revolution. Surfaces with constant positive or negative Gaussian curvature. Gaussian curvature in terms of area. Line of curvature, Rodrigue’s formula for line of curvature, Equivalence of Surfaces: Isometry between surfaces, local isometry, and characterization of local isometry.

Unit IV

Christoffel symbols. Expressing Christoffel symbols in terms of metric coefficients and their derivative. Theorema egregium (Gaussian curvature is intrinsic). Isometric surfaces have same Gaussian curvatures at corresponding points. Gauss equations and Manardi Codazzi equations for surfaces. Fundamental theorem for regular surface. (Statement only).

Recommended Books:


Suggested Readings:

1. W. Klingenberg: A course in Differential Geometry (Spring Verlag)
2. C.E. Weatherburn: Differential Geometry of Three dimensions.
3. T. Willmore: An Introduction to Differential Geometry
4. J. M. Lee: Riemannian Manifolds, An Introduction to Curvature (Spring)

ADVANCED TOPICS IN FUNCTIONAL ANALYSIS

Course No. MM-CP-403  
Maximum Marks: 100
Duration of Examination: 3 hrs  
(a) External Exam: 80
(b) Internal Exam: 20

Unit I
Topological vector spaces (TVC), Definition and Examples. Basic properties – subspaces quotients and products of TVS, Bounded sets & totally bounded sets. characterizing a linear topology in terms of a local’ base. Continuous and bounded linear maps between TVS.
Unit II

Unit III

Unit IV

Recommended Books
2. Swartz, C: Topological Vector Spaces (Marcel Dekker).

Suggested Readings:

ADVANCED TOPICS IN THE ANALYTICAL THEORY OF POLYNOMIALS

Course No. MM-CP-404
Duration of Examination: 3 hrs
Maximum Marks: 100
(a) External Exam: 80
(b) Internal Exam: 20

Unit I

Unit II
Critical points in terms of zeros, Fundamental results on critical points, Convex Hulls and Gauss-Lucas theorem, Some applications of Gauss-Lucas theorem. Extensions of
Gauss-Lucas theorem, Average distance from a line or a point Real polynomials and Jenson’s theorem, Extensions of Jenson’s theorem.

**Unit III**
Derivative estimates on the unit disc, Bernstein’s inequality and generalizations. Refinements, Conditions on the coefficients, Inequalities for polynomials having all zeros on the unit circle. Self-reciprocal polynomials, conditions on the zeros. Inequalities for polynomials involving mean values.

**Unit IV**
Inequalities of S. Bernstein and A. Markov on the unit interval, Extensions of higher order derivatives. Estimates for individual coefficients of polynomials, Inequalities involving two coefficients, Inequalities involving all the coefficients, Coefficient estimates of real trigonometric polynomials. Sharp estimates for individual coefficients.

**Recommended Books**

2. Geometry of polynomials by Morris Marden.

**Suggested Readings:**

1. Topics in polynomials :extremal properties, problems, inequalities, zeroes by G.V.Milovanovic,D.S.Mitrinovic and Th. M. Rassias

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**THEORY OF NUMBERS-II**

**Course No. MM-CP-405**

**Duration of Examination: 3 hrs**

**Maximum Marks: 100**

(a) **External Exam: 80**

(b) **Internal Exam: 20**

**Unit-I**
Integers belonging to a given exponent mod p and related results. Converse of Fermat’s Theorem. If \( \frac{d}{p} \equiv -1 \mod p \), the Congruence \( x^d \equiv 1 \mod p \), has exactly d-solutions. If any integer belongs to t (mod p), then exactly \( \phi(t) \) incongruent numbers belong to t(mod p). Primitive roots. There are \( \phi \) (p-1) primitive roots of a odd prime p. Any power of an odd prime has a primitive root. The
function $\lambda(m)$ and its properties. $a^{\lambda(m)} \equiv 1 \pmod{m}$, where $(a, m)=1$. There is always an integer which belongs to $\lambda(m)$ ($\pmod{m}$). Primitive $\lambda$-roots of $m$. The numbers having primitive roots are $1, 2, 4, p^\alpha$ and $2p^\alpha$ where $p$ is an odd prime.

**Unit II**

Quadratic residues. Euler criterion. The Legendre symbol and its properties. Lemma of Gauss. If $p$ is an odd prime and $(a, 2p)=1$,

$$\left(\frac{a}{p}\right) = (-1)^t$$

where

$$t = \sum_{j=1}^{(p-1)/2}\left[\frac{ja}{p}\right]$$

and

$$\left(\frac{2}{p}\right) = (-1)^{(p^2-1)/8}$$

The law of a Quadratic Reciprocity, Characterization of primes of which $2, -2, 3, -3, 5, 6$ and $10$ are quadratic residues or non residues. Jacobi symbol and its properties. The reciprocity law for Jacobi symbol.

**Unit III**

Number theoretic functions. Some simple properties of $\tau(n), \sigma(n), \phi(n)$ and $\mu(n)$. Mobius inversion formula. Perfect numbers. Necessary and sufficient condition for an even number to be perfect. The function $[x]$ and its properties. The symbols “$O$”, “$o$”, and “$\sim$”. Euler’s constant $\gamma$. The series

$$\sum_{p} \frac{1}{p}$$

diverges. $\prod_{p} p < 4^n$, for $n \geq 2$. Average order of magnitudes of $\tau(n), \sigma(n), \phi(n)$. Farey fractions. Rational approximation.

**Unit IV**

Simple continued fractions. Application of the theory of infinite continued fractions to the approximation of irrationals by rationals. Hurwitz theorem. $\sqrt{5}$ is the best possible constant in the Hurwitz theorem. Relation between Riemann Zeta function and the set of primes. Characters. The $L$-Function $L(S, \chi)$ and its properties. Dirichlet’s theorem on infinity of primes in an arithmetic progression (its scope as in Leveque’s topics in Number Theory, Vol. II. Chapter VI).

**Recommended Books**


**Suggested Readings:**

2. An introduction to the theory of Numbers by G.H Hardy and Wright.
4. An elementary Number theory of E. Landau.

**ADVANCED TOPICS IN DISCRETE MATHEMATICS**

**Course No. MM-CP-406**

**Maximum Marks: 100**

**Duration of Examination: 3 hrs**

**(a) External Exam: 80**

**(b) Internal Exam: 20**

**Unit-I**

Graph matrices, Incidence matrix $A(G)$, Isomorphic of graphs in terms of their incidence matrices, Rank of incidence matrix, the rank of incidence matrix of connected graph with $n$ vertices, sub matrices of $A(G)$, Cur-set matrix $C(G)$, Rank $C(G)$=rank of $A(G)$= rank of $G$, relationships between $A_j$, $B_j$, $C_j$, Path matrix, Adjacency matrix $X(G)$, Powers of $X$, Relation between $A(G)$ and $X(G)$. 
Unit II
Coloring, chromatic number $\chi(G)$, A graph is bicolourable iff it has no odd cycles, Bounds for $\chi(G)$, Bounds on sum and product of the chromatic number of a graph and its complement, Five color theorem, Four color theorem (statement only), Every planar graph is four colorable iff every cubic bridgeless plane map is 4-colorable, Every planar graph is 4-colorable iff $\chi'(G)=3$ for every bridgeless planar graph, Heawood Map-coloring theorem, Uniquely colorable graphs.

Unit III
Edge graphs, A connected graph is isomorphic to its edge graph iff it is a cycle, Whitney’s theorem on edge graphs, Characterization of edge graphs of trees, edge graphs and traversibility, total graphs, Eccentricity sequence and sets, Lesniak theorem for trees, Construction of trees, Neighborhoods, Lesniak theorem for graphs.

Unit IV
Digraphs, types of digraphs, Digraphs and binary relations, Directed paths and connectedness, Euler digraphs, Trees with directed edges, Arborescence, Ordered trees, Spanning arborescence, Fundamental cycles in digraphs, Matrices $A$, $B$, $C$ of digraphs, The determinant of every square sub matrix of $A$ is 1, -1 or 0. Rows of cycle matrix are orthogonal to the rows of the incidence matrix, Number of spanning trees, Fundamental cycle matrix, Adjacency matrix of a digraph, Connectedness and the adjacency matrix, Number of arborescence, tournaments, score sequences, Landau’s theorem, Oriented graphs.

Recommended Books

1. F. Harary, Graph Theory, Addison- Wesley.

Suggested Readings:

1. K.R Parthasarty : Basic Graph Theory, Tata Mc-Graw Hill
3. D.B. West Introduction to Graph Theory, Prentice Hall.
5. S.Pirzada and A.Dharwadkar, Graph Theory, Universities Press(Orient Longman)
MATHEMATICAL STATISTICS

Course No. MM-CP-407
Duration of Examination: 3 hrs

Unit I

Some Special Distributions, Bernoulli, Binomial, Trinomial, Multinomial, Negative Binomial, Poisson, Gamma, Chi-square, Beta, Cauchy, Exponential, Geometric, Normal and Bivariate Normal Distributions.

Unit II
Distribution of Functions of Random Variables, Distribution Function Method, Change of Variables Method, Moment generating function Method, t and F Distributions, Dirichelet Distribution, Distribution of Order Statistics, Distribution of $X$ and $\frac{nS^2}{\sigma^2}$, Limiting distributions, Different modes of convergence, Central Limit theorem.

**Unit III**
Interval Estimation, Confidence Interval for mean, Confidence Interval for Variance, Confidence Interval for difference of means and Confidence interval for the ratio of variances. Point Estimation, Sufficient Statistics, Fisher-Neyman criterion, Factorization Theorem, Rao- Blackwell Theorem, Best Statistic (MvUE), Complete Sufficient Statistic, Exponential class of pdfs.

**Unit IV**
Rao-Crammer Inequality, Efficient and Consistent Estimators, Maximum Likelihood Estimators (MLE’s). Testing of Hypotheses, Definitions and examples, Best or Most powerful (MP) tests, Neyman Pearson theorem, Uniformly most powerful (UMP) Tests, Likelihood Ratio Test, Chi-square Test.

**Recommended Books**
1. Hogg and Craig : An Introduction to Mathematical Statistics

**Suggested Readings:**
1. C.R.Rao : Linear Statistical Inference and its Applications

**WAVELET ANALYSIS**

- **Course No. MM-CP-408**
- **Maximum Marks: 100**
- **Duration of Examination: 3 hrs**
- **(a) External Exam: 80**
- **(b) Internal Exam: 20**

**Unit-I:** ELEMENTS OF FOURIER ANALYSIS: Fourier series, Fourier transforms, Inversion formula, Parseval Identity and Plancherel Theorem, Continuous-time convolution and the delta function, Heisenberg uncertainty principle, Poisson's summable formula, Shannon sampling theorem, Fourier transforms of tempered distributions
Unit-II: WAVELET TRANSFORM: Time - frequency localization, definition and examples of wavelets, Dyadic wavelets, Wavelet series, Orthonormal wavelet bases, continuous and discrete wavelet transform, frames.

Unit-III: SCALING FUNCTIONS AND MULTI-RESOLUTION ANALYSIS (MRA): Multiresolution analysis, orthonormal systems and Riesz systems, scaling equations and structure constants, from scaling function to MRA and orthonormal wavelet.

Unit –IV: COMPACTLY SUPPORTED WAVELETS AND CONVERGENCE PROPERTIES: Spline wavelets and their properties, wavelets with compact support, construction of compact wavelets, smoothness of wavelets, convergence properties of wavelet series.

Recommended Books


BANACH ALGEBRAS AND SPECTRAL THEORY

Course No. MM-CP-409
Duration of Examination: 3 hrs

Maximum Marks: 100
(a) External Exam: 80
(b) Internal Exam: 20

Unit-I
Banach Algebra:- Preliminaries on Banach Algebra’s Inertible elements, the spectrum, spectral radius and the spectral radius formula, Gelfand- Mazur theorem, Gelfand mapping, maximal ideal space and its characterization, continuity of multiplicative functionals on a Banach algebra.
Unit-II
B*-Algebra and the Gelfand Naimark Theorem, Ideals in C(X) and application to stone-Cech compactification and Banach stone theorem, structure of commutative C*-Algebras.

Unit-III
Compact operators in Banach spaces, spectral theorem for compact Hermitian operators, spectral theorem for compact normal operators and its consequences.

UNIT-IV
Invariant subspace problem and its validity for compact Hermitian operators, Lomonosov’s theorem on the existence of invariant subspaces for operators commuting with compact operators.

Recommended Books
4. G.B. Folland, Real Analysis.

Text Books for M.A/M.Sc Mathematics (I-IV Semester)

1. I.N. Heristein : Topics in Algebra.
3. Surjeet Singh and Qazi Zameer-ud-din: Modern Algebra
7. R. Goldberg : Methods of Real Analysis
8. W. Rudin : Principles of Mathematical Analysis
9. J.M. Apostol : Mathematical Analysis
10. S.M. Shah and Saxena: Real Analysis
11. A.J. White : Real Analysis, An Introduction
12. L. Royden : Real Analysis
13. G.F. Simmons : Introduction to topology and Modern Analysis
14. J. Munkres : Topology
15. K.D. Joshi : Introduction to General topology
16. J.L. Kelley : General topology
17. Mardeshwar; General topology
18. S.T. Ha: Introduction to General topology
24. Nihari Z. Conformal mapping
25. A.I. Markushevish : Theory of Functions of a Complex variable
27. S. Lang : Complex Analysis.
30. D. Sarason: Complex Function Theory
34. A Text Book of Matrices by Shanti Narayan, S. Chand and company Ltd.
35. Matrix Analysis by Rajendra Bhatia, Springer.
36. Fourier Series and Boundary value Problems by Churchill.
38. Fourier Series by Rainville.
40. F. Harary, Graph Theory, Addison-Wisley.
41. Narsingh Deo: Graph Theory with Applications to Engineering and Computer Sciences, P-III.
42. D.B. West Introduction to Graph Theory prentice, Hall, India.
44. O. Ore: Theory of Graphs, AMS.
45. K.R Parthasarty: Basic Graph Theory, Tata McGraw Hill.
47. W.T. Tutte: Connectivity in Graphs, University of Toronto Press.
48. W. Klingenberg: A course in Differential Geometry (Spring Verlag)
49. C.E. Weatherburn: Differential Geometry of Three dimensions.
50. T. Willmore: An Introduction to Differential Geometry
51. J. M. Lee: Riemannian manifolds, An Introduction to Curvature (Spring)
52. B.V. Limaya: Functional Analysis.
54. L.A. Lusternick & V.J. Sobolov: Elements of Functional Analysis
55. J.B. Conway: A Course in Functional Analysis
56. Royden, L.: Real Analysis (PHI)
57. Goldberg, R.: Methods of Real Analysis
58. Barra, D. G.: Measure theory and Integration (Narosa)
61. Chae, Lebesgue Integration.
62. T.M. Apostol: Mathematical Analysis
63. S.M. Shah and Saxena: Real Analysis
64. P. Hartmen: Ordinary Differential Equations
65. W.T. Reid: Ordinary Differential Equations
68. Lectures on Partial differential equations by G. Petrosky.

71. Partial differential equations by I. N. Sneddon.