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-C101**	**Advanced Algebra – I**	C	4	4	40	60	100
2	**MMT-C102**	**Real Analysis**	C	4	4	40	60	100
3	**MMT-C103**	**Complex Analysis**	C	4	4	40	60	100
4	**MMT-C104**	**Topology**	C	4	4	40	60	100
5	**SS***	**Soft Skills Elective**	SS	4	4	40	60	100
	SEMESTER-II							
6	**MMT-C201**	**Advanced Algebra – II**	C	4	4	40	60	100
7	**MMT-C202**	**Advanced Real Analysis**	C	4	4	40	60	100
8	**MMT-C203**	**Methods of Applied Mathematics**	C	4	4	40	60	100
9	**MMT-C204**	**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-C301**	**Theory of Analytic Functions**	C	4	4	40	60	100
12	**MMT-C302**	**Theory of Numbers-I**	C	4	4	40	60	100
13	**MMT-C303**	**Functional Analysis**	C	4	4	40	60	100
14	**Elective Course***	**Elective Course I**	E	4	4	40	60	100
15	**Elective Course***	**Elective Course II**	E	4	4	40	60	100
	SEMESTER-IV							
16	**MMT-C401**	**Differential Geometry**	C	4	4	40	60	100
17	**MMT-C402**	**Graph Theory**	C	4	4	40	60	100
18	**MMT-C403**	**Functional Analysis-II**	C	4	4	40	60	100
19	**Elective Course***	**Elective Course III**	E	4	4	40	60	100
20	**Elective Course***	**Elective Course IV**	E	4	4	40	60	100
							Grand Total	**2000**

Notes:

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

***THE COURSE CODE WILL DEPEND ON THE SELECTION MADE BY THE STUDENT FOR THE ELECTIVE COURSE FROM THE LIST OF ELECTIVES GIVEN IN ANNEXURE – I.**

ANNEXURE - I

1. Soft Skill Electives:

SS E101 - IT Skills (Not available to MSc. I.T students.)
SS E102 - Communication Skills (Not available to MA English students.)
SS E103 - Management Skills (Not available to MBA students.)

2. Social Orientation Electives:

SO E201 - Human Rights
SO E202 - Disaster Management
SO E203 - Environment and sustainable Development

3. List of Electives for Elective Course I and Elective Course II.

MMT E301: Operations Research
MMT E302: Commutative Algebra
MMT E303: Coding Theory
MMT E304: Probability & Statistics-I
MMT E305: Fuzzy logic

4. List of Electives for Elective Course III.

MMT E401: Probability & Statistics-II
MMT E402: Theory of Semi-rings
MMT E403: Advanced Topics in Analytical Theory of Polynomials
MMT E404: Wavelet Analysis
MMT E405: Fluid Dynamics

ELECTIVES WILL BE OFFERED SUBJECT TO THE AVAILABILITY OF FACULTY.

SEMESTER – I

MMT-C101: 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 $n\geq5$

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-C102 : Real Analysis

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-C103: 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 $|Z| \leq R$ $|W| \leq R_1$'. 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, behavior 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-C104: <u>Topology</u>

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, neighborhoods, 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**", 2nd 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-C201 : <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 homomorphism and module isomorphism's.

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 (Only relevant portions)

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. I & II,** 3rd Edition, Hindustan Publishing Corporation, New-Delhi, 2002.

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-C202: Advanced Real Analysis

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. Measure 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 neighborhoods 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. H.L. Royden, "**Real Analysis**", Pearson, 2008
2. S.C. Malik & and Savita Arora, "**Mathematical Analysis**", 3rd Edition, New Age International (P) Ltd., New Delhi,2008
3. G.De Barra, "**Measure Theory and Integration**" Narosa Publishing House, New Delhi
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. Walter Rudin, "**Principles of Mathematical Analysis",** 3rd Edition, MC Graw Hill Publications, 1976.
5. G.B. Folland, "**Real Analysis",** Brooks-Cole, 1992
6. T.M. Apostol, "**Mathematical Analysis**"

MMT-C203 : Methods of Applied Mathematics

Matrix Analysis

Unit – I

A review characteristic & minimal equations of a matrix, Caley-Hamilton theorem, trace of a matrix, orthogonal and unitary matrices, 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, mutual relation between eigen vectors corresponding to different eigen values, the necessary and sufficient condition for a square matrix of order n to be similar to a diagonal matrix, orthogonal reduction of real symmetric matrices

Unit – II

Normal matrices, Schur's theorem: Every square matrix is unitarily similar to a triangular matrix. The necessary and sufficient condition for a square matrix to be a unitarily similar to a diagonal matrix

Quadratic forms : The Kroneckers and Lagranges reduction, reduction by orthogonal transformation of real quadratic matrices, necessary and sufficient condition for quadratic form to be a positive definite, rank , index and signature of a quadratic form. If A= [a_{ij}] is a positive definite matrix of order n, then $|A| \leq a_{11}\, a_{22} \ldots a_{nn}$. Hadmard's inequality. If B = [b_{ij}] is an arbitrary non-singular real square matrix of order n, then

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

Fourier Series

Unit – III

Euler – Fourier Formula, piecewise montonic and piecewise continuous functions, periodic functions. Fourier series expansion of a function f(x) in the intervals $(-\pi,\pi)$, (-c,c) and (a,b). Fourier series for even and odd functions. Fourier sine series expansion and Fourier cosine series expansion of f(x) in the intervals $(0,\pi)$ and (0,c). some theorems : if f(x) is bounded and integrable function on $(-\pi,\pi)$ and if a_n, b_n are its Fourier coefficients, then $\sum_{n=1}^{\infty} (a^2_n + b^2_n)$ converges. Riemann-Lebesgue theorem. If a function f(x) is bounded and integrable on [0,a], a>0 and monotonic in]0, δ], $0<\delta<a$, then $\lim_{n\to 0} \int_o^a f(x)\frac{\sin nx}{x}\,dx = f(0+) \int_0^{\infty})\frac{\sin x}{x}\,dx$

Dirchlet's criterion for a set of exact conditions on convergence in the theory of Fourier series.Everywhere continuous non-differential function.

Numerical Analysis

Unit-IV

Numerical Solution for algebraic equations, method of iteration and Newton-Raphson method, Rate of Convergence, Solution of Systems of linear algebraic equations using Gauss elimination and Gauss-Seidel methods, finite differences, Lagrange, Hermite and spline interpolation, numerical differentiation and integration

Text Books (Only Relevant Portions)

1. Franz E. Hohn, "**Elementary Matrix Algebra**", American Publishing Company, Pvt. Ltd.
2. Shanti Narayan, "**A Text Book of Matrices**", S. Chand Co. Ltd.
3. Churchill, "**Fourier Series & Boundary Value Problems**"

Reference Books

1. S.S. Sastry, "**Introductory Methods of Numerical Analysis**", Prentice Hall of India, 2005
2. Richard Bellman, "**Introductory to Matrix Analysis**" ,McGraw Hill Book Company.
3. Rajendra Bhatia, "**Matrix Analysis**", Springer
4. Goldberg, "**Methods of Real Analysis**", Oxford and IBH Pub. Co.
5. S.C. Chopra and P.C. Raymond, "**Numerical Methods for Engineers**", Tata McGraw Hill Company, New Delhi, 2000
6. M.K. Jain, "**Numerical & Solution of Differential Equations**", Wiley Eastern Ltd., 1979
7. R.L. Burden & J. Douglas Faires, "**Numerical Analysis**", 4thEdition, P.W.S. Kent Publishing Company, Boston, 1989
8. C.F. Gerald & P.O. Wheatley, "**Applied Numerical Methods**", Pearson Education, 2002
9. K. Atikinson and W. Han, "**Elementary Numerical Analysis**", John Wiley, 2006

MMT-C204 : Ordinary & Partial Differential Equations

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**", Tata MC Graw Hill, Pub., Co. Ltd, New Delhi, 1999.

3. Tyn Myint, “**Partial Differential Equations of Mathematical Physics”,** Elsevier, 1973

Reference Books

1. G.F. Simmons, **“Ordinary Differential Equations with Applications and Historical Notes”,** Tata MC Graw Hill, 2005
2. T. Amarnath, “**An Elementary Course in Partial Differential Equations”,** 2nd Edition, Narosa Publising House
3. I.N. Sheddon, “**Lectures on Partial Differential Equations**”, 3rd Edition Tata MC Graw Hill, 1998
4. P. Hartmen, “**Ordinary Differential Equations**”
5. W.T. Reid, “**Ordinary Differential Equations**”
6. R. Courant, “**Partial Differential Equations**”
7. G. Petrosky, “**Lectures on Partial Differential Equations**”
8. Fritz John, “**Lectures on Partial Differential Equations**”
9. I.C. Evans, “**Lectures on Partial Differential Equations**”

SEMESTER – III

MMT-C301:Theory of Analytic Functions

Unit I

Maximum Modulus Principle, Schwarz Lemma and its generalization, Meromorphic function, Argument Principle, Rouche's theorem with application, 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

Principle of analytic continuation, uniqueness of direct analytical continuations and uniqueness of analytic continuation along a curve. Power series method of analytic continuation, Functions with natural boundaries and related examples. Shewartz reflection principle, functions with +ive real part. Monodromy theorem.

Unit III

Space of analytic functions, Hurwitz's theorem, Montel's theorem, Riemann Mapping theorem, Weistrass factorization theorem, Gamma function and its properties, Riemann Zeta function, Reimann's functional equation. Harmonic functions on a disc, Harnack's inequality and theorem, Drichlet's problem, Green's functions.

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 Caratheadory theorem and the Great Picard theorem. Univalent function. Bieberbach's conjecture (statement only) and the 1/4 – theorem.

TextBooks:

1. L.Ahlfors: Complex Analysis
2. E.C. Titchmarsh : Theory of Functions
3. Richard's Silverman : Complex Analysis

Suggested Books:

1 J.B.Conway : Functions of a complex variable –I
2. A.I.Markushevish :Theory of Functions of a Complex variable
3. Nihari Z. : Conformal Mapping.
4. H.A. Priestly : Introduction to Complex Analysis.
5. S.Lang : Complex Analysis.
6. E.Hille : Analytic Function Theory (2- vol).
7. Liang –Shin Hahn, Bernard Epstein : Classical Complex Analysis.
8. D.Sarason: Complex Function Theory

MMT-C302: NUMBER THEORY

UNIT I Divisibility, the Division Algorithm. Greatest Common Divisor and its properties, Least Common Multiple. Prime numbers , Euclid's first theorem, factorization in primes, Fundamental Theorem of Arithmetic, Linear Diophantine Equations; Necessary and Sufficient condition for solvability of linear Diophantine equations.

UNIT II Sequences of Primes : Euclid's second theorem, infinitude of the primes of the form 4n+3 and 6n+5, No polynomial $f(x)$ with integral coefficients, not a constant, can represent primes for all integral values of x , Fermat numbers and properties, Mersenne numbers, Arbitrary large gaps in the sequence of primes, Congruences, Complete Residue Systems and Reduced Residue Systems and their properties, Euler's $\emptyset$-function; $\emptyset(mn) = \emptyset(m)\emptyset(n)$, with (m,n)=1, Fermat's theorem and Euler's theorem.

UNIT III Wilson's theorem and its application to the solution of the congruence $x^2 \equiv -1(mod\ p)$, Solution of linear congruences, The necessary and sufficient for the solution of the congruence $a_1x_1 + a_2x_2 + \cdots + a_nx_n \equiv c(mod\ m)$, Chinese Remainder Theorem, Congruences of higher degree, Polynomial congruence $f(x) \equiv 0(mod\ m)$, congruences with prime power moduli. Lagrange's theorem; the polynomial congruence $f(x) \equiv 0(mod\ p)$ has at most n solutions, The criteria for the congruence $f(x) \equiv 0(mod\ p)$ of degree n having exactly n solutions.

UNIT IV Factor theorem and its generalization, Polynomial congruence $F(x_1, x_2, \dots, x_n) \equiv 0(\text{mod m})$ in several variables; equivalence of polynomial congruences, number of solutions in polynomial congruences, Chevelley's theorem, Warning's theorem, Quadratic form over the field of characteristic ≠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.

Textbooks:

1. Ivan Niven and H.S. Zuckerman, *An Introduction to the Theories of Numbers*, 5th edition, Wiley Eastern, 2000.
2. Leveque, *Topics in Number Theory, Springer.*
3. Boevich and Shaferwich, *Number theory,*I.R.Academic Press.
4. Apostol *Analytic Number theory, Springer*

Suggested Books:

1. E. Landau *Elementary Number theory* AMS Chelsea publishing
2. J. P. Serre *A course in Arithmetic* GTM Vol Springer
3 D.M. Burton, *Elementary Number Theory*, 2nd edition, Universal Book Stall, New Delhi, 1994.
5. Y. Hsiung, *Elementary Theory of Numbers*, World Scientific, 1992; First Indian Reprint, Allied Publishers Limited, 1995.
6. G.H. Hardy and E.M. Wright, *An Introduction to the Theory of Numbers*, 4th edition, Oxford, Claredon Press, 1960.
7. G.E. Andrews, *Number Theory*, Hindustan Publishing Corporation, New Delhi, 1992.
8. S.G. Telang, *Number Theory,* Tata McGraw Hill Publishing Company Limited, New Delhi, 1996.

MMT-C303: Functional Analysis

Unit-I

Normed Linear Spaces and Banach spaces : Definition & examples, Continuous Linear Transformation 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 Dimentional space, Hahn Banach Theorem and its Applications.

Unit-II

The Natural Embedding of a Normed 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, Orthogonal Complements, Orthogonal Decomposition of Hilbert Space, Orthonormal Systems, Bessel's Inequality, Gram Schmidth Process, Application of G-S process to certain Linearly Independent Sequences in $L2\ [0, 2\pi]$, Orthonormal Basis in Seperable 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***",** 4^{th} Edition, Tata McGraw Hill Ltd, 2004.
2. E.Kreyszig, "*Introductory Functional Analysis with Applications*", John Wiley and Sons (Axia) Pvt Ltd, 2006.
3. J.B. Conway, **"***A Course in Functional Analysis***"**, 2nd Edition Springer Verlag, **2006.**

Suggested Books:

1. B.V. Llmaya, "Functional Analysis", 2nd Edition, New Age International (P) Ltd, 1996.
2. .Martin Schechter, "Principles of Functional Analysis", 2nd Edition, AMS Bookstore, 2002.
3. W. Rudin, "Functional Analysis", McGraw Hill, Inc., 1991.
4. Kosaku Yoshida, "Functional Analysis", Springer Verlay 1974.
5. C. Goffman and G. Pedrick, "A First course in Functional Analysis", Prentice Hall of India, New Delhi.

MMT-E301: Operations Research

Unit-I

Operations research (OR) and its Scope, Modeling in OR, Scientific Method in Operations Research, Linear Programming (LP) Problems and it's Applications, Formulation of LP Problem, Solution of LP Problems – Graphical Method, Simplex Method, Two Phase Method, Big-M Method.

Unit-II

Duality in LP, Dual Simplex Method, Sensitivity Analysis, Integer Programming, Branch and Bound Technique, Parametric Linear Programming, Dynamic Programming, Bellman's Principle of Optimality.

Unit-III

Transportation Problem, Optimal Solution, Degeneracy in Transportation Problem, Unbalanced Transportation Problem, Assignment Problem, Hungarian Method for Assignment Problem, Unbalanced Assignment Problem, Game Theory, Two-Persons-Zero-Sum Game, Game with Mixed Strategies, Graphical Method.

Unit-IV

Queuing Theory, Model-I (M/M/I):(∞/FCFS), Model-II (M/M/I):(N/FCFS), Job Sequencing, Processing n Jobs through Two/Three Machines, Processing Two Jobs through m Machines, Network Analysis, Critical Path Method (CPM), Project Evaluation and Review Technique (PERT), Project Planning with CPM/PERT.

Textbooks

1. H. A. Taha "Operations Research – An Introduction " Macmillan Publishing Co. Inc. , N. Y.
2. Kanti Swarup, P.K.Gupta and Man Mohan → "Operations Research" S. Chand and Sons, New Delhi.
3. J.K. Sharma→ "Operations Research-Theory and Application, Macmillan Pub.

Suggested Books:

1. G. Hadley → "Linear Programming" Narosa Publishing House, 1995.
2. J.K. Sharma → "Operations Research-Problems and Solutions", Macmillan Pub.

   F. S. Hillier and G. J. Lieberman → "Introduction to Operations Research" McGraw Hill International Edition, 1995.

MMT-E302:Commutative Algebra

UNIT I

Rings and Ring homomorphism's, ideals, quotient rings. Zero divisors, Nilpotent elements, units , prime ideals and maximal ideals. Nilradical and Jacobson radical, operations on ideals. Extension and contraction. Modules and module homomorphism's, submodules and quotient modules. Operations on submodules. Direct sum and product. Finitely generated modules. Nakayama's lemma

UNIT II

Exact sequences. Snake lemma. Tensor product of modules, basic properties, flat modules, restriction and extension of scalars, exactness properties of the tensor product. Algebras, tensor product of algebras. Rings and modules of fractions, local properties, extended and contracted ideals in rings of fractions.

UNIT III

Primary decomposition, Ist uniqueness theorem, 2nd uniqueness theorem. Integral independence, the going up theorem, Integrally closed integral domains, The going down theorem. Valuation rings, Noether's normalization lemma

UNIT IV

Chain conditions .Noetherian rings, Hilbert basis theorem, Primary decomposition in Noetherian rings. Artin rings , Structure theorm for Artin rings. Discrete valuation rings, Dedekind domains, fractional ideals .

Text books:

1. Introduction to Commutative Algebra M.F.Atiyah & I.G.Macdonald addison-weisly publishing company
2..Commutative Algebra I ,II Zariski Oscar & Samuel Pierre Springer.

Suggested Books:

1. Algebra Serge Lang Springer, 3rd Edition.
2. Exercises In Modules And Rings (problem Book in Mathematics) Lam 02Springer (2011)

MMT-E303: Probability and statistics I

Unit I

The probability set functions, its properties, probability density function, the distribution function and its properties. Mathematical Expectations, some special mathematical expectations, Inequalities of Makov, Chebyshev and Jensen.

Unit II

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 Correlation coefficient, stochastic independence and its various criteria.

UNIT- III

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

UNIT-IV

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 , Limiting distributions, Different modes of convergence, Central Limit theorem.

Text Books:

1 Hogg and Craig : An Introduction to the Mathematical Statistics
2 S C Gupta and V K Kapoor: Mathematical Statistics,

Suggested Readings:

1. Mood and Grayball : An Introduction to the Mathematical Statistics

DIFFERENTIAL GEOMETRY

Course No. MMT-C401

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. Curvature and torsion of a space curve. The Frenet-Serret theorem. First Fundamental theorem of space curves. Intrinsic equation of a curve. Computation of curvature and torsion. Characterization of Helices and curves on sphere in terms of their curvature and torsion. Evolutes and involutes of space curves.

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 $K(p)= (eg-f^2)/EG-F^2$ .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).

Geodesics: Geodesic curvature, Geodesic curvature is intrinsic, Equations of Geodesic, Geodesic on sphere and pseudo sphere. Geodesic as distance minimizing curves. Gauss-Bonnet theorem (statement only).Geodesic triangle on sphere. Implication of Gauss-Bonnet theorem for Geodesic triangle.

Recommended Books:

1. John Mc Cleary: Geometry from a differentiable Viewpoint. (Cambridge Univ. Press**).**
2. Andrew Pressly, Elementary Differential Geometry (Springer Verlag, UTM).
3. Barret **O'Neil,** Elementary Differential Geometry, Academic Press (2006).
4. C.Baer, Elementary Differential Geometry, Cambridge Univ. Press (2010).

Suggested Readings:

1. W. Klingenberg: A course in Differential Geometry (Spring Verlag)
2. J. M. Lee : Riemannian Manifolds, An Introduction to Curvature (Springer Verlag).

GRAPH THEORY
COURSE NO. MMT-C402

Unit 1 (Graphs, traversibility and degrees)

Introduction of graphs, paths and cycles, operations on graphs, bipartite graphs and Konigs **theorem, Euler graphs and Euler's t**heorem, Konigsberg bridge problem, Hamiltonian graphs **and Dirac's theorem,** signed graphs, balanced signed graphs, degree sequences, Wang-Kleitman theorem, Havel-**Hakimi theorem, Hakimi's theorem, Erdos**- Gallai theorem, degree sets.

Unit 2(Trees and connectivity)

Trees and their properties, centers in trees, binary and spanning trees, Cayley's theorem, fundamental cycles, generation of trees, Helly property, Cut-sets and their properties, Vertex connectivity, edge connectivity, Whitney's theorem, Menger's theorem (vertex and edge
form), properties of a bond, block graphs.

Unit 3 (Planarity and Matrices)

Planar graphs, Kuratowski's two graphs, Embedding on a sphere, Euler's formula, Kuratowski's theorem, geometric dual, Whitney's theorem on duality, regular polyhedras, Incidence matrix A(G), modified incidence matrix A_f, cycle matrix B(G), fundamental cycle matrix B_f, cut-set matrix C(G), fundamental cut set matrix C_f, relation between A_f , B_f and C_f, path matrix, adjacency matrix, matrix tree theorem, eigen values of adjacency matrix, energy of a graph.

Unit 4 (Digraphs and groups of graphs)

Types of digraphs, types of connectedness, Euler digraphs, Hamiltonian digraphs,
arborescence, matrices in digraphs, Camions theorem, tournaments, characterization of score sequences, Landau's theorem, oriented graphs and Avery's theorem, automorphism groups of graphs, graph with a given group, Frucht's theorem, Cayley digraph.

Recommended Books:

1. R. Balakrishnan, K. Ranganathan, A Text Book of Graph Theory, Springer-Verlag, New York
2. F. Harary, Graph Theory, Addison-Wesley
3. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall.
4. S. Pirzada, An Introduction to Graph Theory, Universities Press, Orient Blackswan, 2012.

Reference Books:

1. B. Bollobas, Extremal Graph Theory, Academic Press,
2. W. T. Tutte, Graph Theory, Cambridge University Press.
3. D. B. West, Introduction to Graph Theory, Prentice Hall.

FUNCTIONAL ANALYSIS-II

COURSE NO. MMT-C403

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, Complentability of dual of a Banach space in its bidual, uncomplementability of co.

UNIT II

Dual of Subspace, Quotient space of a normed space. Weak and weak* topologies on a Banach space, Goldstine's theorem, Banach-Alaoglu theorem and its simple consequences. Banach's closed range theorem, injective and surjective bounded
linear mappings between Banach spaces.

UNIT III

l_∞ and C[0,1] as universal separable Banach spaces, l_1 as a quotient universal separable Banach space, Reflexivity of Banach spaces and weak compactness, Completeness of Lp[a,b], Extreme points, Krein-Milman theorem and its simple consequences, Banach Stone Theorem.

UNIT IV

Duals of l_∞, C(X) and Lp spaces. Applications of fundamental theorems to Radon-Nikodym Theorem, Laplace transform. Mazur-Ulam theorem on isometries between real normed spaces, Muntz theorem in L2 [a,b].

RECOMMENDED BOOKS:

1. J.B.Conway; A First Course in Functional Analysis (Springer Verlag).
2. R.E.Megginson; An Introduction to Banach Space Theory (Springer Verlag, GTM, Vol.183).
3. Lawrence Bagget; Functional Analysis, A Primer (Chapman and Hall, 1991).

REFERENCE BOOKS:

1. Ballobas, B; Linear Analysis(Camb. Univ.Press).
2. Beauzamy, B; Indroduction to Banach Spaces and their geometry (North Holland).
3. Walter Rudin; Functional Analysis (Tata McGrawHill).

4. C.D.Aliprantis and K C Border, Infinite Dimensional Alaysis (Springer Verlag, 2006).
5. C. Goffman and G.Pedrick; A first course in functional Analysis (Prentice Hall).

LINEAR ALGEBRA

MMT-E401

UNIT-I

Review of linear transformations and matrices. Eigenvectors, characteristic polynomial, orthogonal matrices and rotations. Inner product spaces, Hermitian, unitary and normal transformations, spectral theorems, bilinear and quadratic forms.

UNIT-II

Modules over commutative rings: examples. Basic concepts: submodules, quotients modules, homomorphisms, isomorphism theorems, generators, annihiliators, torsion, direct product and sum, direct summand, free modules, finitely generated modules, exact and split exact sequences.

UNIT-III

Tensor product of modules: Definition, basic properties and elementary computations. Tensor product of vector spaces.

UNIT-IV

Properties of K[X] over a field K. Structure theorem for finitely generated modules over a PID (proof of uniqueness may be omitted); applications to Abelian groups, rational and Jordan canonical form (details of proofs may be omitted from the exam syllabus).

REFERENCE BOOKS:

1. D.S. Dummit and R.M. Foote, Abstract Algebra.
2. K. Hoffman and R. Kunze, Linear Algebra.
3. N.S. Gopalakrishnan, University Algebra.

PROBABILITY THEORY-II (with measure theory)

COURSE NO. MMT-E402

UNIT-I

Measure theory (-fields, monotone class theorem, Dynkin theorem, probability measures, statement of Caratheodory theorem. Integration: measurable functions, simple functions etc., monotone convergence theorem, dominated convergence theorem, Fatou's lemma.

UNIT-II

Product spaces, statement of Fubini's theorem. Probability: probability measure on R, random variables, distribution function and its properties, independence, Kolmogorov 0-1 law, Borel Cantelli lemma.

UNIT-III

Tchebychev's inequality, Markov inequality. Various modes of convergence, Weak and Strong law of large numbers. Characterstic functions, statements of the uniqueness, inversion and Levy continuity theorems.

UNIT-IV

Convergence in distribution, probability and almost surely, Laws of large numbers, CLT for i.i.d . random variables (finite variance case).

Reference Books:

1. Billingsley
2. Athreya and Sunder
3. Athreya and Lahiri

THEORY OF NUMBERS-II

Course No. MMT-E403 **Maximum Marks: 100**

Unit-I

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

Mobius inversion formula. Perfect numbers. Necessary and sufficient condition for an even **number to be perfect. The function [x] and its properties. The symbols "τ", "o", and " ~" .Euler's constant γ, (n), (n), ϕ(n). Farey fractions. Rational approximation.**

Unit IV

Simple continued fractions. Application of the theory of infinite continued fractions to the approximation of irrationals by r**ationals. Hurwitz theorem. √5 a**s the best possible constant in the Hurwitz theorem, Relation between Riemann Zeta function and the set of primes. Characters. The L-**Function L(S, χ) and its properties. Prime number theorem (scope as in Apostol's book,** Chap.6-7), **Dirichlet's theorem on infinity of primes in an arithmetic progression (its scope as in Leveque's topics in σumber Theory, Vol. II. Chapter VI).**

Recommended Books

1. Topics in number theory by W. J. Leveque, Vol. I and II Addison Wesley Publishing Company, INC.
2. An introduction of the Theory of numbers by I. Niven and H.S Zuckerman.
3. Number Theory by Boevich and I. R. Shaefervich (Academic Press).

Suggested Readings:

1. Analytic Number Theory by T.M Apostal (Springer Verlag).
2. An Introduction to the theory of Numbers by G.H Hardy and Wright (Oxford Univ. Press).
3. A Course in Arithmetic, by J.P. Serre, GTM Vol. (Springer Verlag), 1973.
4. Elementary Number theory of E. Landau(Chelsea Publishing Co., NY), 1958.

<u>**BASIC COURSE IN HARMONIC ANALYSIS**</u>

MMT-E404

UNIT - I

<u>Fourier series</u> (10 lectures):

Heat conduction and Fourier series, Dirichlet kernel and Fejer kernel, Cesaro summability, approximate identity and solution of Dirichlet problem, Divergence of Fourier series using PUB, completeness of trigonometric polynomials in C(T) and Riemann Lebesgue lemma, Plancherel theorem and - convergence of Fourier series, Summability of Fourier series in .

<u>Suggested books</u>:

1. Rajendra Bhatia- Fourier Series, TRIM series, Hindustan Publishing Company, New Delhi.
2. Mark A. Pinsky-Introduction to Fourier analysis and wavelets, Graduate Studies in Mathematics, 102, AMS, 2009.

UNIT - II

<u>Fourier transform in</u> (8 lectures):

Definition, Basic properties dealing with differential operators and multiplication by polynomials and multiplication formula ((f g)^ =). Fourier transform of Gaussian and Poisson Kernel of the upper halfspace, Schwartz class and its image under Fourier transform, Riemann Lebesgue lemma. Approximate identity, Gauss mean, Abel mean and the Fourier inversion. Paley Wiener theorem.

<u>Fourier transform in</u> (4 lectures):

The Plancherel theorem and definition of Fourier transform of functions. Definition of Fourier transform for Lp-functions (1 p < 2). Translation invariant subspaces of as application of Plancherel theorem.

<u>Suggested books</u>:

1. E. M. Stein, G. Weiss-Introduction to Fourier analysis on Euclidean spaces, Princeton University press.
2. W. Rudin-Real and complex analysis.
3. C. Sadosky-Interpolation of operators and singular integrals. An introduction to harmonic analysis. Monographs and Textbooks in Pure and Applied Math., 53. Marcel Dekker, Inc.,1979..

UNIT - III

Tempered distribution (10 lectures):

Basics of distribution, Continuity of Fourier transform on the set of tempered distributions. calculation of Fourier transform of || , 0 < Re( ) < n, || || . Paley Wiener theorem for compactly supported distributions.

Suggested books:

1. W. Rudin-Functional Analysis.
2. Thomas H. Wol_- Lectures on harmonic analysis, University Lecture Series, 29. American Mathematical Society, Providence, RI, 2003.

UNIT - IV

Interpolation of operators (6 lectures):

Riesz Thorin interpolation, Hausdor_-Young inequality, Young's inequality for convolution, Weak Lp spaces and Marcinkiewicz interpolation.

Method of maximal function (6 lectures):

Hardy Littlewood maximal function and its Lp-boundedness, Lebesgue differentiation theorem, pointwise convergence of Abel and Gauss means. Hardy Littlewood Sobolev lemma for Riesz potential (as an application of Hardy Littlewood maximal theorem).

Suggested books:

1. L. Grafakos-Classical Fourier analysis. Second edition. Graduate Texts in Mathematics, 249. Springer, New York, 2008.

2. C. Sadosky-Interpolation of operators and singular integrals. An introduction to harmonic analysis. Monographs and Textbooks in Pure and Applied Math., 53. Marcel Dekker, Inc., New York, 1979.