ಬೆಂಗಳೂರು
ನಗರ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ

BENGALURU
CITY UNIVERSITY

Office of the Registrar, Central College Campus, Dr. B.R. Ambedkar Veedhi, Bengaluru – 560 001.
PhNo.080-22131385, E-mail: registrarbcu@gmail.com

No.BCU/BoS/Syllabus-PG/Science/ 992 /2025-26 Date: 23.09.2025

NOTIFICATION

Sub: Syllabus for the Post Graduate Courses in the Faculty of Science– reg

Ref: 1. Recommendations of the Boards of Studies in the Faculty of Science
2. Academic Council resolution No.04 dated.22.09.2025
3. Orders of Vice-Chancellor dated. 23.09.2025

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The Academic Council in its meeting held on 22.09.2025 has approved the syllabus prepared by different Board of Studies for the Post Graduate Courses in the Faculty of Science. Accordingly, the following CBCS Syllabus for the Semester PG Courses of Science Faculty are hereby notified for implementation effective from the academic year 2025-26.

Sl. No.	Programmes
1.	M.Sc. Chemistry – I & II Semester
2.	M.Sc. Biochemistry – I to IV Semester
3.	M.Sc. Physics – I & II Semester
4.	M.Sc. Mathematics – I to IV Semester
5.	M.Sc. Psychology– I to IV Semester
6.	M.Sc. Counselling Psychology – I to IV Semester
7.	M.Sc. Fashion & Apparel Design – I to IV Semester
8.	M.Sc. Zoology – I & II Semester
9.	M.Sc. Botany – I to IV Semester
10.	M.Sc. Computer Science – I & II Semester
11.	M.Sc. Speech Language Pathology – I to IV Semester
12.	Master of Computer Applications – I & II Semester

The detailed Syllabi for above subjects are notified in the University Website: www.bcu.ac.in for information of the concerned.

REGISTRAR

Copy to;

1. The Registrar(Evaluation), Bengaluru City University
2. The Dean, Faculty of Science, BCU.
3. The Principals of the concerned affiliated Colleges of BCU- through email.
4. The P.S. to Vice-Chancellor/Registrar/Registrar (Evaluation), BCU.
5. Office copy / Guard file / University Website: www.bcu.ac.in

BENGALURU CITY UNIVERSITY

Department of Studies and Research in Mathematics

Syllabus
For

M.Sc. Mathematics
CBCS–2025 Scheme

Revised with effect from
Academic Year 2025 – 2026

MISSION AND VISION OF THE NEW SYLLABUS IN MATHEMATICS

Mission

Improve retention of mathematical concepts in the student.

- To develop a spirit of inquiry in the student.
- To improve the perspective of students on mathematics as per modern requirement.
- To initiate students to enjoy mathematics, pose and solve meaningful problems, to use abstraction to perceive relationships and structure and to understand the basic structure of mathematics.
- To enable the teacher to demonstrate, explain and reinforce abstract mathematical ideas by using concrete objects, models, charts, graphs, pictures, posters with the help of FOSS (Free and open source software) tools on a computer.
- To make the learning process student-friendly by having a shift in focus in mathematical teaching, especially in the mathematical learning environment.
- Exploit tech-savvy nature in the student to overcome math-phobia.
- To set up a mathematics laboratory in every college in order to help students in the exploration of mathematical concepts through activities and experimentation.
- To orient students towards relating Mathematics to applications.

Vision

- To remedy Math phobia through authentic learning based on hands-on experience with computers.
- To foster experimental, problem-oriented and discovery learning of mathematics.
- To show that ICT can be a panacea for quality and efficient education when properly integrated and accepted.
- To prove that the activity-centered mathematics laboratory places the student in a problem solving situation and then through self-exploration and discovery habituates the student into providing a solution to the problem based on his or her experience, needs, and interests.
- To provide greater scope for individual participation in the process of learning and becoming autonomous learners.
- To provide scope for greater involvement of both the mind and the hand which facilitates cognition.
- To ultimately see that the learning of mathematics becomes more alive, vibrant, relevant and meaningful; a program that paves the way to seek and understand the world around them. A possible by-product of such an exercise is that math-phobia can be gradually reduced amongst students.
- To help the student build interest and confidence in learning the subject.

Board of Studies in Mathematics (PG) Members

Prof. Medha Itagi Huilgol, Department of Studies and Research in Mathematics, Bengaluru City University, Bengaluru-560001	Chairperson
Prof. Ramesh B. Kudenatti, Department of Studies and Research in Mathematics, Bengaluru City University, Bengaluru-560001	Member
Prof. B. Chaluvaraju, Department of Mathematics, Bangalore University, Bengaluru-560056	Member
Prof. Harina P. Waghamore, Department of Mathematics, Bangalore University, Bengaluru-560056	Member
Prof. Lokesha V., Department of Mathematics, Vijayanagara Sri Krishnadevaraya University, Ballary	Member
Prof. V. B. Awati, Department of Mathematics, Rani Channamma University, Belagavi	Member
Prof. H. S. Ramane, Department of Mathematics, Karanatak University, Dharwad	Member
Prof. Vasuki K.R., Department of Studies and Research in Mathematics, University of Mysore, Mysuru	Member
Prof. Gireesha B. J., Department of Mathematics, Kuvempu University, Shankaraghatta	Member
Prof. U. S. Mahabaleshwar, Department of Mathematics, Davanagere University, Davanagere	Member

Scheme of Instruction and Examination

I Semester									
Subjects	**Papers**		**Instruction hrs/week**	**Duration of Exam (hrs)**	**Marks**			**Credits**
					IA	**Exam**	**Total**	
Core Subject	**Theory**	**M101T:** Algebra-I	4	3	30	70	100	4
		M102T: Real Analysis	4	3	30	70	100	4
		M103T: Topology-I	4	3	30	70	100	4
		M104T: Ordinary Differential Equations	4	3	30	70	100	4
		M105T: Discrete Mathematics	4	3	30	70	100	4
Practicals		**M106P:** Python practicals on Discrete Mathematics	4	3	15	35	50	2
Soft Core	**Theory**	**M107SC:** Elementary Number Theory	3	3	30	70	100	2
Total of Credits								**24**

II Semester

Subjects	Papers		Instruction hrs/week	Duration of Exam (hrs)	Marks			Credits
					IA	Exam	Total	
Core Subjects	Theory	**M201T :** Algebra – II	4	3	30	70	100	4
		M202T : Complex Analysis	4	3	30	70	100	4
		M203T : Topology-II	4	3	30	70	100	4
		M204T : Partial Differential Equations	4	3	30	70	100	4
		M 205T: Numerical Analysis-I	4	3	30	70	100	4
Practicals		**M206P:** Python Practicals on Numerical Analysis-I	4	3	15	35	50	2
Soft Core Theory		**M 207SC:** Mathematical Statistics	3	3	30	70	100	2
Total of Credits								**24**

III Semester									
Subjects	**Papers**		**Instruction hrs/week**	**Duration of Exam (hrs)**	**Marks**			**Credits**
					IA	**Exam**	**Total**	
Core Subjects	**Theory**	**M 301T:** Linear Algebra	4	3	30	70	100	4
		M 302T: Functional Analysis	4	3	30	70	100	4
		M303T: Differential Geometry	4	3	30	70	100	4
		M304T: Fluid Mechanics	4	3	30	70	100	4
		M 305T: Numerical Analysis-II	4	3	30	70	100	4
Practicals		**M306P:** Python Practicals on Numerical Analysis-II	4	3	15	35	50	2
Open Electives	**Elective 1**	**M 307OE(A):** Elements of calculus	4	3	30	70	100	4
	Elective 2	**M 307OE (B):** Mathematics for everyone						
Total of Credits								**26**

<table>
<tr><th colspan="9">IV Semester</th></tr>
<tr><td rowspan="14">Core Subject and Electives</td><td rowspan="2">Compulsory Theory</td><td>M 401T
Measure And Integration</td><td>4</td><td>3</td><td>30</td><td>70</td><td>100</td><td>4</td></tr>
<tr><td>M402T
Mathematical Methods</td><td>4</td><td>3</td><td>30</td><td>70</td><td>100</td><td>4</td></tr>
<tr><td rowspan="10">Electives (Choose any 4)</td><td>M403T(A):
Algebraic Combinatorics</td><td rowspan="10">4x 4</td><td rowspan="10">4 x 3</td><td rowspan="10">4X 30</td><td rowspan="10">4 X 70</td><td rowspan="10">4 X 100</td><td rowspan="10">4X 4</td></tr>
<tr><td>M403T (B):
Codes, Designs and Networks</td></tr>
<tr><td>M-403T (C):
Computational Fluid Dynamics</td></tr>
<tr><td>M 403T (D):
Finite Element Methods with Applications</td></tr>
<tr><td>M403T (E):
Flight Dynamics</td></tr>
<tr><td>M 403T (F):
Graph Theory</td></tr>
<tr><td>M 403T (G):
Magnetohydrodynamics</td></tr>
<tr><td>M 403T (H):
Modelling and Simulation</td></tr>
<tr><td>M 403T (I):
Riemannian Geometry</td></tr>
<tr><td>M 403T (J):
Special Functions</td></tr>
<tr><td>Practicals</td><td>M404P:
Latex and Latex Beamer</td><td>4</td><td>3</td><td>15</td><td>35</td><td>50</td><td>2</td></tr>
<tr><td colspan="8">Total of Credits</td><td>26</td></tr>
<tr><td colspan="8">Program Grand total of credits</td><td>100</td></tr>
</table>

In the first two semesters there are 4 core papers, one practical paper and 1 soft core paper. In each semester total credits are 24. In the third semester, the courses '**M 307OE(A)**' and '**M 307OE(B)**' are "Open Elective Courses" which are offered only to students of other departments. The other courses are offered to the students of the department. In the fourth semester, the core subjects'M401T' and 'M402T' are compulsory and the student can choose any four (4) core papers from M403T(A) – (J). An elective paper can be offered only of there are a minimum of 05 students.

Scheme of evaluation:

Internal assessment marks for theory for 30 marks

Two internal tests: 30 marks

Internal assessment marks for practical for 15 marks

Two internal tests: 15 marks

Break-up of end semester practical marks allotment for 35 marks

Practical Record	: 5 marks
Actual Practicals	: 24 marks
Viva	: 06 marks

<u>Question paper pattern for End semester core theory examination</u>

Instructions:

Answer any 5 full questions each carrying 14 marks out of 8 questions chosen 2 each from Units I-IV. Each question may contain subdivisions.

<u>Question paper pattern for End semester soft core theory examination</u>

Instructions:

Answer any 5 full questions each carrying 14 marks out of 8 questions chosen at least 2 each from Units I-III. Each question may contain subdivisions.

Syllabus for Each Semester

FIRST SEMESTER

M101T	ALGEBRA-I	4 Credits (56 Hours)

Group Theory (Recapitulation): Groups, Subgroups, Cyclic groups, Normal Subgroups, Quotient groups, Homomorphism, Types of homomorphisms.

Permutation groups: **14 Hrs.**

Permutation groups, symmetric groups, cycles and alternating groups, dihedral groups, Isomorphism theorems and its related problems, Automorphisms, Inner automorphisms, groups of automorphisms and inner automorphisms and their relation with centre of a group. Group action on a set, Orbits and Stabilizers, The orbit-stabilizer theorem, The Cauchy-Frobenius lemma, Conjugacy, Normalizers and Centralizers, Class equation of a finite group and its applications.

Sylow's, simple, solvable groups: **14 Hrs.**

Sylow's groups and subgroups, Sylow's theorems for a finite group, Applications and examples of p-Sylow subgroups. Solvable groups, Simple groups, Applications and examples of solvable and simple groups, Jordan –Holder Theorem.

Ring Theory (Recapitulation): Rings, Some special classes of rings (Integral domain, division ring, field).

Homomorphisms and Isomorphisms on rings: **14 Hrs.**

Homomorphisms of rings, Kernel and image of Homomorphisms of rings, Isomorphism of rings, Ideals and Quotient rings, Fundamental theorem of homomorphism of rings, Theorems on principal, maximal and prime ideals, Field of quotients of an integral domain, Imbedding of rings.

Euclidean and Polynomial rings: **14 Hrs.**

Euclidean rings, Prime and relatively prime elements of a Euclidean ring, Unique factorization theorem, Fermat's theorem, Polynomial rings, The division algorithm. Polynomials over the rational field, Primitive polynomial, Content of a polynomial. Gauss lemma, Eisenstein criteria, Polynomial rings over commutative rings, Unique Factorization Domains.

TEXT BOOKS:

1. I. N. Herstein, Topics in Algebra, 2nd Edition, John Wiley and Sons, 2007.
2. S. Singh and Q. Zameeruddin, Modern Algebra, Vikas Publishing House, 1994.
3. N. Jacobson, Basic Algebra-I, 2nd ed., Dover Publications, 2009.

REFERENCE BOOKS:

1. M. Artin, Algebra, Prentice Hall of India, 1991.

2. D. F. Holt, B. Eick and E. Obrien, Handbook of computational group theory, Chapman & Hall/CRC Press, 2005.
3. J. B. Fraleigh, A first course in abstract algebra, 7th ed., Addison-Wesley Longman, 2002.

M102T	Real Analysis	4 hours/week(56 Hours)	4 Credits

Foundations of Analysis: **14 Hrs.**
Finite and infinite sets, Countable and uncountable sets, Uncountability of real numbers, Archimedean property, Supremum Infimum, Convergence of sequence and series, power series, summation by parts, addition and multiplication of series, rearrangements, double series and infinite products.

Sequence and series of functions: **14 Hrs.**
Pointwise and Uniform Convergence, Cauchy Criterion for uniform convergence, Weierstrass M-test, Uniform convergence and continuity, Bounded variation, Uniform convergence and Differentiation. Uniform convergence and bounded variation- Equi-continuous families of functions, uniform convergence and boundedness, The Stone-Weierstrass theorem and Weierstrass approximation of continuous function, illustration of theorem with examples-properties of power series, exponential and logarithmic functions, trigonometric functions.

Riemann–Stieltjes Integrals: **14 Hrs.**
Definition and existence of the Riemann Integral, extension to Riemann–Stieltjes Integrals, Linear properties of the integral, the integral as the limit of sums, Uniform convergence Riemann–Stieltjes Integral, Integration and Differentiation, Integration of vector valued functions, First and second mean value theorems, Change of variable rectifiable curves.

Euclidian $\boldsymbol{n}$ −space $\boldsymbol{R^n}$: **14 Hrs.**
Functions of several variables, continuity and differentiation of vector-valued functions, Linear transformation of $\mathbf{R}^{\mathbf{k}}$, properties and invertibility, directional derivative, chain rule, partial derivative, Hessian matrix, Heine-Borel theorem, Bolzano-Weierstrass theorem, the inverse function theorem and its illustrations with examples, the implicit function theorem with illustrations and examples, the rank theorem-illustration and examples.

TEXT BOOKS:
1. W. Rudin: Principles of Mathematical Analysis, McGraw Hill, 1983.
2. T. M. Apostol: Mathematical Analysis, New Delhi, Narosa, 2004.
REFERENCE BOOKS:
1. S. Goldberg: Methods of Real Analysis, Oxford & IBH, 1970.
2. J. Dieudonne: Treatise on Analysis, Vol. I, Academic Press, 1960.

M103T	Topology-I	4 hours/week (56 Hours)	4 Credits

Metric spaces: **14 Hrs.**
Definition of a metric, open and closed balls, Cauchy and convergence of sequences, continuity, complete metric spaces, contraction mapping theorem, Banach fixed theorem, bounded and totally bounded sets, Cantor's intersection theorem, nowhere dense sets, Baire's category theorem, isometry, embedding of a metric space in a complete metric space.

Topology: **14 Hrs.**
Definition and examples open and closed sets, neighborhoods and limit points, closure, interior and boundary of a set, relative topology, bases and sub-bases, the subspace topology, the order topology.

Continuity and connectedness: **14 Hrs.**
Continuity and homeomorphism, pasting lemma, connected spaces, connected sets in real line, intermediate value theorem, components and path components, local connectedness and path connectedness.

Compact spaces: **14 Hrs.**
Compact spaces, compact subspaces of real line, Lebesgue number lemma, locally compact spaces, Alexandroff's one-point compactification, compactness and completeness.

TEXT BOOKS:

1. J. R. Munkres, Topology, Second Edition, Prentice Hall of India, 2007
2. W. J. Pervin, Foundations of General Topology, Academic Press, 1964.

REFERENCE BOOKS:

1. G. F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw Hill, 1963.
2. J. Dugundji, Topology, Prentice Hall of India, 1975
3. J. L. Kelley, General Topology, Van Nostrand, Princeton, 1955.

M104T	Ordinary Differential Equations	4 hours/week (56 Hours)	4 Credits

Second and higher order equations: **14 Hrs.**
Linear differential equations of n^{th} order, fundamental sets of solutions, Wronskian – Abel's identity, theorems on linear dependence of solutions, adjoint – self - adjoint linear operator, Green's formula, Adjoint equations, the n^{th} order nonhomogeneous linear equations- Variation of parameters - zeros of solutions – comparison and separation theorems.

Eigenvalue problems: **14 Hrs.**
Fundamental existence and uniqueness theorem. Dependence of solutions on initial conditions, existence and uniqueness theorem for higher order and system of differential equations–Eigenvalue problems–Sturm-Liouville problems- Orthogonality of eigenfunctions - Eigenfunction expansion in a series of orthonormal functions- Green's function method.

Power series solutions: **14 Hrs.**

Power series solution of linear differential equations- ordinary and singular points of differential equations, Classification into regular and irregular singular points; Behaviour of solution at singular points and the point at infinity. Series solution about an ordinary point and a regular singular point – Frobenius method- Hermite, Laguerre, Chebyshev and Gauss Hypergeometric equations and their general solutions. Generating function, Recurrence relations, Rodrigue's formula, Orthogonality properties.

Stability analysis: **14 Hrs.**

Linear system of homogeneous and non-homogeneous equations (matrix method) Linear and Non-linear autonomous system of equations - Phase plane - Critical points – stability - Liapunov direct method – Limit cycle and periodic solutions-Bifurcation of plane autonomous systems.

TEXT BOOKS:

1. G. F. Simmons, Differential Equations, TMH Edition, New Delhi, 1974.
2. M. S. P. Eastham, Theory of ordinary differential equations, Van Nostrand, London, 1970.
3. S. L. Ross, Differential equations (3rd edition), John Wiley & Sons, NewYork, 1984.

REFERENCE BOOKS:

1. E. D. Rainville, P. E. Bedient, Elementary Differential Equations, McGraw Hill, New York, 1969.
2. E. A. Coddington, N. Levinson, Theory of ordinary differential equations, McGraw Hill, 1955.
3. A. C. King, J. Billingham, S. R. Otto, Differential equations, Cambridge University Press, 2006.

M105T	**Discrete Mathematics**	**4 hours/week(52 Hours)**	**4 Credits**

Relations: **14 Hrs.**

Types of relations, representing relations using matrices and diagraphs, closure of relations, paths in diagraphs, transitive closures, Warshal's algorithm, order relations, partial ordered sets, Zorn's lemma, Hasse diagram, extremal elements, lattices, modeling with recurrence relations with examples of Fibonacci numbers and tower of Hanoi problem, solving recurrence relations.

Counting principles: **14 Hrs.**

Product rule, summation rule, inclusion–exclusion principle, pigeonhole principle, arrangements and selections with and without repetitions, distributions-basic models, binomial coefficients, generating functions-definition, examples, solutions, exponential generating functions, solutions of recurrence relations using generating functions, the cycle index, Burnside lemma, pattern inventory, Polya's enumeration.

Introduction to graph theory: **14 Hrs.**

Types of graphs, basic terminology, subgraphs, representing graphs as incidence matrix and adjacency matrix, graph isomorphism, paths and cycles in graphs, cycle matrix of a graph, traversibilty in graphs: breadth first search, depth first search techniques, Euler and Hamiltonian paths, necessary and sufficient conditions for Euler circuits and paths in simple, undirected graphs, vertex degree based conditions for hamiltonicity, traveling salesman's problem, nearest neighbor method, distance in graphs, distance matrix of a graph, Dijkstra's algorithm to find the shortest distance paths in graphs and digraphs.

Graph parameters and trees: **14 Hrs.**

Planarity in graphs, Euler's polyhedron formula, basic results on planarity testing, definition and basic results on vertex connectivity, edge connectivity, covering, independence.

Trees as models, types of trees, properties and characterization of trees, minimum spanning trees: Prim's and Kruskul's algorithms, tree traversibility: preorder, inorder, postorder, matrix tree theorem.

TEXT BOOKS:

1. C. L. Liu, Elements of Discrete Mathematics, Tata McGraw-Hill, 2000.
2. K. L. Rosen, WCB, McGraw-Hill, 6th edition, 2004.

REFERENCE BOOKS:

1. J. P. Tremblay and R.P. Manohar, Discrete Mathematical Structures with applications to computer science, McGraw Hill, 1975.
2. F. Harary, Graph Theory, Addition Wesley, 1969.
3. J. H. Van Lint and R. M. Wilson, A course on Combinatorics, Cambridge University Press, 2006.
4. A. Tucker, Applied Combinatorics, John Wiley & Sons, 1984.

M106P	**Python practicals on Discrete Mathematics**	**4 hours/week**	**2 Credits**

List of Programs:

1. Basics of Python: Recapitulation.
2. Introducing "Networkx" package. Drawing graphs with different attributes.
3. Solving recurrence relations with boundary conditions.
4. Finding a generating function, given a sequence of coefficients.
5. Representing relations using digraphs and finding the nature of the given relation.
6. Warshall's algorithm to find transitive closure.
7. Hasse' diagram.
8. Lattice properties with extremal elements.
9. Graph Isomorphism.
10. Breadth and depth first search algorithms.
11. Dijkstra's algorithm to find shortest distance paths and lengths.
12. Checking given graph to be Eulerian.
13. Nearest Neighbor method.
14. Determining minimum spanning tree using Prim's/ Kruskal's algorithm.

M107SC	**Elementary Number Theory**	**3 hours/week (42 hours)**	**2 Credits**

Divisibility and Primes: **14 Hrs.**

Recapitulation of division algorithm, Euclid's algorithm, least common multiples, linear diophantine equations, prime numbers and prime-power factorizations, distribution of primes, Fermat and Mersenne primes, primality testing and factorization.

Congruences: **14 Hrs.**

Recapitulation of basic properties of congruences, residue classes and complete residue systems, linear congruences, reduced residue systems and the Euler-Fermat theorem, pseudoprimes, rho method, Fermat's factorization, Fermat's little theorem, polynomial congruences, modulo *p* and Langrange's theorem, simultaneous linear congruences, simultaneous non-linear congruences, an extension of Chinese remainder theorem, solving congruences modulo prime powers.

Quadratic Residues and sums of squares: **14 Hrs.**

Quadratic residues, Legendre's symbol and its properties, Euler's criterion, Gauss lemma, the quadratic reciprocity law and its applications, the Jacobi symbol, applications to diophantine equations; Sums of two squares, sums of four squares, the Pythagoras theorem, Pythagorean triples and their classification, Fermat's last theorem (Case $n = 4$), finite and infinite continued fractions.

REFERENCES:

1. G. A. Jones, J. M. Jones, Elementary Number Theory, Springer UTM, 2007.
2. T. M. Apostol, Introduction to Analytic Number Theory, Springer, 1989.
3. D. Burton, Elementary Number Theory, McGraw-Hill, 2005.
4. H. S. Zuckerman, H. L. Montgomery, Introduction to the Theory of Numbers, Wiley, 2000.
5. H. Davenport, The Higher Arithmetic, Cambridge University Press, 2008.
6. N. Koblitz, A course in Number theory and Cryptography, Springer, 1994.

SECOND SEMESTER

M201T	**Algebra-II**	**4 hours/week (56 hours)**	**4 Credits**

Recapitulation: Rings, Some special classes of rings (Integral domain, division ring, field, maximal and prime ideals).

Extended Ring Theory: **14 Hrs.**

Local ring, the nil radical and Jacobson, radical, operation on ideals, extension and contraction, the prime spectrum of a ring, Module Theory: Modules, submodules and quotient modules, modules homomorphisms, isomorphism theorems of modules.

Finite modules and Modules with chain conditions: **14 Hrs.**

Direct sums, universal isomorphism theorem, free modules, finitely generated modules, Nakayama lemma, simple modules, exact sequences of modules, Modules with chain conditions - Artinian and Noetherian modules, modules of finite length, Artnian rings, Noetherian rings, Hilbert basis theorem.

Extension Fields: **14 Hrs.**

Extension fields**,** finite and algebraic extensions, degree of extension, algebraic elements and algebraic extensions, field adjunction, transcendence of e, roots of a polynomial, splitting fields.

Field theory: **14 Hrs.**

Construction with straight edge and compass, characteristic of a field, simple and separable extensions, finite fields, Galois Theory: elements of Galois theory, fixed fields, normal extension, Galois groups over rationals, degree, distance.

TEXT BOOKS:

1. M. F. Atiyah, I. G. Macdonald, Introduction to Commutative Algebra, Addison-Wesley.
2. I. N. Herstein, Topics in Algebra, 2nd Edition, Vikas Publishing House, 1976.

REFERENCE BOOKS:

1. C. Musili, Introduction to Rings and Modules, Narosa Publishing House, 1997.
2. M. Reid, Under-graduate Commutative Algebra, Cambridge University Press, 1996.
3. M. Artin, Algebra, Prentice Hall of India, 1991.
4. N. Jacobson, Basic Algebra-I, HPC, 1984.
5. J. B. Fraleigh, A first courses in Algebra, 3rd edition, Narosa 1996.

M202T	**Complex Analysis**	**4 hours/week (56 hours)**	**4 Credits**

Recapitulation: Analytic functions, harmonic conjugates, elementary functions, Cauchy's theorem and integral formula.

Basics of complex analysis: **14 Hrs.**

Morera's theorem, Cauchy's Theorem for triangle, rectangle, and disk, zeros of analytic functions, the index of a closed curve, counting of zeros. principles of analytic continuation, fundamental theorem of algebra**,** power series, radius of convergences, power series representation of analytic function, Taylor's series, Laurent's series.

Singularities: **14 Hrs.**

Singularities, poles, classification of singularities, characterization of removable singularities, poles, behavior of an analytic function at an essential singular point, residue theorem, evaluation of definite integrals, branch cut point and integrals around, argument principle, Rouche's theorem.

Extremal theorems and integrals: **14 Hrs.**

Maximum modulus theorem, Schwartz lemma, convex functions, Hadamard's three circle theorem, Phragmén-Lindelöf theorem, open mapping theorem and applications, harmonic functions, mean value theorem, Poisson integral formula, Jensen formula, Poisson-Jensen formula.

Spaces of complex valued functions: **14 Hrs.**

Spaces of continuous, analytic and meromorphic functions, Riemann mapping theorem, Weierstrass factorization theorem, Riemann zeta function, simple connectedness and Mittag-Leffler's theorem.

TEXT BOOKS:
1. J. B. Conway, Functions of one complex variable, Narosa, 1987.
2. L.V. Ahlfors, Complex Analysis, McGraw Hill, 1986.

REFERENCE BOOKS:
1. R. Nevanlinna, Analytic functions, Springer, 1970.
2. E. Hille, Analytic Theory, Vol. I, Ginn, 1959.
3. S. Ponnaswamy, Functions of Complex variable, Narosa Publications, 1999.

M203T	**Topology-II**	**4 hours/week(52 hours)**	**4 Credits**

Product spaces: **14 Hrs.**
Limit point compactness, sequential compactness, the product topology, projection maps, product invariant properties for finite products, the quotient maps, the quotient topology, the Tychonoff theorem.

Countability and separation axioms: **14 Hrs.**
The axioms of countability: First axiom space, second countable space, Lindelof spaces, separable spaces, Separation axioms: T_0– space and T_1 -spaces –definitions and examples, properties, characterization of T_0 - and T_1 –spaces, T_2- space and its properties, regularity and T_3–spaces, characterization of regularity, Metric spaces are T_2 and T_3.

Normality: **14 Hrs.**
Normality and the T_4 - spaces, characterization of normality, metric space is T_4, normality of compact Hausdorff spaces and regular Lindelof spaces, Urysohn's lemma, Tietze's extension theorem, complete regularity, complete normality and T_5-spaces.

Paracompactness and Homotopy: **14 Hrs.**
Metrizability, Urysohn metrization theorem, local finiteness, refinement, paracompactness, normality of paracompact spaces, homotopy of paths, the fundamental group, covering spaces, the fundamental group of a circle.

TEXT BOOKS:
1. J. R. Munkres, Topology, 2nd Ed., Pearson Education (India), 2001.
2. W. J. Pervin, Foundations of General Topology, Academic Press, 1964.

REFERENCE BOOKS:
1. G. F. Simmons: Introduction to Topology and Modern Analysis, McGraw-Hill International Edition.
2. J. L. Kelley, General Topology, Van Nostrand, Princeton, 1955.
3. J. Dugundji, Topology, Prentice Hall of India, 1975.

M204T	Partial Differential Equations	4 hours/week (56 hours)	4 Credits

First Order Equations: **14 Hrs.**

First Order Partial Differential Equations: Basic definitions, Origin of PDEs, Classification, Geometrical interpretation. The Cauchy problem, the method of characteristics for Linear, Semi-linear, Quasi-linear and Non-linear equations, complete integrals, Examples of equations to analytical dynamics.

Second Order equations **14 Hrs.**

Second Order Partial Differential Equations: Definitions of Linear and Non-Linear equations, Linear Superposition principle, Classification of second-order linear partial differential equations into hyperbolic, parabolic and elliptic PDEs, Reduction to canonical forms, solution of linear Homogeneous and non-homogeneous with constant coefficients, Variable coefficients, Monge's method.

Solutions of hyperbolic and elliptic equations: **14 Hrs.**

Wave equation: Solution by the method of separation of variables and integral transforms The Cauchy problem, Wave equation in cylindrical and spherical polar coordinates.

Elliptic equation: Solution by the method of separation of variables and integral transforms. Dirichlet's, Neumann's and Churchills problems, Dirichlet's problem for a rectangle, half plane and circle, Solution of Laplace equation in cylindrical and spherical polar coordinates

Solution of parabolic equations: **14 Hrs.**

Diffusion equation: Fundamental solution by the method of variables and integral transforms, Solution of the equation in cylindrical and spherical polar coordinates. Solutions by Greens function method for hyperbolic, parabolic and elliptic equations.

TEXT BOOKS:

1. I. N. Sneddon, Elements of PDE's, McGraw Hill Book company Inc., 2006.
2. L Debnath, Nonlinear PDE's for Scientists and Engineers, Birkhauser, Boston, 2007.
3. F. John, Partial differential equations, Springer, 1971.

REFERENCE BOOKS:

1. F. Treves: Basic linear partial differential equations, Academic Press, 1975.
2. M.G. Smith: Introduction to the theory of partial differential equations, Van Nostrand, 1967.
3. S. Rao: Partial Differential Equations, PHI, 2006.

M205T	Numerical Analysis-I	4 hours/week (56 hours)	4 Credits

Solution of nonlinear equation in one variable: **14 Hrs.**

Examples from algebraic and transcendental equations where analytical methods fail. Examples from system of linear and non-linear algebraic equations where analytical solutions are difficult or impossible. Floating-point number and round-off, absolute and relative errors.

Fixed point iterative method- convergence and acceleration by Aitken's Δ^2-process. Newton-Raphson methods formultiple roots and their convergence criteria, Ramanujan method, Bairstow's method, Sturm sequence for identifying the number of real roots of the polynomial functions, complex roots-Muller's method. Homotopy and continuation methods.

Solving system of equations: **14 Hrs.**

Review of matrix algebra. Gauss-elimination with pivotal strategy. Factorization methods (Crout's, Doolittle and Cholesky). Tri-diagonal systems-Thomas algorithm. Iterative methods: Matrix norms, error analysis and ill-conditioned systems- Jacobi and Gauss- Seidel methods, Chebyshev acceleration. Introduction to steepest descent and conjugate gradient methods. Solutions of nonlinear equations: Newton-Raphson method, Quasilinearization (quasi-Newton's) method, successive over relaxation method.

Interpolation: **14 Hrs.**

Review of interpolations basics, Lagrange, Hermite methods and error analyses, Splines-linear, quadratic and cubic (natural, Not a knot and clamped), Bivariate interpolation, Least-squares, Chebyshev and rational approximations.

Numerical integration: **14 Hrs.**

Review of integrations. Gaussian quadrature- Gauss-Legendre, Gauss-Chebyshev, Gauss-Lagaurre, Gauss-Hermite and error analyses, adaptive quadratures, multiple integration with constant and variable limits. Adaptive quadratures.

TEXT BOOKS:

1. S. D. Cante, C de Boor, Elementary numerical analysis, Tata-Mc Graw-Hill, 3rd edition, 1980.
2. R. L. Burden, J. D. Faires, Numerical Analysis, Thomson-Brooks/Cole, 7th edition, 1989.
3. D. Kincade, W. Cheney, Numerical analysis, American Mathematical Society, 3rd edition, 2002.

REFERENCE BOOKS:

1. A. Iserles, A first course in the numerical analysis of differential equations, Cambridge texts in applied mathematics, 2nd edition, 2008.
2. J. Stoer, R. Bulirsch, Introduction to Numerical Analysis, Springer, 2nd edition New York.
3. S. V. Tsynkov, V. S. Ryaben'kii, A Theoretical Introduction to Numerical Analysis, Chapman and Hall /CRC, USA, 2007.

M206P	**Python Practicals on Numerical Analysis-I**	**4 hours/week**	**2 Credits**

List of programs: Recapitulation of Python

1. Fixed-point iterative method
2. Newton-Raphson method
3. Newton-Raphson method for multiple roots
4. Ramanujan method
5. Mullers method
6. Gauss-elimination method with pivoting
7. Crout’s LU Decomposition method
8. Doolittle LU Decomposition method
9. Thomas Algorithm
10. Jacobi and Gauss-Seidel iterative methods
11. Lagrange interpolation method
12. Gauss-Legendre, Gauss-Chebyshev methods
13. Gauss-Hermite method
14. Double integrals

M207SC	Mathematical Statistics	3 hours/week (42 hours)	4 Credits

Basics of probability: **14Hrs.**

Probability, sample space, class of events: classical and axiomatic definitions of probability, their consequences, conditional probability, Bayes' theorem and applications, random variables, probability distribution functions, probability expectations, Raw theorem and applications, moment generating function, probability generating function, Chebyshev's and Jensen's inequalities and applications.

Distributions: **14Hrs.**

Standard discrete distribution and their properties – Bernoulli, binomial, geometric, negative binomial, Poisson distributions, standard continuous distributions and their properties, uniform, exponential, normal, beta, gamma distributions, functions of random variables, transformation technique and applications, sampling distributions, chi-squares, *t* and their properties.

Hypothesis testing: **14Hrs.**

Random sequences, statistical inference and testing hypothesis, sequences of random variables - convergence in distribution and in probability, Chebyshev's weak law of large numbers, central limit theorem and applications, point estimation-sufficiency, unbiasedness, method of moments, maximum likelihood estimation, testing of hypotheses -basic concepts, Neyman-Pearson lemma, MP test, likelihood ratio tests, t- test, chi-square test and their applications, nonparametric tests and their applications - sign, Wilcoxon signed-rank test, run test.

TEXT BOOKS:

1. V. K. Rohatgi, An introduction to probability theory and mathematical statistics, Wiley Eastern ltd, 1985.

REFERENCE BOOKS:

1. B. R. Bhat, Modern Probability Theory, an introductory text, Wiley eastern Ltd, 1981.
2. B. A. Robert, Probability and Mathematical Statistics, Academic Press, Inc. NY, 1972.
3. R. V. Hogg, A. T. Craig, Introduction to Mathematical Statistics, McMillan and Co., 6th Ed, 2004.
4. E. L. Lehmann, J. P. Romano, Testing Statistical Hypothesis, 3rd Ed., Springer, 2005.
5. J. E. Freund, Mathematical Statistics, Prentice Hall India, 6th Ed, 2012.

THIRD SEMESTER

M301T	**Linear Algebra**	**4 hours/week (56 hours)**	**4 Credits**

Recapitulation: Vector Spaces, Subspaces, Direct sums, Linear transformation, Linear Operators.

Linear transformations: **14 Hrs.**
Algebra of Linear transformations, minimal polynomials, regular and singular transformations, range and rank of a transformation and its properties, the matrix representation of a linear transformation, composition of a linear transformation and matrix multiplication, polynomials and matrices, the change of coordinate matrix, transition matrix, the dual space, characteristic polynomials, characteristic roots and vectors, Cayley-Hamilton theorem.

Canonical forms: **14 Hrs.**
Invariant subspaces, triangular canonical form, nilpotent canonical form, Jordan canonical form, rational canonical forms, diagonalizability and other canonical forms.

Inner product spaces: **14 Hrs.**
Orthogonal complements, Gram-Schmidt orthonormalization, real quadratic forms, classification and extremality of quadratic forms, bilinear forms, symmetric and skew-symmetric bilinear forms, rank and signature, Sylvester's law of inertia, QR decomposition and applications.

Positive definite matrices: **14 Hrs.**
Hermitian matrices: definition and example, check for positive definiteness, characterizations, semidefiniteness, polar and singular value decomposition with applications, Hadamard product and Schur product theorem, congruence and simultaneous diagonalization, positive definite ordering, inequalities for positive definite matrices: Hadamard's, Fischer's, Szasz's, Oppenheim's, Ostrowski-Taussky, Minkowaski's inequalities.

TEXT BOOKS:

1. K. Hoffman and R. Kunze, Linear Algebra, Pearson Education (India), 2003. Prentice-Hall of India, 1991.
2. I. N. Herstein, Topics in Algebra, 2nd Ed., John Wiley & Sons, 2006
3. S. Freidberg. A. Insel, L Spence: Linear Algebra, Fourth Edition, PHI, 2009.
4. R. A. Horn, C. R. Johnson, Matrix Analysis, Cambridge University Press, 1985.

REFERENCE BOOKS:

1. S. Lang, Linear Algebra, Springer-Verlag, New York, 1989.
2. M. Artin, Algebra, Prentice Hall of India, 1994.
3. G. Strang, Linear Algebra and its Applications, Brooks/Cole Ltd., New Delhi, 3Edition, 2003.
4. L. Hogben, Handbook of Linear Algebra-Chapman and Hall-CRC (2006).
5. J. Gilbert, L. Gilbert, Linear Algebra and Matrix theory, Academic Press, 1995.

M302T	Functional Analysis	4 hours/week(56 hours)	4 Credits

Normed linear spaces: **14Hrs.**

Banach Spaces: Definition and examples. Quotient Spaces. Convexity of the closed unit sphere of a Banach Space. Examples of normed linear spaces which are not Banach. Holder's inequality. Minkowski's inequality. Linear transformations on a normed linear space and characterization of continuity of such transformations. The set $B(N,N')$ of all bounded linear transformations of a normed linear space N into normed linear space N'. Linear functionals, the conjugate space N*. The natural imbedding of N into N**. Reflexive spaces.

Banach space results: **14Hrs.**

Hahn -Banach theorem and its consequences, Projections on a Banach Space. The open mapping theorem and the closed graph theorem. The uniform boundedness theorem. The conjugate of an operator, properties of conjugate operator.

Inner product spaces: **14Hrs.**

Inner product spaces, Hilbert Spaces: Definition and Examples, Schwarz's inequality. Parallelogram Law, polarization identity. Convex sets, a closed convex subset of a Hilbert Space contains a unique vector of the smallest norm. Orthogonal sets in a Hilbert space. Bessel's inequality. orthogonal complements, complete orthonormal sets, Orthogonal decomposition of a Hilbert space. Characterization of complete orthonormal set. Gram-Schmidt orthogonalization process.

Conjugate Hilbert spaces: **14Hrs.**

The conjugate space H* of a Hilbert space H. Representation of a functional f as f(x) = (x, y) with y unique. The Hilbert space H*. Interpretation of T* as an operator on H. The adjoint operator T* on B (H). Self-adjoint operators, Positive operators. Normal operators. Unitary operators and their properties. Projections on a Hilbert space. Invariant subspace. Orthogonality of projections. Eigen values and eigen space of an operator on a Hilbert Space. Spectrum of an operator on a finite dimensional Hilbert Space. Finite dimensional spectral theorem.

TEXT BOOKS:

1. B. V. Limaye, Functional Analysis, Wiley Eastern, 1998.
2. E. Kreyszig, Introduction to Functional Analysis with Applications, John Wiley & Sons, 2000.

REFERENCE BOOKS:

1. G. Backman, L. Narici, Functional Analysis (Academic), 2006.
2. P. R. Halmos, Finite dimensional vector paces, Van Nostrand, 1958.
3. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Intl. Edition, 1998.

M303T	Differential Geometry	4 hours/week (56 hours)	4 Credits

Calculus on Euclidean Space: **14 Hrs.**

Euclidean spaces, natural coordinate functions, differentiable functions, tangent vectors and tangent spaces, vector fields, directional derivatives and their properties, curves in E^3, velocity and speed of a curve, Reparametrization of a curve, 1-forms and differential forms, wedge product of forms, mappings of Euclidean spaces, derivative map.

Frame Fields: **14 Hrs.**

Arc length parametrization of curves, vector field along a curve, tangent vector field, normal vector field and binormal vector field, curvature and torsion of a curve, the Frenet formulas, Frenet approximation of unit speed curve and geometrical interpretation, properties of plane curves and spherical curves, arbitrary speed curves, cylindrical helix, covariant derivatives and covariant differentials, cylindrical and spherical frame fields, connection forms, attitude matrix, structural equations, isometries of E^3 - translation, rotation and orthogonal transformation, the derivative map of an isometry.

Calculus on a Surface: **14 Hrs.**

Coordinate patch, Monge patch, surfaces in E^3, special surfaces- sphere, cylinder and surface of revolution, parameter curves, velocity vectors of parameter curves, patch computation, parametrization of surfaces- cylinder, surface of revolution and torus, tangent vectors, vector fields and curves on a surface in E^3, directional derivative of a function on a surface of E^3, differential forms and exterior derivative of forms on surface of E^3, pull back functions on surfaces of E^3.

Shape Operators: **14 Hrs.**

Definition of shape operator. Shape operators of sphere, plane, cylinder and saddle surface. Normal curvature, Normal section. Principal curvature and principal direction. Umbilic points of a surface in E^3. Euler's formula for normal curvature of a surface in E^3. Gaussian curvature, Mean curvature and Computational techniques for these curvatures. Minimal surfaces. Special curves in a surface of E^3 - Principal curve, geodesic curve and asymptotic curves. Special surface - Surface of revolution.

TEXT BOOKS:

1. B. O' Neil, Elementary Differential Geometry, Academic Press, New York and London, 1966.
2. T. J. Willmore, An introduction to Differential Geometry, Clarendon Press, Oxford, 1959.

REFERENCE BOOKS:

1. D. J. Struik, Lectures on Classical Differential Geometry, Addison Wesley, Massachusetts, 1961.
2. N. Prakassh, Differential Geometry- an integrated approach. Tata McGraw-Hill, 1981.

M304T	**Fluid Mechanics**	**4 hours/week (56 hours)**	**4 Credits**

Continuum mechanics: **14 Hrs.**

Coordinate transformations - Cartesian tensors - Basic Properties - Transpose -Symmetric and Skew tensors - Isotropic tensors- Deviatoric Tensors - Gradient, Divergence and Curl of a tensor field- Integral Theorems.

Continuum Hypothesis- Configuration of a continuum – Mass and density – Description of motion – Material and spatial coordinates - Material and Local time derivatives- Stream lines - Path lines - Vorticity and Circulation - Examples. Transport formulas –Strain tensors - Principal strains, Strain-rate tensor- Stress components and Stress tensor - Normal and shear stresses - Principal stresses.

Balance laws: **14 Hrs.**

Fundamental basic physical laws- Law of conservation of mass - Principles of linear and angular momenta - Balance of energy – Examples, Motion of non-viscous fluids –stress tensor- Euler Equation-Bernoulli's equation- simple Consequences-Helmholtz vorticity equation - Permanence of vorticity and circulation-Dimensional analysis – Non-dimensional numbers.

Exact solutions: **14 Hrs.**

Motion of Viscous fluids- Stress tensor – Navier-Stokes equation - Energy equation- Diffusion of vorticity- Energy dissipation due to viscosity. Simple exact solutions of Navier-Stokes equation: (i) Plane Poiseuille and Hagen- Poiseuille flows (ii) Generalized plane Couette flow (iii) Steady flow between two rotating concentric circular cylinders (iv) Stokes' first and second problems.

Boundary layer theory: **14 Hrs.**

Drag and lift, Prandtl boundary layer theory, momentum and thermal boundary layer equations, structures of boundary layer equations, Karman's momentum integral equation, Karman-Pohlhausen's method, Karman's momentum theorem. Flow parallel to a semi-infinite flat plate, Flow over a wedge.

TEXT BOOKS:

1. D.S. Chandrasekharaiah, L. Debnath, Continuum Mechanics, Academic Press, 1994.
2. A. J. M. Spencer, Continuum Mechanics, Longman, 1980.
3. S. M. Yuan, Foundations of Fluid Mechanics, Prentice Hall, 1976.
4. H. L. Evans, Laminar boundary layer theory, Addison-Wesley Publishing Company, London, 1968.

REFERENCE BOOKS:

1. P. Chadwick, Continuum Mechanics, Allen and Unwin, 1976.
2. L.E. Malvern, Introduction to the Mechanics of a Continuous Media, Prentice Hall, 1969.
3. Y.C. Fung, A First course in Continuum Mechanics, Prentice Hall (2nd edition), 1977.
4. P. K. Kundu, I. M. Cohen, D. R. Dowling, Fluid Mechanics,5th edition, 2010.
5. C.S.Yih, Fluid Mechanics, McGraw-Hill, 1969.

M305T	**Numerical analysis-II**	**4 hours/week (56 hours)**	**4 Credits**

Solutions of IVPs: **14 Hrs.**

Numerical solution of ordinary differential equations
Examples from ODE where analytical solution are difficult or impossible.
Initial value problems**:** Picard's method, implicit Runge-Kutta fourth order: derivation, error analysis; Methods for systems and higher order ODEs, Stability of these schemes; Multistep methods- the Adams-Bashforth and Adams-Moulton predictor-Corrector methods. Variable step size; Local and global errors, stability analyses for these methods; Solution of linear ODEs through eigenfunction approach.

Solutions of BVPs: **14 Hrs.**

Boundary value problems**:** Shooting methods: Linear and nonlinear; cubic spline methods, Rayliegh Ritz methods, Galarkin method, Chebyshev collocation methods, finite difference methods.

Solutions of parabolic and elliptic equations: **14 Hrs.**

Numerical solution of partial differential equations: Examples from PDE where analytical solution are difficult or impossible.
Elliptic equations: Difference schemes for Laplace and Poisson's equations.

Parabolic equations: Difference methods for one-dimension– methods of Schmidt, Laasonen, Dufort-Frankel and Crank- Nicolson. Alternating direction implicit method for two-dimensional equation. Stability and convergence analyses for these schemes..

Solutions of hyperbolic equations: **14 Hrs.**
Difference methods for one-dimension- explicit and implicit schemes, D'Yakonov split and Lees alternating direction implicit methods for two-dimensional equations, stability and convergence analyses for these schemes.

TEXT BOOKS:

1. M. K. Jain, Numerical solution of differential equations, Wiley Eastern, 2 Edition, 1979.
2. R. L. Burden, J. D. Faires, Numerical Analysis, Thomson-Brooks/Cole, 7edition, 1989.
3. J. W. Thomas, Numerical partial differential equations: finite difference methods, Springer, 2 Edition, 1998.

REFERENCE BOOKS:

1. A Iserles: A first course in the numerical analysis of differential equations, Cambridge texts in applied mathematics, 2 edition.,2008.
2. G. D. Smith, Numerical solution of partial differential equations: finite difference methods Oxford Applied Mathematics and Computing Science Series, 3rd Edition, 1985.

M 306P	**Python Practicals on Numerical Mathematics -II**	**4 hours/week**	**2 Credits**

List of Programs:

1. Implicit Runge-Kutta 4^{th} order method
2. Runge-Kutta-Fehlberg order method
3. Runge-Kutta for system of equations
4. Adam's Predictor-corrector method
5. Shooting methods
6. Galarkin method
7. Rayleigh Ritz method
8. Chebyshev collocation method
9. Finite difference method
10. Laplace and Poisson equation
11. Schmidt Method
12. Crank-Nicolson method
13. ADI method
14. Explicit method for wave equation

M 307OE(A)	Elements of Calculus	4 hours/week (56 hours)	4 Credits

Differential Calculus: **14 Hrs.**

Limit and continuity, properties of limits and classification of discontinuities. Derivatives, Rules for Differentiation, higher order derivatives, chain rule, implicit differentiation. Successive differentiation and Leibnitz Theorem. Statement of Rolle's Theorem, Mean Value Theorem, Taylor and Maclaurin's theorems.

Integral Calculus: **14 Hrs.**

Integration. Methods of Integration: substitution method, partial fractions, integration by parts, definite integrals, indefinite integrals.

Applications of differentiation and integration: **14 Hrs.**

Increasing and decreasing functions. Relative Extrema: maxima and minima, convexity, curve sketching.

Applications: **14 Hrs.**

Asymptotes, concavity, convexity, and points of inflection. Determine the average value of a function, area between two curves, volume of a solid figure, simple examples.

TEXT BOOKS:

1. L. Bers, F. Karal, Calculus, IBH Publishing, Bombay
2. S. Misra, Fundamentals of Mathematics-Differential Calculus, First Edition, Pearson, India, 2013.
3. S. Misra, Fundamentals of Mathematics-Integral Calculus, First Edition, Pearson, India, 2013.

REFERENCE BOOKS:

1. Courant, R. and F. John, Introduction to Calculus and Analysis, Volume I.
2. Courant, R. and F. John, Introduction to Calculus and Analysis, Volume II.

M 307OE (B)	Mathematics for Everyone	4 hours/week (56 hours)	4 Credits

Biography of selected mathematicians and elementary number theory: **14 Hrs.**

Indian Mathematicians: Aryabhata, Varahamihira, Bhaskara I & II, Brahmagupta, Mahaviracharya, Nagarjuna, Srinivasa Ramanujan. Foreign Mathematicians: Euler, Gauss, Riemann, Euclid,Rene Descartes, Leibnitz, Al-Khwarizmi, Hilbert, Fermat and Cauchy.

The Number Systems: Natural numbers, Integers, Rational & Irrational numbers, Real numbers, complex number, Prime number. Elements of Higher Arithmetic Concepts of divisibility, Congruence’s, Residue classes, Theorems of Fermat, Euler and Wilsons, Linear congruence, Chinese Remainder Theorems, Elementary arithmetical functions, Applications of cryptography.

Foundations of discrete mathematics: **14 Hrs.**

The concept of Sets: Subsets and Equality of sets, set operations (Union, Intersection and Difference). Equivalence Relations and Types of Functions (One - one, Onto, Many –one functions with examples), Mathematical Logic, Methods of proof, Mathematical Inductions. Partial Ordered sets, Hasse diagrams, Isomorphism, Extermal elements in poset, Lattice, Distributive lattice, Complemented lattice, Boolean lattices, Boolean Algebras, Boolean functions, Applications to Switching circuits.

Groups and Graphs: **14 Hrs.**

Groups, subgroups, cyclic groups, Normal subgroups. Quotient groups, homorphisms, Natural homomorphisms. Kernel and image of a homomorphism and their properties. Isomorphism and Fundamental theorem of homomorphism of groups. Application of chemistry.
Introduction to graph theory, types of graphs, Subgraphs, Degree, Distance, Standard graphs, Bipartite graph, Regular graph, Complement of a graph, Graph isomorphism, Graph Operations. Eulerian and Hamiltonian graphs, Traveling Salesman's Problem.

Solid geometry and Elements of Calculus: **14 Hrs.**

Analytical Geometry in three dimensions: Direction cosines and direction ratios, planes, straightlines, angle between planes/ straight lines, coplanar lines, shortest distance between skew lines, right circular cone and right circular cylinder
Functions of one Variable: Limits, continuity and differentiations of functions of a single variable. Derivative of a composite function, Parametric function, logarithmic function, Exponential and inverse functions. Derivative of higher order. Partial Derivatives and total derivative Homogenous functions and Euler's Theorem.

TEXT BOOKS:

1. C. L. Liu, Elements of Discrete Mathematics, Tata McGraw–Hill, 2000.
2. R. P. Grimaldi, Discrete and Combinatorial Mathematics, 4^{th}Edition, Addison-Wesley, 1999
3. K. L. Rosen, WCB McGraw-Hill, 6^{th} ed., 2004.
4. D. M. Burton, Elementary Number theory, Tata McGraw-Hill, New Delhi, 6Ed.

REFERENCE BOOKS:

1. I. N. Herstein, Topics in Algebra, 2^{nd} Edition, Vikas Publishing House, 1976
2. S. L. Loney, The elements of Coordinate geometry, London Macmillan & Co., 1966.
3. S. Lipschutz and M. Lipson, Theory and Problems of Discrete Mathematics, Schaum series 2^{nd} Tata McGraw Hill, 1998.
4. G. B. Thomas and R. L. Finney, Calculus and Analytical Geometry, 9th Ed., 2012.

FOURTH SEMESTER

M401T	**Measure And Integration**	**4 hours/week (56 hours)**	**4 Credits**

Algebra of sets: **14 Hrs.**

Algebra of sets, sigma algebras, open subsets of real line, F_σ and G_δ sets, Borel sets. (Lebesgue) Outer measure of a subset of R, existence, non-negativity and monotonicity of Lebesgue outer measure, Relation between Lebesgue outer measure and length of an interval; Countable subadditivity of Lebesgue outer measure; translation invariance. Relations between the outer measure of an arbitrary set and the outer measure of open sets, (Lebesgue) measurable sets, (Lebesgue) measure, Complement, union, intersection and difference of measurable sets, denumerable union, and intersection of measurable sets; Countable sub additivity and additivity of measure; Cantor's set, F_σ and G_δ sets. The class of measurable sets as an algebra, sigma-algebra.

Measure theory: **14 Hrs.**

The measure of the intersection of a decreasing and increasing sequence of measurable sets; measures of limit superior, limit inferior of sequences of measurable sets. Measurable functions: Scalar multiple, sum, difference, and product of measurable functions. Measurability of a continuous function and measurability of a continuous image of measurable function. Sequence of functions, Egoroff's theorem. The structure of measurable functions, Lusin theorem, Frechet theorem. Convergence pointwise and convergence in measures of a sequence of measurable functions.

Lebesgue Integral: **14 Hrs.**

Characteristic function of a set, simple function, Lebesgue integral of a simple function, Lebesgue integral of a bounded measurable function, Lebesgue integral and Riemann integral of a bounded function defined on a closed interval; Lebesgue integral of a non-negative function; Lebesgue integral of a measurable function, Properties of Lebesgue integral. Convergence theorems and Lebesgue integral; The bounded convergence theorem, Fatou's lemma, Monotone convergence theorem, Lebesgue dominated convergence theorem.

Differentiation and integration: **14 Hrs.**

Differentiation of monotone functions, Vitali covering lemma, Functions of bounded variation, Jordan Decomposition theorem, Differentiability of an integral. Absolute continuity: Absolute continuity, sum, difference, product, quotient of absolute continuous functions, Absolute continuity and bounded variation, absolute continuity and indefinite integrals. Product measure, integration on product spaces, Fubini's theorems, Lebesgue measure on R^2, product of finitely many measurable spaces.

TEXT BOOKS:

1. H. L. Royden, Real Analysis, Macmillan, 1963.

REFERENCE BOOKS:

1. P. R. Halmos, Measure Theory, East West Press, 1962.
2. W. Rudin, Real & Complex Analysis, McGraw Hill, 1966.

M402T	**Mathematical Methods**	**4 hours/week (56 hours)**	**4 Credits**

Integral Transforms: **14 Hrs.**

General definition of integral transforms, Kernels, etc. Development of Fourier integral, Fourier transforms – inversion, Illustration on the use of integral transforms, Laplace, Fourier, Hankel transforms to solve ODEs and PDEs - typical examples. Discrete orthogonality and Discrete Fourier transform. Wavelets with examples, wavelet transforms.

Integral Equations: **14 Hrs.**
Definition, Volterra and Fredholm integral equations. Solution by separable kernel, Neumann's series resolvent kernel and transform methods, Convergence for Fredholm and Volterra types. Reduction of IVPs BVPs and eigenvalue problems to integral equations. Hilbert Schmidt theorem, Raleigh Ritz and Galerkin methods.

Asymptotic Expansions: **14 Hrs.**
Asymptotic expansion of functions, power series as asymptotic series, Asymptotic forms for large and small variables. Uniqueness properties and Operations.
Asymptotic expansions of integrals; Method of integration by parts (include examples where the method fails), Laplace method and Watson's lemma, method of stationary phase and steepest descent.

Perturbation methods: **14 Hrs.**
Regular and singular perturbation methods: Parameter and co-ordinate perturbations. Regular perturbation solution of first and second order differential equations involving constant and variable coefficients. Duffings equation, Vanderpol oscillator, small Reynolds number flow. Singular perturbation problems, Matched asymptotic expansions, simple examples. Linear equation with variable coefficients and nonlinear BVP's. Problems involving Boundary layers. Poincare–Lindstedt method for periodic solution. WKB method.

TEXT BOOKS:

1. I. N. Sneddon, The use of Integral Transforms, Tata Mc Graw Hill, Publishing Company Ltd, New Delhi, 1974.
2. R. P. Kanwal, Linear integral equations theory and techniques, Academic Press, New York, 1971.
3. C. M. Bender, S. A. Orszag, Advanced mathematical methods for scientists and engineers, Mc Graw Hill, New York, 1978.
4. H. T. Davis, Introduction to nonlinear differential and integral equations, Dover Publications, 1962.
5. A. H. Nayfeh, Perturbation Methods, John Wiley & sons New York, 1973.

REFERENCE BOOKS:

1. M. D. Raisinghania, Integral equations and Boundary value problems, 6th edition, S Chand and Co., 2013.
2. R. V. Churchill: Operational Mathematics, Mc. Graw Hill, New York, 1958.

ELECTIVE PAPERS

M403T(A)	Algebraic Combinatorics	4 hours/week (56 hours)	4 Credits

Characteristic Polynomial: **14 hrs.**
Fundamentals of matrix theory, algebraic notations, power series, limits, operations on power series, Exp and Log, non-linear equations, examples.
Characteristic Polynomial: Coefficients and recurrences, walks and the characteristic polynomials, eigenvalues and eigenvectors, regular graphs, spectral decomposition.

Walk generating functions: **14 hrs.**
Jacobi theorem, decomposition formula, the Christoffel-Darboux identity, vertex reconstruction, cospectral graphs, random walks on graphs. Quotients of graphs: Equitable partitions, walk-regular graphs, generalized interlacing, covers, spectral radius of trees.

Association schemes: **14 hrs.**
Generously transitive permutation groups, p's and q's, P- and Q-polynomial association schemes, products, primitivity and imprimitivity, codes and anticodes, equitable partitions of matrices, characters of abelian groups, Cayley graphs, translation schemes and duality.

Distance and strongly regular graphs: **14 hrs.**
Distance regular graphs: Some families, distance matrices, parameters, quotients, imprimitive distance regular graphs, codes, completely regular subsets Strongly regular graphs: Basic theory, conference graphs, designs, orthogonal arrays. Representations of distance-regular graphs: Representations of graphs, the sequence of cosines, injectivity, eigenvalue multiplicities, bounding the diameter, spherical designs, bounds for cliques, feasible automorphisms.

TEXT BOOKS:
1. C. D. Godsil, Algebraic Combinatorics, Chapman and Hall/CRC, 1993.

REFERENCE BOOKS:
1. C. D. Godsil and C. Royle, Algebraic graph theory, Springer Verlag, 2002.
2. A. Tucker, Applied Combinatorics, 4^{th} Ed., John Wiley and Sons, 2002.
3. R. P. Grimaldi, Discrete and Combinatorial Mathematics: An applied introduction, 4^{th} Ed., Pearsons Education Inc., 1999.
4. N. L. Biggs: Algebraic Graph Theory, Cambridge University Press (2nd Ed.)1996.

M403T B	**Codes, Designs and Networks**	**4 hours/week (56 hours)**	**4 Credits**

Algebraic Codes: **14 hrs.**
Elements of coding theory, the Hamming metric, the parity-check and generator metrics, group codes, decoding with coset leaders, hamming matrices, self-orthogonal codes, symmetric codes over F_3, problems, f-augmenting paths, Max nearly perfect binary codes and uniformly packed codes, types of codes: linear codes, cyclic codes, bounds for codes, nonlinear codes, convolutional codes, quantum-error correcting codes, codes over fields of order 4, self-dual codes.

Combinatorial Designs: **14 hrs.**
Basic concepts, experimental designs, combinatorial designs, examples, block designs, group divisible designs, systems of distinct representatives, balanced designs, pairwise balanced designs, balanced incomplete block designs (BIBD), partially balanced incomplete block designs (PBIBD), Steiner systems, symmetric designs, resolvable and near-resolvable designs, latin squares, Hadamard matrices and Hadamard designs.

Directed Graphs: **14 hrs.**
Preliminaries of digraph, oriented graphs, elementary theorems on digraphs, distance in digraphs, tournaments, cyclic and transitive tournaments, spanning path in a tournament, tournaments with a

hamiltonian path, strongly connected tournaments, classes of digraphs: acyclic digraphs,, transitive digraphs, strong digraphs, line digraphs, de Bruijn and Kautz digraphs, series-parallel digraphs, quasi-transitive digraphs, intersection digraphs, planar digraphs and their applications.

Networks: **14 hrs.**

Flows and cuts in Networks, basic definitions and properties, reductions among different flow models, flow decompositions, working with the residual network, solving max Flow problems, Max flow-Min Cut problems, f- augmenting paths, Max flow- Min cut theorem, polynomial algorithms to find Max(s,t) flow, unit capacity and simple networks, circulations and feasible flows, minimum value of feasible (s, t)-flow, minimum cost flows, applications of flows: Ford- Fulkerson, Edmonds and Karp algorithm to find Max Flow, maximum matchings in bipartite graphs, the directed Chinese postman problem, finding subdigraphs with prescribed degrees, path-cycle factors in directed multigraphs, cycle subdigraphs covering specified vertices, assignment problem, transportation problem, properties of 0-1 networks.

TEXT BOOKS:

1. A. Tucker, Applied Combinatorics, 4^{th} Ed., John Wiley and Sons, 2002.
2. R. P. Grimaldi, Discrete and Combinatorial Mathematics: An applied introduction, 4^{th} Ed., Pearsons Education Inc., 1999.
3. J. Bang-Jensen, G. Gutin, Digraphs: Theory, Algorithms and Applications, Springer-Verlag, 2007.

REFERENCE BOOKS:

1. W. D. Wallis, Combinatorial designs, Marcel Decker, Inc. NY, 1988.
2. C. J. Colbourn and J. H. Dinitz, Handbook of Combinatorial designs, CRC press, 1996.
3. K. H. Rosen, Handbook of Combinatorial Mathematics, 2^{nd} Ed., CRC press, 2018.

M403T C	**Computational Fluid Dynamics**	**4 hours/week (56 hours)**	**4 Credits**

Solutions of PDEs: **14 Hrs.**

Review of partial differential equations, numerical analysis, fluid mechanics.

Finite Difference Methods: Derivation of finite difference methods, finite difference method to parabolic, hyperbolic and elliptic equations, finite difference method to nonlinear equations, Coordinate transformation for arbitrary geometry, Central schemes with combined space-time discretization-Lax-Friedrichs, Lax-Wendroff, MacCormack methods

Modeling of the flow problems: **14 Hrs.**

Artificial compressibility method, pressure correction method – Lubrication model, Effect of magnetic field, flow through porous media, Convection dominated flows – Euler equation – Quasilinearization of Euler equation, Compatibility relations, nonlinear Burger equation.

Introduction to FEM: **14 Hrs.**

Finite Element Methods: Introduction to finite element methods, one-and two-dimensional bases functions – Lagrange and Hermite polynomials elements, triangular and rectangular elements, Finite element method for one-dimensional problem: model boundary value problems, discretization of the domain, derivation of elemental equations and their connectivity, composition of boundary conditions and solutions of the algebraic equations.

FEM for PDEs: **14 Hrs.**

Finite element method for two-dimensional problems: model equations, discretization, interpolation functions, evaluation of element matrices and vectors and their assemblage. Solution of parabolic, hyperbolic and elliptic PDEs.

TEXT BOOKS:

1. T. J. Chung, Computational Fluid Dynamics, Cambridge Univ. Press, 2003.
2. J. Blazek, Computational Fluid Dynamics, Elsevier, 2001.
3. H. Lomax, T. H. Pulliam, D. W. Zingg, Fundamentals of Computational Fluid Dynamics, NASA Report, 2006.

REFERENCE BOOKS

4. C.A J. Fletcher, Computational techniques for Fluid Dynamics, Vol. I & II, Springer-Verlag 1991.

M403T D	**Finite Element Method with Applications**	**4 hours/week (56 hours)**	**4 Credits**

Weighted Residual Approximations: **14 Hrs.**

Point collocation, Galerkin and Least Squares method. Use of trial functions to the solution of differential equations.

Finite Elements: **14 Hrs.**

One dimensional and two dimensional basis functions, Lagrange and serendipity family elements for quadrilaterals and triangular shapes. Isoparametric coordinate transformation. Area coordinates standard 2- squares and unit triangles in natural coordinates.

Finite Element Procedures: **14 Hrs.**

Finite Element Formulations for the solutions of ordinary and partial differential equations: Calculation of element matrices, assembly and solution of linear equations.

14 Hrs.

Finite Element solution of one dimensional ordinary differential equations, Laplace and Poisson equations over rectangular and nonrectangular and curved domains. Applications to some problems in linear elasticity: Torsion of shafts of a square, elliptic and triangular cross sections.

TEXT BOOKS:

1. O.C. Zienkiewiez and K. Morgan, Finite Elements and approximation, John Wiley, 1983.
2. P. E. Lewis and J.P. Ward, The Finite element method- Principles and applications, Addison Wiley, 1991.
3. L. J. Segerlind, Applied finite element analysis (2nd Edition), John Wiley, 1984.

REFERENCE BOOKS:

1. O.C. Zienkiewicz and R. L. Taylor, The finite element method. Vol.1 Basic formulation and Linear problems, 4th Edition, New York, McGraw Hill, 1989.
2. J.N. Reddy, An introduction to finite element method, New York, McGraw Hill, 1984.
3. D.W. Pepper and J.C. Heinrich, The finite element method, Basic concepts and applications, Hemisphere, Publishing Corporation, Washington, 1992.
4. S.S. Rao, The finite element method in Engineering, 2nd Edition, Oxford, Pergamon Press, 1989.
5. D. V. Hutton, fundamental of Finite Element Analysis, 2004.

6. E. G. Thomson, Introduction to Finite Elements Method, Theory Programming and applications, Wiley Student Edition, 2005.

M403T E	Flight Dynamics	4 hours/week (56 hours)	4 Credits

Fluid Mechanics of Aircraft: 14 hrs.
Fluid statics and the atmosphere, Fluid dynamics- Conservation of mass, The momentum theorem, Euler's equation of motion, Bernoulli's equation, Determination of free stream velocity, Potential flow- velocity potential and stream function, Calculation of flows for circular cylinders, arbitrary shapes.

Cruising Flight Performance: 14 hrs.
Forces and moments acting on a flight vehicle – Equation of motion of a rigid flight vehicle – Different types of drag –estimation of parasite drag co-efficient by proper area method- Drag polar of vehicles from low speed to high speeds – Variation of thrust, power with velocity and altitudes for air breathing engines. Performance of airplane in level flight – Power available and power required curves. Maximum speed in level flight – Conditions for minimum drag and power required.

Maneuvering Flight Performance: 14 hrs.
Steady level flight-Maximum and minimum speed and variations with altitude, Steady climb, angle of climb, absolute and service ceiling. Range and endurance – Brequetformulae; range in constant velocity flight; Effect of wind. Accelerated level flight and climb; Gliding flight (Maximum rate of climb and steepest angle of climb, minimum rate of sink and shallowest angle of glide) -Turning performance (Turning rate turn radius). Bank angle and load factor – limitations on turn – V-n diagram and load factor**.**

Static Longitudinal Stability: 14 hrs.
Degree of freedom of rigid bodies in space – Static and dynamic stability – Purpose of controls in airplanes -Inherently stable and marginal stable airplanes – Static, Longitudinal stability – Stick fixed stability – Basic equilibrium equation – Stability criterion – Effects of fuselage and nacelle – Influence of CG location Power effects – Stick fixed neutral point – Stick free stability-Hinge moment coefficient – Stick free neutral points-Symmetric maneuvers – Stick force gradients – Stick force per 'g' – Aerodynamic balancing.

TEXT BOOKS:
1. C. D. Perkins, R. E. Hage, Airplane Performance stability and Control, John Wiley & Son, Inc, NY, 1988.
2. R.C. Nelson, Flight Stability and Automatic Control, McGraw-Hill Book Co., 2004.
3. W. Mc Cornick., Aerodynamics, Aeronautics and Flight Mechanics, John Wiley, NY, 1979.

REFERENCES:
1. B. Etkin, Dynamics of Flight Stability and Control, Edn. 2, John Wiley, NY, 1982.
2. A. W. Babister, Aircraft Dynamic Stability and Response, Pergamon Press, Oxford, 1980.
3. D. O. Dommasch, S. S. Sherby, T. F. Connolly, Aeroplane Aero dynamics, Third Edition, Issac Pitman, London, 1981.
4. B. W. Mc Cornick, Aerodynamics, Aeronautics and Flight Mechanics, John Wiley, NY, 1995

M403T F	Graph Theory	4 hours/week (56 hours)	4 Credits

Graph Theory (Recapitulation): Graphs, subgraphs, spanning and induced subgraph, degree, distance, standard graphs, Graph isomorphism.

Connectivity and planarity: **14 Hrs**.

Cut- vertex, bridge, blocks, vertex-connectivity, edge-connectivity and some external problems, Mengers theorems, properties of *n*-connected graphs with respect to vertices and edges.

Planarity: Plane and planar graphs, planarity testing algorithm, Euler identity, non planar graphs, maximal planar graphs, outer planar graphs, maximal outer planar graphs, characterization of planar graphs, Kuratowski's theorem, duals of graphs, crossing number.

Colorability: **14 Hrs.**

Vertex coloring, color class, *n*-coloring, chromatic index of a graph, chromatic number of standard graphs, bichromatic graphs, coloring algorithms, colorings in critical graphs, relation between chromatic number and clique number/independence number/maximum degree, edge coloring, edge chromatic number of standard graphs, coloring of a plane map, four color problem, five color theorem, uniquely colorable graphs, chromatic polynomial of a graph.

Matching and factorization: **14 Hrs.**

Matching: Basic terminology, perfect matching, augmenting paths, maximum matching, Hall's theorem for bipartite graphs, the personnel assignment problem, Hungarian algorithm, matching algorithms for bipartite graphs, Factorizations: 1-factorization, 2-factorization, Partitions: degree sequence, Havel's and Hakimi algorithms and graphical related problems.

Spectra and graph algorithms: **14 Hrs.**

Spectrum of a graph, characteristic polynomial, decomposition, algebraic connectivity, cospectrality, eigenvalues of adjacency, distance, Laplacian matrices and corresponding eigenvectors, energy.

Graph algorithms: Time complexity, depth-first search, breadth-first search, backtracking, branch and bound, etc., minimum spanning tree algorithms, all-pairs-shortest distance path algorithm, Floyd's algorithm, optimal binary search tree algorithm.

TEXT BOOKS:

1. G. Chartrand and P. Zhang, Introduction to Graph Theory, McGraw Hill, International edition, 2005.
2. C. Godsil, C. Royle, Algebraic Graph Theory, Springer-Verlag, 2002.
3. T. Coreman, C. Leiserson, R. Rivest, C. Stein, Introduction to Algorithms, MIT Press, 2001.

REFERENCE BOOKS:

1. D. B. West, Introduction to Graph Theory, Pearson Education Asia, 2nd Edition, 2002.
2. J. A. Bondy and V. S. R. Murthy, Graph Theory with Applications, Macmillan, London, 2004.
3. J. Gross and J. Yellen, Graph Theory and its application, CRC Press LLC, Boca Raton, Florida, 2000.
2. N. L. Biggs, Algebraic Graph Theory, Cambridge University Press (2nd Ed.)1996.
6. F. Harary, Graph Theory, Addison -Wesley,1969.

M 403T G	Magnetohydrodynamics	4 hours/week (56 hours)	4 Credits

Electrodynamics: **14 Hrs**.

Electrostatics and electromagnetic units –derivation of Gauss law-Faraday's law- Ampere's law and solenoidal property-–conservation of charges-electromagnetic boundary conditions. Dielectric materials.

Basic Equations and Classical MHD: **14 Hrs**.

Derivation of basic equations of MHD - MHD approximations -Non-dimensional numbers – Boundary conditions on velocity, temperature and Magnetic field. Alfven's theorem- Frozen-in-phenomenon-illustrative examples-Kelvin's circulation theorem-Bernoulli's equations-Analogue of Helmholtz vorticity equation-Ferraro's law of isorotation.

Magnetostatics and Flow Problems: **14 Hrs**.

Force free magnetic field and important results thereon-illustrative examples on abnormality parameter-Chandrasekhar's theorem-Bennett pinch and instabilities associated with it. Hartmann flow- Hartmann – Couette flow- Temperature distribution for these flows.

Alfven waves: **14 Hrs.**

Lorentz force as a sum of two surface forces- cause for Alfven waves-applications-Alfven wave equations in incompressible fluids- equipartition of energy– experiments on Alfven waves- dispersion relations- Alfven waves in compressiblefluids- slow and fast waves-Hodographs.

TEXT BOOKS:

1. T. G. Cowling, Magnetohydrodynamics, Interscience, 1957.
2. V. C. A. Ferraro, C. Plumpton: An Introduction to Magneto-FluidMechanics, Oxford University Press, 1961.
3. G. W. Sutton, A. Sherman : Engineering Magnetohydrodynamics, McGraw Hill, 1965.
4. A. Jeffrey, Magnetohydrodynamics, Oliver & Boyd, 1966.
5. K. R. Cramer, S. I. Pai, Magnetofluid Dynamics for Engineers and Applied Physicists, Scripta Publishing Company, 1973.

REFERENCE BOOKS:

1. D. J. Griffiths, Introduction to Electrohydrodynamics, Prentice Hall, 1997.
2. P. H. Roberts, An Introduction to Magnetohydrodynamics, Longman, 1967.
3. H. K. Moffat, Magnetic field generation in electrically conducting fluids, Cambridge University Press, 1978.

M403T H	Modelling and Simulation	4 hours/week (56 hours)	4 Credits

Concept of mathematical Modeling: **14 hrs.**

Definition, Classification, Characteristics and Limitations.

Models leading to ordinary differential equations: Setting up of first order differential equations from Real world problems – Qualitative solution and sketching for first-order Differential equations – Difference &

Differential equation models for population Growth – Growth and Decay Models – single species population models – Spread of Technological innovations – Higher order linear models- spring and dashpot systems – electrical circuit equation – Model for detection of diabetes – Mixing processes – Non-linear system of equations – Combat models – Predator-prey equation, qualitative theory of differential equation – Interacting species – spread of epidemics, Modeling Linear systems by frequency response methods.

Models leading to linear and nonlinear partial differential equations: 14 hrs.
Simple models, conservation law – Traffic flow on highway – Flood waves in rivers – glacier flow, roll waves and stability, shallow water waves– Convection diffusion – processes Burger's equation, Convection – reaction processes – Fisher's equation. Telegraphers equation, heat transfer in a layered solid, Chromatographic models, sediment transport in rivers.

Modeling of ground water flow: 14 hrs.
Porous Media-Aquifers-Porosity- Permeability and Averages-Derivations od Darcy and Darcy equations**.** Basic ground water flow using Darcy model, Dam seepage, Duipuit approximation, Subsurface flow with similarity solutions.

Air Pollution and Biomechanics: 14 hrs.
Air pollution: Background-origin-Atmospheric composition, sources of air pollution, primary and secondary air pollutants, effects of air pollution, mathematical principles of air pollution using gradient diffusion model, conservation of mass, momentum, and species, turbulent flow in atmosphere, mixture of SPM and atmospheric fluid, dispersion of SPM aerosols.
Modeling in Biomechanics: Fundamental concepts of biomechanics, mathematical modeling of hemolysis, Synovial joints and coronary artery diseases (mainly based on dispersion phenomena).

TEXT BOOKS:
1. M. Braun, C. S. Coleman and D. A. Drew, Differential Equation Models, Springer Verlag, 1978.
2. L. Debnath, Nonlinear partial differential equations, Hillhauser, Boston, 1997.

REFERENCE BOOKS:
1. N. Gerschenfeld, The nature of Mathematical Modeling, Cambridge University Press, 1999
2. A. C. Fowler, Mathematical Models in Applied Sciences, Cambridge University Press, 1997.

M403T(I)	**Riemannian Geometry**	**4 hours/week (56 hours)**	**4 Credits**

Differentiable manifolds: 14 Hrs.
Charts, atlases, differentiable structures, topology induced by differentiable structures, equivalent atlases, complete atlases; Manifolds: examples of manifolds, properties of induced topology on manifolds, tangent and cotangent spaces to a manifold, vector fields, Lie bracket of vector fields.

Smooth maps and diffeomorphism: 14 Hrs.
Derivative (Jacobi) of smooth maps and their matrix representation, pull back functions, tensor fields and their components, transformation formula for components of tensors, operations on tensors, contraction, covariant derivatives of tensor fields.

Riemannian Metric: 14 Hrs.
Riemannian metric, connections, Riemannian connections and their components, parallel translation, fundamental theorem of Riemannian geometry, curvature and torsion tensors, Bianchi identities, curvature tensor of second kind, sectional curvature, space of constant curvature, Schur's theorem.

Curves and geodesics in Riemannian manifold: 14 Hrs.
Geodesic curvature, Frenet formula, hypersurfaces of Riemannian manifolds Gauss formula, Gauss equation, Codazzi equation, sectional curvature for a hyper surface of a Riemannian manifold, Gauss map, Weingartan map and fundamental forms on hypersurface, equations of Gauss and Codazzi, Gauss theorem egregium.

TEXT BOOKS:

1. Y. Matsushima, Differentiable manifolds. Marcel Dekker Inc. New, York, 1972.
2. W. M. Boothby, An introduction to differentiable manifolds and Riemannian Geometry, Academic Press Inc. New York, 1975.
3. N. J. Hicks, Notes on differential Geometry D. Van Nostrand company Inc. Princeton, New Jersey, New York, London (Affiliated East-West Press Pvt. Ltd. New Delhi), 1998.

REFERENCE BOOKS:

1. R. L. Bishop and Grittendo, Geometry of manifolds, Academic Press, New York, 1964.
2. L. P. Eisenhart, Riemannian Geometry, Princeton University Press, Princeton, New Jersey, 1949.
3. H. Flanders, Differential forms with applications to the physical science, Academic Press, New York, 1963.
4. R. L. Bishop and S. J. Goldberg, Tensor analysis on manifolds, Macmillan Co.,1968.
5. K. S. Amur, D.J. Shetty and C. S. Bagewadi, An introduction to differential Geometry, Narosa Pub. New Dehli, 2010.

M403T(J)	**Special Functions**	**4 hours/week (56 hours)**	**4 Credits**

Hypergeometric series: 14 Hrs.
Definition- convergence- Solution of second order ordinary differential equation or Gauss equation- Confluent hypergeometric series- binomial theorem, integral Representation- Gauss's Summation formula- Chu-Vandermonde summation formula, Pfaff-Kummer transformation formula- Euler's transformation formula, Pfaff-Saalschutz summation formula, Kummer's formula.

Basic-hypergeometric series: 14 Hrs.
Definition- Convergence- q− binomial theorem- Heines transformation formula and its q-analogue- Jackson transformation formula- Jacobi's triple product identity and its applications (proof as in ref. 9)- Quintuple product identity (proof as in reference 10)- Ramanujan's $1\psi1$ summation formula and its applications- A new identity for $(q;q)_\infty^{10}$ with an application to Ramanujan partition congruence modulo 11- Ramanujan theta-function identities involving Lambert series.

$q-$series and Theta-functions: **14 Hrs.**

Ramanujan's general theta-function and special cases- Entries 18, 21, 23, 24, 25, 27, 29, 30 and 31 of Ramanujan's Second note book (as in text book reference 4), sums of two square and two triangular numbers, sums of four squares and triangular numbers using Jacobi triple product identity and 1ψ1 summation formula.

Partitions: **14 Hrs.**

Definition of partition of a positive integer- Graphical representation- Conjugate- Self-conjugate- Generating function of $p(n)$- other generating functions- A theorem of Jacobi- Theorems 353 and 354- applications of theorem 353- Congruence properties of $p(n)$- $p(5n + 4) \equiv 0 \pmod 5$ and $p(7n + 4) \equiv 0 \pmod 7$- Two theorems of Euler- Rogers-Ramanujan Identities- combinatorial proofs of Euler's identity, Euler's pentagonal number theorem. Franklin combinatorial proof. Restricted partitions- Gaussian. (portion to be covered as per Chapter-XIX of An Introduction to the Theory of Numbers written by G. H. Hardy and E. M. Wright).

TEXT BOOKS:

1. C. Adiga, B. C. Berndt, S. Bhargava and G. N. Watson, Chapter 16 of Ramanujan's second notebook: Theta-function and q-series, Mem. Amer. Math. Soc., 53, No.315, Amer. Math. Soc., Providence, 1985.
2. T. M. Apostol: Introduction to Analytical number theory, Oxford University Press, 2000.
3. G. E. Andrews, The theory of Partition, Cambridge University Press, 1984.
4. B. C. Berndt, Ramanujans notebooks, Part-III, Springer-Verlag, New York, 1991.
5. B. C. Berndt, Ramanujan's notebooks, Part-IV, Springer-Verlag, New York, 1994.
6. B. C. Berndt, Ramanujans notebooks, Part-V, Springer-Verlag, New York, 1998.
7. George Gasper and Mizan Rahman, Basic hyper-geometric series, Cambridge University Press, 1990.
8. G. H. Hardy and E. M. Wright, An Introduction of the Theory of Numbers, Oxford University Press, 1996.

REFERENCE BOOKS:

1. B. C. Berndt, S. H. Chan, Zhi-Guo Liu, H. Yesilyurt, A new identities for $(q;q)_\infty^{10}$ with an application to Ramanujan partition congruence modulo 11, Quart. J. Math. 55, 13-30, 2004.
2. M. S. Mahadeva Naika and H. S. Madhusudhan, Ramanujan's Theta-function identities involving Lambert Series, Adv. Stud. Contemp. Math., 8, No.1, 3-12, MR 2022031 (2004j: 33021), 2004.
3. M. S. Mahadeva Naika, K. Shivashankara, Ramanujan's ${}_1\Psi_1$ summation formula and related identities, Leonhard Paul Euler Tricentennial Birthday Anniversary Collection, J. App. Math. Stat., 11(7), pp. 130-137, 2007.
4. S. Kongsiriwong, Zhi-Guo Liu, Uniform proofs of q-series-product identity, Result. Math., 44(4), pp. 312-339, 2003.
5. S. Cooper, The Quintuple product identity, International Journal of Number Theory, Vol. 2(1), 115-161, 2006.

M404P	Latex and Latex Beamer	4 hours/week	2 Credits

1. Using environment, type the following text

1. Numbering
a. Type 1
• bullet 1
• bullet 2
b. Type 2 ○ bullet type circle 1 ○ bullet type circl 2
2. Numbering
i. Type 3
▪ Bullet type rectangles

2. Display the following

i. Roman letters I, II, III, IV so on and I, ii, iii, iv so on
ii. Alphabets: a, b, c, d, so on
iii. Uppercase alphabets: A, B, C,
iv. Include special symbols: @, $, %, &, ×, (), {}, \, /, #, !
v. Include Mathematical symbols: Δ, π, φ, ∞, μ, α, η, θ, λ, ξ, χ, τ, σ, β, Ω, Ψ, Υ, ϑ, etc.

3. Write and Display Mathematical Equations
4. Create a table in different forms
5. Import figures and graphs into latex document
6. Draw different figures using latex commands
7. Create frames in different formats
8. Create frames containing mathematical expressions
9. Create frames containing tables and figures
10. Create Bibliography in frames

TEXT BOOKS / OPEN SOURCE MATERIALS:

1. C. T. Batts, A Beamer Tutorial in Beamer.
2. http://www.ctan.org/tex-archive/macros/latex/contrib/beamer.doc/
3. http://latex-beamer.sourceforge.net