Rayat Shikshan Sanstha's

YASHAVANTRAO CHAVAN INSTITUTE OF SCIENCE, SATARA

(An Autonomous College)

Lead College of

Karmaveer Bhaurao Patil University, Satara

Reaccredited by NAAC with 'A+' Grade

Choice Based Credit System with Multiple Entry and Multiple Exit Option

(NEP-2020)

Syllabus For

Master of Science

Part - I

MATHEMATICS

Semester I and II

(Syllabus to be implemented from Academic Year 2023-24)

A. RULES AND REGULATIONS:

1. Any person who has taken the degree of B. Sc. of this Institute or the degree of any other statutory University and has kept four terms in the Institute as post-graduate student be admitted to the examination for the degree of Master of Science (M. Sc.)in Mathematics.
2. A student shall be held eligible for admission to the M. Sc. Mathematics programme provided s/he has passed the B. Sc. examination with Mathematics as a principal subject or with a subsidiary/interdisciplinary/applied/allied subjects and has passed the entrance examination conducted by the Institute.
3. The students with B. Sc. from other universities shall be eligible if they qualify through the entrance examination.
4. While preparing the merit list for M. Sc. admission, the performance at the entrance examination should be considered.
5. The examination shall be split up into four semesters.
6. The commencement and conclusion of each semester shall be notified by the Institute from time to time.
7. A student who has passed in semester examination shall not be allowed to take the examination in the same semester again.
8. Each theory Course in each semester as well as each practical course shall be treated as separate head of passing.
9. The result shall be declared at the end of each semester examination as per Institute rules.

B. SYLLABUS FOR MASTER OF SCIENCE (M.Sc.):

1. **Title: Subject: - Mathematics**
2. **Year of implementation: June 2023 onward**

3. **General Objectives of the Programme:**

The Primary objective of an M.Sc. Mathematics program is to deepen students understanding of various areas of mathematics including algebra, analysis, geometry, number theory etc. The program aims to provide advanced theoretical and practical knowledge in these areas. The program aims to bridge the gap between theoretical concepts and practical applications. The objective is to equip students with the skills to apply mathematical techniques to real world problems in various domains such as finance, engineering, computer science etc. The program includes components that focus on enhancing students professional skills which includes training in communication, presentation skills, teamwork and the ability to analyze problems formulate logical arguments and devise innovative solutions using mathematical techniques.

The overall structure of the course to be implemented from the academic year 2023–2024 onwards is as given below. Students are required to undertake a research project in all the semesters at the department. In the project, the student is expected to study research methodology that includes literature survey, experimental work and report writing following the IMRAD (Introduction, Aims and objectives, Materials andMethods, Results and Discussion) system. Students shall compulsorily deliver one seminar/research Course before submission of project and submit a certificate from theHead of the Department regarding satisfactory completion of the same at the time of the practical examination of semester IV. Students shall also undergo industrial training at the end of M.Sc. I through compulsory internships.

4. **Duration:**

- The course shall be a full-time course.
- The course shall be of two years, consisting of four semesters.

5. **Fee Structure:**

- **Entrance Examination fees:** as prescribed by the Institute.
- **Course Fee:** as prescribed by the Institute.

6. **Structure of Course**

Level	Sem	Major			RM	OJT	RP	Total
		DSC Mandatory		DSE Elective				
		T	P	T				
6	I	12 (3 Papers)	2	4 (1 paper out of two)	4	- - -	---	22
	II	12 (3 Papers)	2	4 (1 paper out of two)	---	- - -	4	22
6.5	III	12 (3 Papers)	2	4 (1 paper out of two)	---	- - -	6	22
	IV	12 (3 Papers)	---	4 (1 paper out of two)	---	4	---	22
Total		48	6	16	4	4	10	88
		70			8		10	

M.Sc. Part I

Semester I

Nature of the Course	Course Code	Name of the Course
Theory	MMT 411	Linear Algebra
	MMT 412	Advanced Calculus
	MMT 413	Real Analysis
	MMT 414 E-I	Classical Mechanics
	MMT 414 E-II	Graph Theory
	MMT 415	Research Methodology
Practical	MMP 416	Lab I: Differential Equations (Based on MMT 411, 412, 413)

Semester II

Nature ofthe Course	Course Code	Name of the Course
Theory	MMT 421	Algebra
	MMT 422	Topology
	MMT 423	Complex Analysis
	MMT 424 E-I	Differential Geometry
	MMT 424 E-II	Lattice Theory
	MMT 425	Research Project
Practical	MMP 426	Lab II: Numerical Analysis (Based on MMT 421, 422, 423)

SEMESTER I

MMT 411 Linear Algebra

Course Objectives: Student should be able to…

1. understand algebra of linear transformation.
2. study inner product spaces.
3. learn canonical forms and its examples.
4. acquire the concept of Hermitian and self-adjoint linear transformation.

Credits=4	**SEMESTER-I** **MMT 411: Linear Algebra**	**No. of lectures per unit**
UNIT I	Direct sum of a vector space, Dual Spaces. Annihilator of a subspace, Quotient Spaces. Algebra of Linear transformation.	**(15)**
UNIT II	Adjoint of a Linear Transformation, Inner product spaces, eigen values and eigen vectors of a linear transformation. Diagonalization. Invariant subspaces.	**(15)**
UNIT III	Canonical forms, Similarity of Linear transformations, Reduction to Triangular forms, Nilpotent transformation, Primary decomposition theorem, Jordan blocks and Jordan forms, Invariants of Linear transformations**.**	**(15)**
UNIT IV	Hermitian, Self adjoint, Unitary and normal linear transformation, symmetric bilinear forms, skew symmetric bilinear forms, group preserving bilinear forms**.**	**(15)**

Course Outcomes: Student will be able to…

1. understand basic notions in Linear Algebra and use the results in developing advance mathematics.
2. determine the properties of linear transformation and inner product spaces.
3. construct canonical forms and bilinear forms.
4. apply properties of bilinear forms.

Recommended Books:

1. Herstein I. N., Topics in Algebra, 2nd edition, Wiley Eastern Limited.
2. Kenneth Hoffman and R. Kunze, Linear Algebra, Prentice Hall of India Pvt. Ltd.

Reference Books:

1. A. R. Rao and P. Bhimashankaran, Linear Algebra, Hindustan Book Agency.
2. Surjit Singh, Linear Algebra, Vikas Publication House, 1997.
3. Gilbert Strang, Introduction to Linear Algebra, Wellesley Cambridge Press.

MMT 412: Advanced Calculus

Course Objectives: Student should be able to…

1. learn pointwise and uniform convergence of sequence of functions.
2. study rearrangement of sequence and series and effect of rearrangement on sum or limit.
3. understand Multivariable Calculus.
4. get knowledge of a line integral and properties.

Credits=4	**SEMESTER-I** **MMT 412: Advanced Calculus**	**No. of lectures per unit**
UNIT I	**Sequence of Functions**	**(15)**
	Pointwise convergence of sequence of function, Examples of sequence of real valued functions, Definition of uniform convergence, Uniform convergence and continuity, Cauchy condition for uniform convergence, Uniform convergence and Riemann Integration, Uniform convergence and Differentiation, double sequence, Uniform convergence and double sequence, Mean Convergence.	
UNIT II	**Series of Functions**	**(15)**
	Rearrangement of Series, subseries, double series, Rearrangement theorem for double series, Multification of series, Power series, Real Power series, The Taylors series generated by function, Bernstein's theorem, Binomial series.	
UNIT III	**The Directional Derivative**	**(15)**
	The Directional Derivative, The Directional Derivative and Continuity, Total Derivative, Total Derivative in terms of partial derivative, The Matrix of linear function, Jacobian Matrix, Chain Rule, Mean value function for differentiable function,	
UNIT IV	**Multivariable Calculus**	**(15)**
	A sufficient condition for differentiability, sufficient condition for equality of mixed partial derivatives, Taylors formula for functions R^n to R^1, The Inverse function theorem (statement only), Implicit function theorem (statement only) and their applications, Extrema of real valued function of one variable, Extrema of real valued function of several variables	

Course Outcome: Student will be able to…

1. understand convergence of double sequence and double series.
2. check the convergence of sequence and series of functions.
3. analyze differentiability of functions of several variables.
4. apply inverse and implicit function theorems for functions of several variables.

Recommended Books:

1. Apostol, Mathematical Analysis, 2nd edition, Narosa Publishing House, 1974

Reference Books:

1. Walter Rudin, Principles of Mathematical Analysis, 3rd edition, McGraw Hill book company.
2. Apostol T. M., Calculus Vol. I, Vol. II, 2nd edition, Wiley India Pvt. Ltd.
3. Fleming W., Functions of several variables, 2nd edition, Springer Verlag, 1977.

MMT 413: Real Analysis

Course Objectives: Student should be able to…

1. study Lebesgue outer Measure and Lebesgue Measurable Sets.
2. understand Lebesgue Measurable functions and properties.
3. acquire the concept of Lebesgue Integration.
4. learn norm linear space and inequalities.

Credits=4	**SEMESTER-I** **MMT 413: Real Analysis**	**No. of lectures per unit**
UNIT I	Open Sets, Closed Sets and Borel sets, Lebesgue Outer measure, The sigma Algebra of Lebesgue Measurable Sets, Countable Additivity, Continuity and Borel-Cantelli Lemma, Non-measurable Sets**.**	**(15)**
UNIT II	Sums, Product and Composition of Measurable Functions, Sequential Pointwise limits and simple Approximation. Littlewood's Three Principles, Egoroff's theorem and Lusin's Theorem, Lebesgue Integration of a Bounded Measurable Function, Lebesgue Integration of a non- negative Measurable function.	**(15)**
UNIT III	The General Lebesgue Integral, Characterization of Riemann and Lebesgue Integrability, Differentiability of Monotone Functions, Lebesgue's Theorem, Functions of Bounded Variations: Jordan's theorem**.**	**(15)**
UNIT IV	Absolutely Continuous Functions, Integrating Derivatives: Differentiating Indefinite Integrals, Inequalities of Young, Holder and Minkowski, the Riesz- Fischer Theorem.	**(15)**

Course Outcomes: Student will be able to…

1. understand the properties of Lebesgue measurable sets.
2. demonstrate the measurable functions and properties.
3. characterize Riemann and Lebesgue integrability.
4. derive completeness of normed linear spaces.

Recommended Book: -

1. Royden H. L., P. M. Fitzpatrick, Real Analysis, 4th edition, PHI Learning Pvt. Ltd., New Delhi, 2010.

Reference Books:

1. Rana I. K., An Introduction to Measure and Integration, Narosa Book Company, 1997.
2. Jain P. K., Gupta V. P., Lebesgue measure and Integration, Wiley Easter Limited, 1986.
3. Barra G. de., Measure Theory and Integration, New Age International (P) Ltd., 1981.
4. Berberian S. K., Measure and Integration, McMillan, New York, 1965.
5. Rudin W., Principles of Mathematical Analysis, McGraw-Hill Book Co, 1964.
6. Halmos P. K., Measure Theory, Vas Nostrand, 1950.

MMT 414 E-I: Classical Mechanics

Course Objectives: Student should be able to…

1. understand conservative force and D'Alembert's Principle.
2. study Geodesics in a plane and space to find maximum and minimum enclosed area.
3. get the concept of Hamiltonian function and Routh's procedure.
4. learn Kinematics of rigid body motion.

Credits=4	**SEMESTER-I** **MMT 414 E-I: Classical Mechanics**	**No. of lectures per unit**
UNIT I	Mechanics of a particle, Mechanics of a system of particles, conservation theorems, conservative force with examples, constraints, Generalized co-ordinates, D'Alembert's Principle, Lagrange's equations of motion , the forms of Lagrange's equation for non-conservative system and partially conservative and partially non-conservative system, Lagrangian for charged particle in electromagnetic field, kinetic energy as a homogeneous function of generalized velocities, Non- conservation of total energy due to the existence of non-conservative forces. Cyclic co-ordinates and generalized momentum, conservation theorems, motion of a particle under central force and first integral.	**(15)**
UNIT II	Functionals, basic lemma in calculus of variations, Euler-Lagrange's equations, first integrals of Euler-Lagrange's equations, the case of several dependent variables Undetermined end conditions, Geodesics in a plane and space, the minimum surface of revolution, the problem of Brachistochrone, Isoperimetric problems, problem of maximum enclosed area, shape of a hanging rope. Hamilton's principle for conservative and non-conservative systems.	**(15)**
UNIT III	Hamiltonian function, Hamiltonian Canonical equations of motion, Derivation of Hamilton's equations from variational principle, Physical significance of Hamiltonian, the principle of least action, Jacobi's form of the least action principle, cyclic co-ordinates and Routh's procedure. Orthogonal transformations, Properties of transformation matrix, infinitesimal rotations.	**(15)**
UNIT IV	The Kinematics of rigid body motion: The independent co-ordinates of rigid body, the Eulerian angles, Euler's theorem on motion of rigid body, Angular momentum and kinetic energy of a rigid body with one point fixed, the inertia tensor and moment of inertia, Euler's equations of motion, Caley- Klein parameters, Matrix of transformation in Caley Klein parameters, Relations between Eulerian angles and Caley-Klein parameters**.**	**(15)**

Course Outcomes: Student will be able to…

1. discuss the motion of system of particles using Lagrangian and Hamiltonian approach.
2. solve extremization problems using variational calculus.
3. construct Hamiltonian using Routh Process.
4. use infinitesimal and finite rotations to analyze motion of rigid body.

Recommended Books:

1. Herbert Goldstein, Charles Poole, John Safko, Classical Mechanics, Pearson, Delhi, 2013.
2. Goldstein H., Classical Mechanics, Narosa Publishing House, New Delhi,1998.

Reference Books:

1. Gupta A. S., Calculus of Variations with Applications, Prentice Hall of India, 1997.
2. Rana N. C. and Jog P. S., Classical Mechanics, Tata McGraw Hill, New Delhi, 1991.
3. Whittaker E. T., A Treatise on the Analytical Dynamics of Particles and Rigid Bodies, Cambridge University Press, 1965.
4. Gelfand I. M. and Formin S. V., Calculus of Variations, Prentice Hall of India, 1963.

MMT 414 E-II: Graph Theory

Course Objectives: Student should be able to…

1.understand and apply fundamental concepts in Graph theory.
2. study the methods for characterizing distributive lattices.
3. learn graph theory-based tools in solving practical problems
4. acquire applications of graph theory to practical problems and other branches of Mathematics.

Credits=4	**SEMESTER-I** **MMT 414 E-II: Graph Theory**	**No. of lectures per unit**
UNIT I	Trees and connectivity: Definitions and simple properties, Bridges, spanning trees, cut vertices and Connectivity. Euler Tours: Euler graphs, Properties of Euler graph, The Chinese postman problem.	**(15)**
UNIT II	Hamiltonian Cycles, Hamiltonian graphs, The travelling salesman problem, Matching's and Augmenting path, The marriage problem, The Personal Assignment problem.	**(15)**
UNIT III	The Optimal Assignment problem, A Chinese postman Problem, Postscript, Planer Graphs: Plane and Planar graphs, Euler's formula, Platonic bodies Kurotowskis theorem, non-Hamiltonian plane Graphs, The dual of a plane graph.	**(15)**
UNIT IV	Colouring: Vertex coloring, vertex coloring algorithms, critical graphs, cliques, Edge coloring, Map coloring, Directed graphs: Definition, Indegree and outdegree, Tournaments, traffic flow. Networks: Flows and Cuts, The Ford and Fulkerson Algorithm, Separating seen.	**(15)**

Course Outcomes: Student will be able to…

1. understand trees and connectivity and its properties.
2. determine whether graph is Hamiltonian or planar.
3. solve problems using vertex and edge Colouring.
4. construct models of real word problem using graph theory.

Recommended Book:

1. John Clark and Derek Holton, A first look at graph theory, World Scientific Publishing Co Pt Ltd, 1991.

Reference Books:

1. West Douglas B., Introduction to Graph Theory,2nd Edition, Pearson Education Asia,2001.
2. Parthsarthy K. R., Basic Graph Theory, Tata McGraw Hill publishing Co. Ltd. New Delhi,1994.
3. Harary F., Graph Theory, Narosa Publishing House 1989.

MMT415: Research Methodology

Course Objectives: Student should be able to…

1. learn fundamental principles and techniques of conducting research in mathematics.
2. understand various research methods and approaches used in mathematics research, such as experimental, theoretical, and computational methods.
3. gain the knowledge of different types of mathematical proofs, their structure, and their role in mathematical research.
4. study methods to conduct literature reviews, analyze existing mathematical research, and identify gaps or areas for further investigation.

Credits (Total Credits 4)	**SEMESTER – I** **MMT415: Research Methodology**	**No. of hours per unit**
Unit – I	**Fundamentals of Research**	**(10)**
	Aims and objectives of research, types of research- basic, novel and applied research, tools for searching research topic-books, journals, internet, discussions etc., research hypothesis, steps in research design, qualities of a researcher, ethics in research – plagiarism, literature review.	
Unit – II	**Mathematical Writing**	**(20)**
	Mathematical Writing: What Is a Theorem? Proofs, The Role of Examples, Definitions, Notation, Words versus Symbols, Displaying Equations, Parallelism, Dos and Don'ts of Mathematical Writing. Writing a Paper: Audience, Organization and Structure, Title, Author List, Date, Abstract, Key Words and Subject Classifications. The Introduction, Review of Literature, Computational Experiments, Tables, Citations, Conclusions, Acknowledgements, Appendix, Reference List, Specifics and Deprecated Practices. Revising a Draft: How to Revise, Examples of Prose, Examples Involving Equations, Examples from My Writing, A Revised Proof, A Draft Article for Improvement.	
Unit – III	**Research Publication**	**(10)**
	Publishing a Paper: Choosing a Journal, submitting a Manuscript, The Refereeing Process, How to Referee, The Role of the Copy Editor, Checking the Proofs, Copyright Issues, SIAM Journal Article: A case study. Writing and defending a thesis: The Purpose of a Thesis, Content, Presentation, The Thesis Defense. Quality indices of research publication: impact factor, H- index, science citation index.	
Unit – IV	**Research Tools and Techniques**	**(20)**
	Latex: Basics of Latex, simple typesetting, fonts, type size, Document class, page style, page numbering, parts of document, Tables in Latex, Typesetting mathematics: custom commands, symbols, equations, operators etc., Cross references in Latex. Scilab: Introduction, installation, the console, the editor, using exec, Basic elements of language, Matrices and matrix operations, Looping and branching, Functions, Plotting in Scilab.	

Course Outcomes: Student will be able to…

1. explain the fundamental principles and theories underlying mathematical research.
2. apply mathematical writing techniques to effectively communicate complex ideas and results.
3. analyze existing mathematical research publications to identify the research question, methodology, and main findings.
4. evaluate the accuracy, reliability, and validity of the results obtained using research tools and techniques.

Reference Books:

1. Carol Ellison, Concise Guide to Writing Research Papers, McGraw Hill, New York, 2010.
2. Kothari C. R., Research Methodology, 2nd revised edition, New Age International Publishers Pvt. Ltd., New Delhi, 2004.
3. Kaltenborn K. F. and Kuhn K, The journal impact factor as a parameter for the evaluation of researchers and research, Revista Espanola de Enfermedades Digestivas, 96(7), (2004), 460-476.
4. Steven G. Krantz, A Primer of Mathematical Writing, University Press Hyderabad, 1998. https://arxiv.org/pdf/1612.04888.pdf
5. Stegmann J., How to evaluate journal impact factors, Nature, 390(6660), (1997), 550-550.
6. Higham Nicholas J., Handbook of writing for the mathematical sciences, SIAM, 1961.
7. Hirsch J. E., An index to quantify an individual's scientific research output, https://arxiv.org/abs/physics/0508025
8. Latex Tutorials: A Primer, Indian Tex Users Group, http://sarovar.org/projects/ltxprimer ; http://www.tug.org.in/tutorials.html
9. Michael Baudin, Introduction to Scilab, www.scilab.org/content/download/247/1702/file/introscilab.pdf

MMP 416: Lab I - Differential Equations

Course Objectives: Student should be able to…

1.understand the procedure to find Wronskian and its properties.

2. study Initial value problems and reduction to initial value problems.

3. learn Sturm Liouville theory and The Legendre equations.

4. acquire the concept of Bessel equation and singular points at infinity.

Credits=2	**SEMESTER-I** **MMP 416: Lab I-Differential Equations**	**No. of lectures**
1	Computations on second order homogeneous equations, Initial value problems for second order equations, Linear dependence Independence.	3
2	Computations on the Wronskian.	3
3	Computations on non-homogeneous equations of order two.	3
4	Computations on homogeneous equations of order n	3
5	Computations on initial value problem for the n^{th} order equations and non-homogeneous equations of n^{th} order.	3
6	Computations on linear equations with variable coefficient, non-homogeneous equations of n^{th} order, the Wronskian and linear dependence, independence for n functions.	3
7	Computations on reduction of the order of a homogeneous equation.	3
8	Computations on homogeneous equations with analytic coefficients.	3
9	Computations on the Legendre equations.	3
10	Computations on linear equations with Regular Singular points and Euler equations.	3
11	Computations on Bessel Equations and Regular singular point at infinity.	3
12	Computations on method of successive approximation, existence and uniqueness.	3
13	Computations on the Lipschitz condition of the successive approximation and. convergence of the successive approximation.	3
14	Application of Sturm Liouville theory to solve ordinary differential equations with self-adjoint boundary conditions including eigenvalue problems and orthogonal expansions	3
15	Use of Green's functions to solve linear ordinary differential equations subject to specific boundary conditions and analyze their applications in physics and engineering.	3
16	Solution of higher order ordinary differential equations by reducing them to systems of first order equations and analyzing their solution and behavior	3

17	Application of Laplace transforms to solve ordinary differential equations and convert them into algebraic equations for easier analysis and solution	3
18	Solution of boundary value problems for ordinary differential equations using techniques like shooting methods or finite difference methods and analyze the behavior of solutions.	3
19	Application of Runge Kutta method to solve ordinary differential equations and analyze their accuracy and convergent properties.	3
20	Application of finite difference methods or spectral methods to solve ordinary differential equations and analyze their accuracy and convergent properties.	3

Course Outcomes: Student will be able to…

1. solve problems modeled by linear differential equations.
2. use power series methods to solve differential equations about ordinary points and regular singular points.
3. construct approximate solutions using method of successive approximation.
4. establish uniqueness of solutions of differential equations.

Reference Books:

1. E. A. Coddington, An Introduction to ordinary differential equations, Prentice Hall of India Pvt. Ltd., New Delhi, 2012.
2. G. Teschl, Ordinary Differential equations and Dynamical Systems, Providence, RI: American Mathematical Society, 2012.
3. M. Hirsch, Differential equations, Dynamical Systems and Linear Algebra, Academic Press, 2004.
4. M. Tenenbaum and H. Pollard, Ordinary Differential Equations, Mineola, NY: Dover Publications, 1985
5. G. F. Simmons, Differential Equations with Applications and Historical note, McGraw Hill Inc., New York, 1972.
6. E. D. Rainvills, Elementary differential equations, The Macmillan company, New York, 1964.
7. E. A. Coddington and Levinson, Theory of ordinary differential equations, McGraw Hill, New York, 1955.
8. G. Birkoff and G. G. Rota, Ordinary Differential equations, John Wiley and Sons.

SEMESTER II

MMT 421: Algebra

Course Objectives: Student will be able to…

1. learn some special groups and their properties.
2. study group action on a set and its applications.
3. understand ring of polynomials, UFD and PID.
4. obtain information about modules and its properties.

Credits=4	**SEMESTER-II** **MMT 421: Algebra**	**No. of lectures per unit**
UNIT I	Simple groups, simplicity of A_n (n>5), Commutator subgroups, normal subgroup and subnormal series, Jordan-Holder theorem, Solvable groups, isomorphism theorems, Zassenhaus Lemma, Schreier refinement theorem.	**(15)**
UNIT II	Group Action on a set, isometry subgroups, Burnside theorem, Sylow's theorems, p-groups, class equation and applications**.**	**(15)**
UNIT III	Rings of polynomials, Factorization of polynomials over fields, irreducible polynomials, Eisenstein criterion, ideals in F[x], unique factorization domain, principle ideal domain, Gauss lemma, Euclidean Domain**.**	**(15)**
UNIT IV	Modules, sub-modules, quotient modules, homomorphism and isomorphism theorems, Fundamental theorem for modules**.**	**(15)**

Course Outcomes: Student should be able to…

1. introduce and discuss module structure over a ring.
2. check irreducibility of polynomials over Q using Eisenstein criterion.
3. use homomorphism and isomorphism theorems.
4. apply Sylow theorems on p-groups.

Recommended Book:

1. Fraleigh John B., A first course in Abstract Algebra, 3rd edition, Narosa Publishing house, New Delhi. (Unit I and II)
2. Musili C., Introduction to Rings and Modules, 2nd revised edition, Narosa Publishing House, New Delhi. (Unit III and IV)

Reference Books:

1. Jacobson N., Basic Algebra, Hind Publishing Corporation, 1984.
2. Gallian Joseph A., Contemporary Abstract Algebra, 4^{th} edition, Narosa Publishing House, New Delhi.
3. Bhattacharya, Jain and Nagpal, Basic Abstract Algebra, 2^{nd} edition, Narosa Publishing House, New Delhi.

MMT 422 Topology

Course Objectives: Student will be able to…

1. study Topological spaces and their geometric properties.
2. learn homeomorphic topological spaces.
3. understand compact and connected spaces.
4. acquire the concept of completely regular and completely normal spaces.

Credits=4	**SEMESTER-II** **MMT 422: Topology**	**No. of lectures per unit**
UNIT I	Topological Spaces, Examples, Open Sets, closed sets, Neighborhoods, Bases, Subbases, Limit Points, Closer Interior, Various ways of defining topologies, Hereditary properties.	**(15)**
UNIT II	Continuous functions, Homeomorphisms, Topological properties, Compact Spaces, connected spaces, Connected subspaces of real lines, Components, Separation axioms T_0, T_1, T_2 axioms.	**(15)**
UNIT III	First and second axioms spaces, Separable Spaces, Lindelöf spaces, Regular and normal Spaces, Product Spaces (For T0, T1, T2 Compact and Connected)	**(15)**
UNIT IV	Completely regular and completely normal Spaces, Urysohn Lemma and Urysohn Metrization theorem	**(15)**

Course Outcomes: Student will be able to…

1. understand fundamental concepts in topological spaces.
2. use properties of connected and compact spaces.
3. classify various topological spaces using properties.
4. apply Urysohn Lemma and Urysohn Metrization theorem.

Recommended Books:

1. Pervin W. J., Foundations of General Topology, Academic Press, New York, 1964.

Reference Books:

1. Munkers J. R., Topology, 2nd edition, Pearson Education (Singapore), 2000.
2. Joshi K. D., Introduction to General Topology, New Age International, 1983.
3. Willard S., General Topology, Addition-Wesley Publishing Company,1970.
4. Simmons G. F., Introduction to Topology and Modern Analysis, McGraw Hill Book Company, New Delhi, 1963.
5. Kelley J. L., General Topology, Springer-Verlag, New York, 1955.

MMT 423 Complex Analysis

Course Objectives: Student will be able to…

1. study power series and its properties.
2. learn Analytical functions and examples on it.
3. understand Laurent series and classification of singularities.
4. acquire the concept of conformal maps and discuss Riemann Mapping Theorem.

Credits=4	**SEMESTER-II** **MMT 423: Complex Analysis**	**No. of lectures per unit**
UNIT I	Power series, Radius of convergence, Bilinear Transformation, Analytic functions, Cauchy's- Riemann equations, Harmonic functions, Power series representation of analytic functions.	**(15)**
UNIT II	Zeros of Analytic functions, Cauchy's theorem, Morera's theorem, Cauchy's Integral formula, Cauchy's inequality' Liouville's Theorem, Fundamental theorem of algebra, Maximum modulus theorem, Open mapping theorem.	**(15)**
UNIT III	Laurent series expansion theorem, Cauchy residue theorem, classification of singularities, Evaluation of integral, the argument principle, Rouche's theorem.	**(15)**
UNIT IV	Conformal maps, Normal families, Hurwitz theorem, Riemann mapping theorem.	**(15)**

Course Outcomes: Student should be able to…

1. compute region of convergence of Power Series.
2. evaluate complex integration along the curve via Cauchy's theorem and integral formula.
3. derive the Cauchy residue theorem and apply it to several kinds of real integrals.
4. construct conformal maps and apply its properties.

Recommended Books:

1. Conway J. B., Functions of One Complex Variable, 3rd edition, Narosa Publishing House, 1973.

Reference Books:

1. Ponnusamy S., Foundations of Complex Analysis, 2nd edition, Narosa Publication House, 2015.
2. Brown J. and Churchill R., Complex Variables and Applications, 8th edition, McGraw Hill India, 2014.
3. Ponnusamy S. and Silverman H., Complex Variables and Applications, Birkhauser Boston, 2006.
4. Serge Lang, Complex Analysis, 4th edition, Springer, 1999.
5. Alfors L. V., Complex Analysis, McGraw Hill, 1979.

MMT 424 E-I: Differential Geometry

Course Objectives: Student will be able to…

1. study Euclidean space, curves and their properties.
2. learn the Frenet Formulae & Frenet approximation of curves.
3. understand co-ordinate Patches, fundamental forms of a surface.
4. acquire concepts of the Shape operator, Asymptotic and Geodesic Curves.

Credits=4	**SEMESTER-II** **MMT 424 E-I: Differential Geometry**	**No. of lectures per unit**
UNIT I	Vector Space, Euclidean Space in R^3. Tangent Vectors and vector fields, Frame fields, Natural Frame Fields, Directional Derivatives, Curve in R^3 and reparameterization of curves, Standard curves, Speed of curve, length of curve, 1-forms, differential forms**.**	**(15)**
UNIT II	The Frenet Formulae for unit speed curve, Frenet approximation of curves, Arbitrary Speed Curves, Frenet formulae for arbitrary speed curves, Co-variant Derivative, Isometries in R^3, Orthogonal Transformations.	**(15)**
UNIT III	Co-ordinate Patches, Surface in R^3, Simple Surface, Cylinder Surface, Surface of Revolution and parameterization of a region, parameterization of a cylinder and surface of revolution, Smooth overlapping patches, Tangent and normal vector fields on a surface.	**(15)**
UNIT IV	The Shape operator of surface M in R^3, Normal curvature, Principal curvature, Gaussian and mean curvatures, Umbilic Points, Fundamental forms of a surface, Computational Techniques, Special curves on surface, Asymptotic and Geodesic Curves**.**	**(15)**

Course Outcomes: Student should be able to…

1. understand fundamental notions in Euclidean Space.
2. evaluate Frenet formulae for unit speed curve and arbitrary speed curve.
3. apply coordinate patches for identification of surfaces.
4. formulate shape operator for evaluation of Principal and Normal curvatures.

Recommended Book:

1. Neill O', Elementary Differential Geometry, revised edition, B, Academic Press, 2006.

Reference Book:

1. Somasundaram D., Differential Geometry- First Course, Narosa Publishing House, New Delhi, 2010.

MMT 424 E-II: Lattice theory

Course Objectives: Student will be able to…

1. understand basic theories of lattices and their equivalence.
2. study the methods for characterizing distributive lattices.
3. learn Pseudo complemented lattices and its special subsets of pseudo complemented lattices.
4. acquire concept of ideals and filters in lattices.

Credits=4	**SEMESTER-II** **MMT 424 E-II: Lattice Theory**	**No. of lectures per unit**
UNIT I	Posets, Definition and examples of posets, definitions of lattices and their equivalence, examples of lattices, description of Lattices, some algebraic concepts, duality principle, Special elements, homomorphism, Isomorphism and isotone maps.	**(15)**
UNIT II	Distributive lattices – Properties and characterizations, Modular lattices – Properties and Characterizations, Congruence relations, Boolean algebras – Properties and characterizations.	**(15)**
UNIT III	Ideals and filters in lattices, Lattice of all ideals I(L), Properties and characterizations of I(L), Stone's theorem and its consequences of operators, Aggregation operations.	**(15)**
UNIT IV	Pseudo complemented lattices, S(L) and D(L) – special subsets of pseudo complemented lattices, Distributive pseudo complemented lattice, Stone lattices – properties and Characterizations.	**(15)**

Course Outcomes: Student should be able to…

1. understand the relation between Posets and Lattice.
2. understand the basic Properties and characterizations of Lattice.
3. apply the ideals and filters in lattices to solve the examples.
4. construct pseudo complemented lattices.

Recommended Book:

1. George Gratzer, Freeman W. H., First concepts and distributive lattices by and company, San Francisco, 1971.

Reference Book:

1. Birkhoff G., Amer, Lattice Theory Math. Soc. Coll. Publications, 3rd Edition, 1973

MMP 425: Lab II- Numerical Analysis

Course Objectives: Student will be able to…

1. study various Numerical methods.
2. learn error estimation and Numerical integration.
3. understand Runge Kutta method and Taylor's series Method.
4. acquire concepts of convergence, consistency and sufficient condition for convergence.

Credits=2	**SEMESTER-II** **MMP 425: Lab II- Numerical Analysis**	**No. of lectures**
1	Implementing Bisection Method: Write a scilab program to find the root of a given equation using the Bisection Method. Test it with different equations and initial guesses.	3
2	Implementing Secant Method: Write a scilab program to find the root of a given equation using the Bisection Method. Test it with different equations and initial guesses.	3
3	Newton-Raphson Method: Develop a scilab program to find the root of an equation using the Newton-Raphson Method. Validate the program using various equations.	3
4	Matrix Factorization method: Doolittle reduction method	3
5	Matrix Factorization method: Crout reduction method	3
6	Numerical Solution of Eigenvalue Problems: Obtain bounds for eigenvalue using Gerschgorin theorem, Breuer theorem.	3
7	Numerical Solution of Eigenvalue Problems: Create a Scilab program to find the eigenvalues and eigenvectors of a matrix using power method.	3
8	Lagrange Interpolation: Implement the Lagrange Interpolation method to approximate a function given a set of data points. Compare the results with the original function.	3
9	Newton's Interpolation: Implement the Newton's Interpolation method to approximate a function given a set of data points. Compare the results with the original function.	3
10	Double Interpolation: Implement the Hermite Interpolation, double interpolation method to approximate a function given a set of data points. Compare the results with the original function.	3
11	Gaussian Elimination: Create a program in scilab to solve a system of linear equations using Gaussian Elimination. Test it with different matrices of varying sizes	3

12	Numerical Integration: Implement the trapezoidal rule for numerical integration of a function. Test the program with different functions and compare the results.	3
13	Numerical Integration: Implement the Simpson's rule for numerical integration of a function. Test the program with different functions and compare the results.	3
14	Numerical Integration: Implement the Legendre integration method for numerical integration of a function. Test the program with different functions and compare the results.	3
15	Numerical Differentiation: Write a program to numerically approximate the derivative of a given function using forward difference methods. Compare the results with the exact derivative.	3
16	Numerical Differentiation: Write a program to numerically approximate the derivative of a given function using backward difference methods. Compare the results with the exact derivative.	3
17	Runge-Kutta Methods: Create a Scilab program to solve ordinary differential equations using Runge-Kutta second order method.	3
18	Runge-Kutta Methods: Create a Scilab program to solve ordinary differential equations using Runge-Kutta Fourth-order method.	3
19	Finite Difference Method: Develop a program to solve a partial differential equation using the finite difference method. Test it with different equations and boundary conditions.	3
20	Numerical Linear Algebra: Explore numerical algorithms for matrix factorizations, matrix inversions or solving least square problems.	3

Course Outcomes: Student should be able to…

1. apply methods to solve linear and nonlinear equations.
2. evaluate numerical integration and analyze error in computation.
3. solve differential equations using various numerical methods.
4. construct LU decomposition of a square matrix.

Reference Books:

1. Sastry S. S., Introductory methods of Numerical Analysis, 5th edition, PHI learning Pvt. Ltd., New Delhi, 2012.
2. Jain M. K., Iyengar S. R. K. and Jain R. K., Numerical methods for scientific and Engineering Computation, 5th edition, New Age International Publishers, 2007.

3. Atkinson K. E., An Introduction to Numerical Analysis, 2nd edition, John Wiley and Sons,1988.
4. Kincaid D. and Cheney W., Numerical Analysis, 3rd edition, American Mathematical Society.