MSc Mathematics

JYOTI NIVAS COLLEGE

Autonomous

Bengaluru , Karnataka

DEPARTMENT OF MATHEMATICS

Based on Bangalore City University Syllabus

BENGALURU CITY UNIVERSITY

Department of Mathematics

Syllabus for
M.Sc., Mathematics
CBCS–2020 Scheme

Revised with effect from Academic Year 2020 – 2021

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 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 techno-savvy nature in the student to overcome math-phobia.
- Propagate FOSS (Free and open source software) tools amongst students and teachers as per vision document of National Mission for Education.
- 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.

Scheme of Instruction and Examination:

<table>
<tr><th colspan="10">I Semester</th></tr>
<tr><th rowspan="2">Subjects</th><th rowspan="2" colspan="2">Papers</th><th rowspan="2">Instruction hrs/week</th><th rowspan="2">Duration of Exam(hrs)</th><th colspan="3">Marks</th><th>Credits</th></tr>
<tr><th>IA</th><th>Exam</th><th>Total</th><th></th></tr>
<tr><td rowspan="6">Core Subject</td><td rowspan="5">Theory</td><td>M101T: Algebra-I</td><td>4</td><td>3</td><td>30</td><td>70</td><td>100</td><td>4</td></tr>
<tr><td>M102T: Real Analysis</td><td>4</td><td>3</td><td>30</td><td>70</td><td>100</td><td>4</td></tr>
<tr><td>M103T: Topology-I</td><td>4</td><td>3</td><td>30</td><td>70</td><td>100</td><td>4</td></tr>
<tr><td>M104T: Ordinary Differential Equations</td><td>4</td><td>3</td><td>30</td><td>70</td><td>100</td><td>4</td></tr>
<tr><td>M105T:Discrete Mathematics</td><td>4</td><td>3</td><td>30</td><td>70</td><td>100</td><td>4</td></tr>
<tr><td>Practicals</td><td>M106P: Maxima practicals based on paper M105T</td><td>4</td><td>3</td><td>15</td><td>35</td><td>50</td><td>2</td></tr>
<tr><td>Soft Core</td><td>Theory</td><td>M107SC: Mathematical Analysis</td><td>3</td><td>3</td><td>30</td><td>70</td><td>100</td><td>2</td></tr>
<tr><td colspan="9">Total of Credits per semester</td><td>24</td></tr>
</table>

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	4	3	30	70	100	4
	Practicals	**M206P: S**cilabPracticals based on M205T	4	3	15	35	50	2
Soft Core	Theory	**M 207SC :** Number Theory	3	3	30	70	100	2
Total of Credits per semester								**24**

III Semester

Subjects	Papers		Instruction hrs/week	Duration of Exam(hrs)	Marks			Credits
					IA	Exam	Total	
Core Subject	Theory	**M 301T:** Differential Geometry	4	3	30	70	100	4
		M302T: Fluid Mechanics	4	3	30	70	100	4
		M 303T: Functional analysis	4	3	30	70	100	4
		M304T: Liner Algebra	4	3	30	70	100	4
		M 305T: Numerical analysis-II	4	3	30	70	100	4
	Practicals	**M306P:** Scilab Practicals based on M305T	4	3	15	35	50	2
Open Elective	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 per semester								**26**

<table>
<tr><th colspan="9">IV Semester</th></tr>
<tr><td rowspan="19">Core Subject and Electives</td><td rowspan="2">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="15">Elective (Choose any 4)</td><td>M 403T A: Riemannian Geometry</td><td rowspan="15">4 x 4</td><td rowspan="15">4 x 3</td><td rowspan="15">4X 30</td><td rowspan="15">4 X 70</td><td rowspan="15">4 X 100</td><td rowspan="15">4 X 4</td></tr>
<tr><td>M 403T B : Special Functions</td></tr>
<tr><td>403T C: Theory of numbers</td></tr>
<tr><td>403T D: Entire And Meromorphic Functions</td></tr>
<tr><td>M 403T E :Magnetohydrodynamics</td></tr>
<tr><td>M 403T F: Fluid Dynamics Of Ocean and Atmosphere</td></tr>
<tr><td>M-403T G: Computational Fluid Dynamics(CFD)</td></tr>
<tr><td>M 403T H: Finite Element Method with Applications</td></tr>
<tr><td>M 403T I : Graph Theory</td></tr>
<tr><td>M 403T J: Design And Analysis Of Algorithms</td></tr>
<tr><td>M403T K: Designs and Codes</td></tr>
<tr><td>M403T L: Algebraic Combinatorics</td></tr>
<tr><td>M403T M: Modelling and Simulation</td></tr>
<tr><td>M403T N: Flight Dynamics</td></tr>
<tr><td>M403T O: Operations Research</td></tr>
<tr><td>Practicals</td><td>M406P: Latex and Latex Beamer Practicals</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 for semester</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 – O).

Scheme of evaluation:

Break-up of internal assessment marks for theory (of 30 marks)

Internal two tests and assignments: 30 marks

Break-up of internal assessment marks for practical (of 15 marks)

Preparatory practical exam or two internal tests: 15 marks

Break-up of practical mark allotment (of 35 marks)

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

Syllabi of Each Semester

FIRST SEMESTER

M101T	ALGEBRA-I	4 Credits (52 Hours)

Group Theory (Recapitulation): Groups, Subgroups, Cyclic groups, Normal Subgroups, Quotient groups, Homomorphism, Types of homomorphisms. **2 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 center of a group. **6 Hrs.**

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. **6 Hrs.**

Sylow's groups and subgroups, Sylow's theorems for a finite group, Applications and examples of p-Sylow subgroups. **6 Hrs.**

Solvable groups, Simple groups, Applications and examples of solvable and simple groups, Jordan – Holder Theorem. **6 Hrs.**

Ring Theory (Recapitulation): Rings, Some special classes of rings (Integral domain, division ring, field). **2 Hrs.**

Homomorphisms of rings, Kernel and image of Homomorphisms of rings, Isomorphism of rings, Ideals and Quotient rings, Fundamental theorem of homomorphism of rings. **6 Hrs.**

Theorems on principle, maximal and prime ideals, Field of quotients of an integral domain, Imbedding of rings. **6 Hrs.**

Euclidean rings, Prime and relatively prime elements of a Euclidean ring, Unique factorization theorem, Fermat's theorem, Polynomial rings, The division algorithm. **6 Hrs.**

Polynomials over the rational field, Primitive polynomial, Content of a polynomial. Gauss lemma, Eisenstein criteria, Polynomial rings over commutative rings, Unique Factorization Domains. **6 Hrs.**

TEXT BOOKS

1. I. N. Herstein, Topics in Algebra, 2nd Edition, John Wiley and Sons, 2007.
2. Surjeet Singh and Qazi 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. Darek F. Holt, Bettina Eick and Eamonaa. 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(52 Hours)	4 Credits

The Riemann – Stieltjes Integral: Definitions and existence of the integral, Linear properties of the integral, the integral as the limit of sums, Integration and Differentiation, Integration of vector valued functions. First and second mean value Theorems, Change of variable rectifiable curves.

18 Hrs.

Sequence and series of Functions: Pointwise and Uniform Convergence, Cauchy Criterion for uniform convergence, Weierstrass M-test, Uniform convergence and continuity, Uniform convergence and Riemann – Stieltjes Integration, Bounded variation, Uniform convergence and Differentiation. Uniform convergence and bounded variation- Equicontinous 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. **18 Hrs.**

Functions of several variables, continuity and Differentiation of vector-valued functions, Linear transformation of $\mathbf{R}^k$ properties and invertibility, Directional Derivative, Chain rule, Partial derivative, Hessian matrix. The Inverse Functions Theorem and its illustrations with examples. The Implicit Function Theorem and illustration and examples. The Rank theorem illustration and examples. **16 Hrs.**

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(52 Hours)	4 Credits

Finite and Infinite sets. Denumerable and Non denumerable sets, Countable and Uncountable sets. Equivalent sets. Concept of Cardinal numbers, Schroeder- Bernstein Theorem. Cardinal number of a power set – Addition of Cardinal numbers, Exponential of Cardinal numbers, Examples of Cardinal Arithmetic, Cantor's Theorem. Card X<Card P(X). Relations connecting $\aleph_0$ and c. Continuum Hypothesis. Zorn's lemma (statement only). **14Hrs.**

Definition of a metric. Bolzano – Weierstrass theorem. Open and closed balls. Cauchy and convergent sequences. Complete metric spaces. Continuity, Contraction mapping theorem. Banach fixed point 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. **12 Hrs.**

Topology: Definition and examples Open and closed sets. Neighborhoods and Limit Points. Closure, Interior and Boundary of a set. Relative topology. Bases and sub-bases. Continuity and homeomorphism, Pasting lemma. **14 Hrs.**

Connected spaces: Definition and examples, connected sets in the real line, Intermediate value theorem, components and path components, local connectedness and path connectedness. **12 Hrs.**

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.

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REFERENCE BOOKS

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

M104T	Ordinary Differential Equations	4 hours/week(52 Hours)	4 Credits

Linear differential equations of nth 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. **13 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. **13 Hrs.**

Power series solution of linear differential equations- ordinary and singular points of differential equations, Classification into regular and irregular singular points; 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. Behaviour of solution at irregular singular points and the point at infinity. **13 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. **13 Hrs.**

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 (3^{rd} edition), John Wiley & Sons, NewYork, 1984.

REFERENCE BOOKS

1. E.D. Rainville and P.E. Bedient : Elementary Differential Equations, McGraw Hill,
2. NewYork, 1969.
3. E.A. Coddington and N. Levinson : Theory of ordinary differential equations, McGraw Hill, 1955.

4. A.C.King, J.Billingham and S.R.Otto: 'Differential equations', Cambridge University Press, 2006.

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

Logic: Introduction to logic, Rules of Inference (for quantified statements), Validity of Arguments, Normal forms. Methods of proof: Direct, Indirect proofs, Proof by contradiction, Proof by cases, etc.
Counting Techniques: The product rule, The sum rule, The inclusion–exclusion principle, The Pigeonhole Principle and examples. Simple arrangements and selections, Arrangements and selections with repetitions, Distributions, Binomial Coefficients. **12 Hrs.**
Modeling with recurrence relations with examples of Fibonacci numbers and the tower of Hanoi problem, Solving recurrence relations. Divide-and-Conquer relations with examples (no theorems). Generating functions, definition with examples, solving recurrence relations using generating functions, exponential generating functions. **8 Hrs.**
Definition and types of relations. Representing relations using matrices and digraphs, Closures of relations, Paths in digraphs, Transitive closures, Warshall's Algorithm. Order relations, Posets, Hasse diagrams, external elements, Lattices. **6 Hrs.**

Introduction to graph theory: Types of graphs, Basic terminology, Subgraphs, Representing graphs as incidence matrix and adjacency matrix. Graph isomorphism.
Connectedness in simple graphs. Paths and cycles in graphs. Distance in graphs: Eccentricity, Radius, Diameter, Center, Periphery. Weighted graphs Dijkstra's algorithm to find the shortest distance paths in graphs and digraphs. Euler and Hamiltonian Paths. Necessary and sufficient conditions for Euler circuits and paths in simple, undirected graphs. Hamiltonicity: noting the complexity of Hamiltonicity, Traveling Salesman's Problem, Nearest neighbor method. **14 Hrs.**
Planarity in graphs, Euler's Polyhedron formula. Kuratowski's theorem (statement only).Vertex connectivity, Edge connectivity, covering, Independence. **6 Hrs.**
Trees, Rooted trees, Binary trees, Trees as models. Properties of trees. Minimum spanning trees. Minimum spanning trees. Prim's and Kruskul's Algorithms. **6 Hrs.**

TEXT BOOKS

1. C. L. Liu: Elements of Discrete Mathematics, Tata McGraw-Hill, 2000.
2. Kenneth 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. Allan Tucker, "Applied Combinatorics", John Wiley & Sons (1984).

M106P	Maxima practicals based on paper M105T	**4hours/week**	**2 Credits**

List of Programs

1. Basics of Maxima- 4hours.
2. Introducing “Graphs” package. Drawing graphs with different attributes.
3. Finding PCNF and PDNF.
4. Solving recurrence relations with boundary conditions.
5. Finding a generating function, given a sequence of coefficients.
6. Representing relations using digraphs and finding the nature of the given relation.
7. Warshall’s algorithm to find transitive closure.
8. Hasse’ diagram.
9. Lattice properties with extremal elements.
10. Graph Isomorphism.
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.

TEXT BOOKS

1. C. L. Liu: Elements of Discrete Mathematics, Tata McGraw-Hill, 2000.
2. Kenneth 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. Allan Tucker, “Applied Combinatorics”, John Wiley & Sons (1984).

M107SC	**Mathematical Analysis**	**3 hours/week (39 hours)**	**2 Credits**

Recap of limits, continuity and differentiability of functions, Continuity and compactness, Continuity and connectedness, Infinite limits and limits at infinity, Mean value theorems, the continuity of derivatives, derivatives of higher order, Taylor's theorems, differentiation of vector valued functions.
13 hours

Numerical sequences and series of real numbers, convergent sequences, Cauchy sequences, upper and lower limits, Some special sequences, Series, Series of non-negative terms, The number e, tests of convergence, Power series, Summation by parts, Absolute convergence, Addition and multiplication of series, Rearrangements.re-arrangements. Double series, infinite products.
17 hours

Topology of R^n, K-cell and its compactness, Heine-Borel Theorem. Bolzano Weierstrass theorem, Continuity, Compactness and uniform continuity. **9 hours**

TEXT BOOKS

1. W. Rudin – Principles of Mathematical Analysis, International Student edition, McGraw Hill, 3rd Ed.
2. T. M. Apostal – Mathematical Analysis, Addison Wesley, Narosa, New Delhi, 2nd Ed.

REFERENCE BOOKS

1. R. R. Goldberg – Methods of real Analysis, Oxford and IBH, New Delhi.
2. Torence Tao – Analysis I, Hindustan Book Agency, India, 2006.
3. Torence Tao – Analysis II, Hindustan Book Agency, India, 2006.
4. Kenneth A. Ross – Elementary Analysis: The Theory of Calculus, Springer International Edition, 2004.

SECOND SEMESTER

M201T	Algebra-II	**4 hours/week (52 hours)**	**4 Credits**

Extended Ring Theory (Recapitulation): Rings, Some special classes of rings (Integral domain, division ring, field, maximal and prime ideals). **2 Hrs.**

Local ring, the nil radical and Jacobson, radical, operation on ideals, extension and contraction. The prime spectrum of a ring. **6 Hrs.**

Modules Theory: Modules, submodules and quotient modules, modules homomorphisms, Isomorphism theorems of modules. **6 Hrs.**

Direct sums, Free modules Finitely generated modules, Nakayama Lemma, Simple modules, Exact sequences of modules. **6 Hrs.**

Modules with chain conditions - Artinian and Noetherian modules, modules of finite length, Artnian rings, Noetherian rings, Hilbert basis theorem. **6 Hrs.**

Filed Theory: Extension fields**,** Finite and Algebraic extensions. Degree of extension, Algebraic elements and algebraic extensions, Adjunction of an element of a field. **6 Hrs.**

Roots of a polynomial, Splitting fields, Construction with straight edge and compass. **6 Hrs.**

More about roots (Characteristic of a field), Simple and separable extensions, Finite fields **6 Hrs.**

Galois Theory: Elements of Galois Theory, Fixed fields, Normal extension, Galois groups over the rationals, degree, distance. **8 Hrs**

TEXT BOOKS

1. M. F. Atiyah and I. G. Macdonald – Introduction to Commutative Algebra, Addison-Wesley. (Part A)
2. I.N. Herstein : Topics in Algebra, 2nd Edition, Vikas Publishing House, 1976. (Part B)

REFERENCE BOOKS

1. C. Musili – Introduction to Rings and Modules, Narosa Publishing House, 1997.
2. Miles 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(52 hours)**	**4 Credits**

Analytic functions, Harmonic conjugates, Elementary functions, Cauchy's Theorem and Integral formula, Morera's Theorem, Cauchy's Theorem for triangle, rectangle, Cauchy's Theorem in a disk, Zeros of Analytic function. The index of a closed curve, counting of zeros. Principles of analytic

Continuation. Liouville’s Theorem, fundaments theorem of algebra**.**

10 Hrs.

Series, Uniform convergence, Power series, Radius of convergences, Power series representation of Analytic function, Relation between Power series and Analytic function, Taylor’s series, Laurent’s series. **10 Hrs.**

Rational Functions, Singularities, Poles, Classification of Singularities, Characterization of removable Singularities, poles. Behaviour of an Analytic functions at an essential singular point. **6 Hrs.**

Entire and Meromorphic functions. The Residue Theorem, Evaluation of Definite integrals, Argument principle, Rouche’s Theorem, Schwartz lemma, Open mapping and Maximum modulus theorem and applications, Convex functions, Hadmard’s Three circle theorem**.** **16 Hrs.**

Phragmen-Lindelof theorem, the Riemann mapping theorem, Weistrass factorization theorem. Harmonic functions, Mean Value theorem. Poisson’s formula, Poisson’s Integral formula, Jensen’s formula, Poisson’s- Jensen’s formula. **10 Hrs.**

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

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

Compact spaces, Compact sets in the real line, limit point, compactness, sequential compactness and their equivalence for metric spaces. Locally Compact spaces, compactification, Alexandroff’sone point compactification. **7 Hrs.**

The axioms of countability: First axiom space, Second countable space, Separability and the Lindelof property and their equivalence for metric spaces. **6 Hrs.**

The product topology, the metric topology, the quotient topology, Product invariant properties for finite products, Projection maps. **6 Hrs.**

Separation axioms: T0–space and T1 spaces –definitions and examples, the properties are hereditary and topological. Characterization of T0 - and T1 –spaces. **7 Hrs.**

T2- space, unique limit for convergent sequences, Regularity and the T3–axiom. Characterization of regularity, Metric spaces are T2 and T3. **6 Hrs.**

Complete regularity, Normality and the T4 - axiom, Metric space is T4, compact Hausdorff space and regular lindelof spaces are normal. **7 Hrs.**

Urysohn’s Lemma, Tietze’s Extension Theorem, Complete normality and the T5 -axiom. **7 Hrs.**

Local finiteness, Paracompactness, Normality of a paracompact space, Metrizability,
Urysohn metrization theorem,
6 Hrs.

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. G 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(52 hours)**	**4 Credits**

First Order Partial Differential Equations: -Basic definitions, Origin of PDEs, Classification, Geometrical interpretation. The Cauchy problem, the method of characteristics for Semi linear, quasi linear and Non-linear equations, complete integrals, Examples of equations to analytical dynamics, discontinuous solution and shockwaves. **13 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. **13 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.
Laplace equation:- Solution by the method of separation of variables and 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 **13 Hrs.**

Diffusion equation: -Fundamental solution by the method of variables and integral transforms, Duhamel's principle, Solution of the equation in cylindrical and spherical polar coordinates.
Solution of boundary value problems: - Green's function method for Hyperbolic, Parabolic and Elliptic equations. **13 Hrs.**

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. Shankar Rao: Partial Differential Equations, PHI, 2006.

M205T	Numerical Analysis	**4 hours/week (52 hours)**	**4 Credits**

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. **4 hours**

Solution of nonlinear equation in one variable

Fixed point iterative method- convergence and acceleration by Aitken's Δ^2-process. Newton-Raphson methods for multiple 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. **10hours**

Solving system of equations

Review of matrix algebra. Gauss-elimination with pivotal strategy. Factorization methods (Cvout'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, Successive Over Relaxation method, Introduction to steepest descent and Conjugate Gradient methods. Solutions of nonlinear equations: Newton-Raphson method, Quasilinearization (quasi-Newton's) method, Homotopy and continuation methods. **14hours**

Interpolation

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. **14 hours**

Numerical integration

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. **10hours**

TEXT BOOKS

1. SD Cante and C de Boor: Elementary numerical analysis, Tata-Mc Graw-Hill, 1980 3 edition.
2. RL Burden and JD Faires: Numerical Analysis, Thomson-Brooks/Cole, 1989, 7 edition.
3. D Kincade and W Cheney: Numerical analysis, American Mathematical Society, 2002, 3rd edition

REFERENCE BOOKS

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

M206P	Scilab Practicals based on M205T	**04 hours/week**	**1 Credit**

List of programs :

Introduction to Scilab – 2 weeks

Programs for finding the root of the function using

1. Fixed-point iterative method

2. Newton-Raphson method
3. Newton-Raphson method for multiple roots
4. Ramanujan method
5. Mullers method

Programs for the solution of system of equations using

6. Gauss-elimination method with pivoting
7. Crout's LU Decomposition method
8. Doolittle LU Decomposition method
9. Thomas Algorithm
10. Gauss-Seidel iterative method
11. Jacobi iterative method
12. Conjugate gradient method

Programs on interpolation using

13. Lagrange interpolation method
14. Cubic Spline interpolation method
15. Rational function approximation

Program on numerical integration using

16. Gauss-Legendre method
17. Gauss-Chebyshev method
18. Gauss-Hermite method
19. Double integrals

Text books

1. SD Cante and C de Boor: Elementary numerical analysis, Tata-Mc Graw-Hill, 1980,3 edition.
2. RL Burden and JD Faires: Numerical Analysis, Thomson-Brooks/Cole, 1989, 7 edition.
3. D Kincade and W Cheney: Numerical analysis, American Mathematical Society, 2002, 3 edition.
4. A Iserles: A first course in the numerical analysis of differential equations, Cambridge texts in applied mathematics, 2008, 2 edition.

M207SC	Elementary Number Theory	**3 hours/week(39 hours)**	**2 Credits**

Divisibility and Primes: 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. **9 Hours**

Congruences:

Recapitulation of basic properties of congruences, Residue classes and complete residue systems, Linear congruences. Reduced residue systems and the Euler-Fermat 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.

12 Hours

Quadratic Residues and Quadratic Reciprocity Law:

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.

12 Hours

Sums of squares, Fermat’s last theorem and Continued fractions:

Sums of two squares, Sums of four squares, The Pythagoras theorem, Pythagorean triples and their classification, Fermat's Last Theorem (Case $n = 4$).

8 Hours

REFERENCES

1. G. A. Jones and J. M. Jones, Elementary Number Theory, Springer UTM, 2007.
2. Tom M. Apostol – Introduction to Analytic Number Theory, Springer, 1989.
3. D. Burton; Elementary Number Theory, McGraw-Hill, 2005.
4. Niven, H.S. Zuckerman & H.L. Montgomery, Introduction to the Theory of Numbers, Wiley, 2000.
5. H. Davenport, The Higher Arithmetic, Cambridge University Press, 2008.