Rayat Shikshan Sanstha's

Sadguru Gadage Maharaj College,Karad

(An Autonomous College)

DEPARTMENT OF MATHEMATICS

NEP-2020 with Multiple Entry and Multiple Exit Option

Syllabus For

M.Sc. Mathematics Part-I

Semester I and II

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

NEP-2020 with Multiple Entry and Multiple Exit Option
M.Sc. (Mathematics) Programme Structure

M.Sc. (Mathematics) Part–I (Level-6.0)

Year	Level	Sem.	Major		RM	OJT / FP	RP	Cum. Cr.	Degree
			Mandatory	Electives					
I	6.0	Sem I	3*4+2	4	4	--	--	22	PG Diploma in Mathematics (after 3Yr UG Degree)
		Sem II	3*4+2	4	--	4	--	22	
Cum. Cr. For PG Diploma in Mathematics			28	8	4	4	--	44	
Exit option: PG Diploma in Mathematics (44 Credits) after Three Year UG Degree									
II	6.5	Sem III	3*4+2	4	--	--	4	22	MSc Mathematics Degree After 3 Year UG Or MSc Mathematics Degree after 4 Year UG
		Sem IV	3*4	4	--	--	6	22	
Cum. Cr. for 1 Year MSc Mathematics Degree			26	8	--	--	10	44	
Cum. Cr. for 2 Year MSc Mathematics Degree			54	16	4	4	10	88	
2 Years-4 Sem. MSc Mathematics Degree (88 credits) after Three Year UG Degree **or** 1 Year-2 Sem MSc Mathematics Degree (44 credits) after Four Year UG Degree									

Abbreviations: Yr.: Year; Sem.: Semester; OJT: On Job Training: Internship/ Apprenticeship; FP: Field projects; RM: Research Methodology; RP: Research Project; Cum. Cr. Cumulative Credits:

M.Sc. (Mathematics) Part–I (Level-6.0)

Semester	**Mandatory Major** 4 credits	**Mandatory Major** 2 credits	**Mandatory Elective (any one)** 4 credits	**Mandatory RM and OJT/FP** 4 credits
I	1) Linear Algebra 2) Real Analysis 3) Ordinary Differential Equations	Numerical Analysis-I	1) Differential Geometry 2) Integral Transforms 3) Basics of Python	Research Methodology
II	1) Complex Analysis 2) Topology 3) Advanced Calculus	Numerical Analysis - II	1) Combinatorics 2) Difference Equations 3) Algebraic Automata Theory	On job Training/ Field project

M.Sc. (Mathematics) Part–II (Level-6.5)

Semester	**Mandatory Major** 4 credits	**Mandatory Major** 2 credits	**Mandatory Elective (any one)** 4 credits	**Mandatory RM and OJT/FP**
III	1) Functional Analysis 2) Algebra 3) Classical Mechanics	Advanced Discrete Mathematics	1) Lattice Theory-I 2) Fuzzy Mathematics – I 3) Algebraic Number Theory	Research Project(4 credits)
IV	1) Field Theory 2) Integral Equations 3) Partial Differential Equations	---	1) Number Theory 2) Fuzzy Mathematics-II 3) Lattice Theory-I	Research Project (6 credits)

M. Sc. Mathematics (Part I) (Level-6.0) (Semester I)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: Linear Algebra
Subject Code: MJ-MMT23-101
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:

1. understand basic notions in Linear Algebra and use the results in developing advanced mathematics.
2. study the properties of Vector Spaces, Linear Transformations, Algebra of Linear Transformations and Inner product space in some details.
3. construct Canonical forms and Bilinear forms.
4. apply knowledge of Vector space, Linear Transformations, Canonical Forms and Bilinear Transformations.

Unit I: Elementary Basic concepts, Linear Independence and Bases, Dual Spaces, Annihilator of a subspace, Quotient Spaces. Inner product spaces, Linear Transformations. **15 Lectures**

Unit II: The Algebra of Linear transformations, Characteristic Roots, Matrices of linear transformations, Eigen values and eigenvectors of a linear transformation, Canonical Forms: Similarity of linear transformations. **15 Lectures**

Unit III: Triangular form, Nilpotent transformations, Jordan Form, Trace and transpose, Determinants. **15 Lectures**

Unit IV: Hermitian, Unitary and Normal linear transformations, Bilinear Forms, Symmetric Bilinear Forms, Skew Symmetric Bilinear Forms. **15 Lectures**

Seminars, Tutorials, Problem solving session and group discussions on above four units

Recommended Book(s):

1. Herstein I. N. : Topics in Algebra, 2nd Edition, Willey Eastern Limited.
2. Hoffman, Kenneth and Kunze R: Linear Algebra, Prentice Hill of India Private Limited., 1984.

Reference Books:

1. A. R. Rao and P. Bhimashankaran, Linear Algebra, Hidustan Book Agency.
2. Surjit Singh, Linear Algebra, Vikas publishing House (1997).
3. Gilbert Strang: Introduction to Linear Algebra, Wellesley-Cambridge Press

M. Sc. Mathematics (Part I) (Level-6.0) (Semester I)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: Real Analysis
Subject Code: MJ-MMT23-102
Total Credits: 04

Course Outcomes: Upon successful completion of this course, the student will be able to:
1. generalize the concept of length of interval.
2. analyze the properties of Lebesgue measurable sets.
3. demonstrate the measurable functions and their properties.
4. understand the concept of Lebesgue integration of measurable functions.
5. characterize Riemann and Lebesgue integrability.
6. prove completeness of L^P Spaces.

UNIT I:
σ-algebra and Borel Sets of Real numbers, Lebesgue Outer Measure, The sigma algebra of Lebesgue measurable sets, Outer and Inner approximation of Lebesgue Measurable Sets, Countable Additivity, Continuity and Borel-Cantelli Lemma. **15 Lectures**

UNIT II:
Nonmeasurable Sets, Lebesgue Measurable Functions: Sums, Product and Composition of Measurable Functions, Sequential Pointwise Limits and Simple Approximation, Littlewood's Three Principles (Statement and importance of Egoroff's Theorem and Lusin's Theorem) **15 Lectures**

UNIT III:
Lebesgue Integral of a Bounded Measurable Function over a Set of Finite Measure, Lebesgue integral of a Measurable Non-negative Function, The General Lebesgue Integral, Characterizations of Riemann and Lebesgue Integrability. **15 Lectures**

UNIT IV:
Lebesgue's Theorem (Statement Only), Functions of Bounded Variations, Jordan's theorem, Absolutely Continuous Functions, Integrating Derivatives: Differentiating Indefinite Integrals, The L^P Spaces: Normed Linear Spaces, The Inequalities of Young, Hölder and Minkowski, The Riesz-Fischer Theorem. **15 Lectures**

Seminars, Tutorials, Problem solving session and group discussions on above four units

Recommended Books:
1. H. L. Royden, P.M. Fitzpatrick, Real Analysis, Fourth Edition, PHI Learning Pvt. Ltd., New Delhi, 2010

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

M. Sc. Mathematics (Part I) (Level-6.0) (Semester I)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: Ordinary Differential Equations
Subject Code: MJ-MMT23-103
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:
1. study basic notions in Differential Equations and use the results in developing advanced mathematics.
2. solve problems modeled by linear differential equations.
3. use power series methods to solve differential equations about ordinary points and regular singular points.
4. construct approximate solutions using method of successive approximation.
5. establish uniqueness of solutions.

Unit I : Linear differential equations with constant coefficients: The second order homogeneous equation, initial value problems for second order equations, linear dependence and independence, formula for the Wronskian, the non-homogeneous equations of order two. **15 Lectures**

Unit II: The homogeneous equations of order n, initial value problems for the nth order equations, the non-homogeneous equation of nth order. Linear equations with variable coefficients: Initial value problems for the homogeneous equations. Solutions of the homogeneous equations, the Wronskian and linear independence. **15 Lectures**

Unit III: Reduction of the order of a homogeneous equation, the non-homogenous equations, homogeneous equations with analytic coefficients, the Legendre equations. Linear equations with regular singular points: The Euler equations, second order equations with regular singular points. **15 Lectures**

Unit IV: The Bessel equation, regular singular points at infinity. Existence and uniqueness of solutions: The method of successive approximations, the Lipschitz condition, convergence of the successive approximation. **15 Lectures**

Seminars, Tutorials, Problem solving session and group discussions on above four units

Recommended books:

1. E. A. Coddington: An introduction to ordinary differential equations. (2012) Prentice Hall of India Pvt.Ltd. New Delhi.

Reference books:

1. G. Birkoff and G.G.Rota, Ordinary differential equations, John Willey and Sons.
2. G.F. Simmons, Differential Equations with Applications and Historical note, McGraw-Hill, Inc. New York. (1972).
3. E.A. Coddington and Levinson, Theory of ordinary differential equations, McGraw-Hill, New York(1955).
4. E.D. Rainvills, Elementary differential equations, The Macmillan company, New York, (1964).

M. Sc. Mathematics (Part I) (Level-6.0) (Semester I)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: Numerical Analysis - I

Subject Code: MJ-MMT23-104

Total Credits: 02

Course Outcomes: Upon successful completion of this course, the student will be able to:

1) apply the methods to solve linear and nonlinear equations.

2) find numerical integration and analyze error in computation.

3) solve differential equations using various numerical methods.

4) determine eigen values and eigen vectors of a square matrix.

5) construct LU decomposition of a square matrix.

Unit I: Transcendental & polynomial equations: Bisection method, Iteration methods based on First degree equation (Secant method, Regula-Falsi method and Newton-Raphson method). Rate of Convergence, Iterative methods (Birge-Vieta method and Bairstow method).

15 Lectures

Unit II: System of linear algebraic equations and eigen value problems: Matrix factorization methods (Doolittle's method, Crout's method), Iteration methods (Jacobi iteration method, Gauss-Seidel iteration method), convergence analysis of iterative methods, Eigen values and eigenvectors, Gerschgorin theorem, Brauer theorem, Jacobi method for symmetric matrices, Power method.

15 Lectures

Seminars, Tutorials, Problem solving session and group discussions on above four units

Recommended Books:

1. M. K. Jain, S. R. K. Iyengar, R. K. Jain, Numerical methods for scientific and Engineering Computation (Fifth Edition), New Age International Publishers 2007.

Reference Books:

1. S. S. Sastry, Introductory methods of Numerical Analysis (Fifth Edition), PHI learning Private Limited, New Delhi 2012.
2. D. Kincaid, W. Cheney, Numerical Analysis Mathematics of Scientific Computing (Third Edition), American Mathematical Society.
3. J.C. Butcher, Numerical methods for ordinary differential equations (Second Edition), John Wiley & Sons Ltd, 2008.
4. Kendall E. Atkinson, An Introduction to Numerical Analysis (Second Edition), John Wiley & Sons 1988.

M. Sc. Mathematics (Part I) (Level-6.0) (Semester I)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: Differential Geometry
Subject Code: GE-MMT23-105
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:
1. find the directional derivatives of the functions.
2. compare the unit-speed and arbitrary-speed curves.
3. apply the Frenet formulas to analyze the curves.
4. examine whether the given set in R3 is a surface.
5. construct the parametrizations of different surfaces.
6. formulate different types of curvatures of given surface.

Unit I: Euclidean space, tangent vectors, directional derivatives, curves in R3, and reparameterization of curves, standard curves, speed of curve, length of curve, mappings **15 Lectures**

Unit II: Mappings, the Frenet formulas, arbitrary-speed curves, covariant derivatives, isometries of R3, orthogonal transformations. **15 Lectures**

Unit III: Coordinate patches, surface in R3, simple surface, cylinder surface, surface of revolution, parametrization of a region, parametrization of cylinder and surface of revolution, smooth overlapping patches, tangent and normal vector fields on a surface. **15 Lectures**

Unit IV: The shape operator of surface M in R3, normal curvature, principal curvatures, Gaussian and mean curvatures, Umbilic points, fundamental forms of a surface, computational techniques. **15 Lectures**

Seminars, Tutorials, Problem solving session and group discussions on above units.

Recommended Books:
1. O'Neill, B., Elementary Differential geometry, Academic Press, Revised Edition 2006.
Reference Books:
1. D. Somasundaram, Differential Geometry- First Course, Narosa Publishing House, New Dehli, 2010.
2. Nirmala Prakash, Differential Geometry, Tata Mcgraw Hill, 1981.
3. K. S. Amur and et al., Differential Geometry, Narosa Publishing House, 2010.
4. Millman, R. and Parker, G. D. Elements of Differential Geometry, Prentice-Hall of India Pvt. Ltd. 1977.
5. Hicks, N. , Notes on Differential Geometry, Princeton University Press (1968)

M. Sc. Mathematics (Part I) (Level-6.0) (Semester I)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: Integral Transforms
Subject Code: GE-MMT23-106

Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:

1. describe the ideas of different types of integral transforms.
2. evaluate the integral transforms of various functions.
3. apply technique of Fourier and Laplace transforms to solve ordinary and partial differential equations.
4. analyze the properties of Fourier transforms and Laplace transforms
5. apply Z- transform to solve difference equations.

UNIT 1: The Laplace Transform, The Transforms of Some Typical Functions, Basic Operational Properties, The inverse Laplace Transform, Applications Involving Laplace Transforms, Evaluating Integrals, Solutions of ODEs, Solutions of PDEs.

15 Lectures

UNIT 2: Fourier Integrals and Fourier Transforms: Fourier Integral Representations, Proof of the Fourier Integral Theorem, Fourier Transform Pairs, Properties of the Fourier Transform, The Convolution Integrals of Fourier.

15 Lectures

UNIT 3: Applications Involving Fourier Transforms: Boundary Value Problems, Heat Conduction in Solids, Mechanical Vibrations, Mellin Transform: Evaluation of Mellin transforms, Complex variable method and Applications.

15 Lectures

UNIT 4: The Henkel Transforms: Evaluation of Henkel transforms, Applications of transform. Finite Transforms: Finite Fourier transform, Z- transform, Solutions of difference equations using Z Transform.

15 Lectures

Seminars, Tutorials, Problem solving session and group discussions on above four units

Recommended Book:

1. Larry Andrews, Bhimsen Shivamoggi, Integral Transforms for Engineers, Prentice Hall of India, New Delhi, 2005.

Reference Books:

1. Lokenath Debnath & Damba Bhatta, Integral Fransforms and their applicaton (2nd Ed), Chapman & Hall/CRC (2007).
2. I. N. Sneddon, Fourier Transforms, McGraw Hill, 1951.
3. Bracemell, Fourier Transforms and Its Applications, McGraw-Hill, 3rd Edition, 1999.

M. Sc. Mathematics (Part I) (Level-6.0) (Semester I)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: Basics of Python
Subject Code: MJ-MMT23-107
Total Credits: 04

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Learn Basic Syntax of Python Programming.
2. Understand and implement concepts of object oriented methodology using Python.
3. Demonstrate file handling techniques.
4. Understand how Python can be used for application development.
5. Design Real life problems and think creatively about solution of them

Unit I: Introduction to Python- an interpreted high level language, interactive mode and script mode.Variables, Expressions and Statements, Variables and Types-mutable and Immutable variable and Keywords. , Operators and Operands in Python. (Arithmetic, relational and logical operators), Operator precedence .Expressions and Statements (Assignment statement); Taking input (using raw_input () and input ()) and displaying output - print statement, Comments in Python. **Conditional and Looping Construct:** if - else statement and nested if – else while, for, use of range function in for, Nested loops, break, continue **15 Lectures**

Unit II: Functions : Built-In Function, invoking built in functions , Functions from math, random, time & date, User Define Function . Strings: Creating, initializing and accessing the elements;String operators: +, *, in, not in, range, slice [n: m], String built in functions & methods, Strings constants defined in string module **15 Lectures**

Unit III: Lists: Concept of mutable lists, creating, initializing and accessing the elements of list, List operations. **Tuples :** Immutable concept, creating, initializing and accessing the elements in a tuple; Tuple functions: cmp(), len(), max(), min(), tuple() .**Sets :**Concept of Sets , creating, initializing and accessing the elements of ,Sets operation(Membership, union, intersection, difference, and symmetric difference. **Dictionaries:** Concept of key-value pair, creating, initializing and accessing the elements in a dictionary, Traversing, Dictionary functions & Methods **15 Lectures**

Unit IV: Modules: Executing modules as scripts, The Module Search Path, “Compiled” Python filesStandard Modules , The dir( ) Function ,Packages Importing * From a Package. I/O and **File Handling:** Output Formatting, Reading and Writing Files (text and binary mode). Exceptions Handling.. **15 Lectures**

Recommended Books:

1. Learning Python By Mark Lutz, O’Reilly Publication
2. Programming with python, A users Book, Michael Dawson, Cengage Learning

Reference Books:

1. Practical Programming: An introduction to Computer Science Using Python, second edition, Paul Gries, Jennifer Campbell, Jason Montojo, The Pragmatic Bookshelf.
2. Python for Informatics: Exploring Information, Charles Severance
3. Introduction to Python for Computational Science & Engineering (A beginner's guide), Hans Fangohr

M. Sc. Mathematics (Part I) (Level-6.0) (Semester I)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: Research Methodology
Subject Code: RM-MMT23-108
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:
1. understand skill of mathematical writing
2. Understand wetting research paper
3. revise the drafts, check the proofs
4. understand the copy copyright issues
5. Type in mathematics using latex

Unit I: 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. **15 Lectures**

Unit II: Writing a Paper (Continued...): 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. **15 Lectures**

Unit III: 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 Defence.

15 Lectures

Unit IV: Quality indices of research publication: impact factor, H- index, science citation index., Using web for literature review: Google Scholar, Scopus, MathSciNet. Latex –Basic Typesetting of Mathematics, Typesetting Theorems. **15 Lectures**

Seminars, Tutorials, Problem solving session and group discussions on above four units

Recommended Book:

1. Higham Nicholas J., Handbook of writing for the mathematical sciences, SIAM, 1961.
1. LATEX Tutorials A Primer, Indian TEX Users Group, Trivandrum, India, 2003 September.https://www.tug.org/twg/mactex/tutorials/ltxprimer-1.0.pdf

References:

1. Stegmann J., How to evaluate journal impact factors, Nature, 390(6660), (1997), 550-550.
2. Kaltenborn K. F. and Kuhn K, The journal impact factor as a parameter for the evaluation of researchers andresearch, Revista Espanola de Enfermedades Digestivas, 96(7), (2004), 460-476.
3. Hirsch J. E., An index to quantify an individual's scientific research output, https://arxiv.org/abs/physics/0508025
4. Garfield E., The evolution of the Science Citation Index, International Microbiology, 10, (2007), 65-69. DOI: 10.2436/20.1501.01.10
5. A Primer of Mathematical Writing, Steven G. Krantz, Universities Press Hyderabad 1998.https://arxiv.org/pdf/1612.04888.pdf 6McGraw- Hill's Concise Guide to Writing Research Papers, Carol Ellison, McGraw-Hill, New York, 2010.

M. Sc. Mathematics (Part I) (Level-6.0) (Semester II)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: Complex Analysis
Subject Code: MJ-MMT23-201
Total Credits: 04

Course Outcomes: Upon successful completion of this course, the student will be able to:
i) enjoy the beauty of analytic functions and related concepts.
ii) analyze the mobius transformation.
ii) apply Cauchy's theorem and integral formula to evaluate complex variable integral.
iv) use residue theorems to evaluate real integrals.
v) use Rouche's theorem to locate roots of polynomial.

Unit I: Power series , Radius of convergence, Bilinear Transformation, Analytic functions , Cauchy's-Riemann equations, Harmonic functions, Power series representation of analytic functions.

(15 L)

Unit II: Zeros of Analytic functions, Cauchy's theorem, Moreras theorem, Cauchy's Integral formula, Cauchy's inequality' Liouville's Theorem, Fundamental theorem of algebra, Maximum modulus theorem, Open mapping theorem.

(15 L)

Unit III: Laurent series expansion theorem, Cauchy residue theorem, classification of singularities, Evaluation of integral, The argument principle, Rouche's theorem.

(15 L)

Unit IV: Conformal maps, Normal families, Hurwitz theorem, Riemann mapping theorem.

(15 L)

Recommended Reading :

1. J. B. Conway: Functions of One Complex Variable (3rd Edition) Narosa Publishing House.

Reference Books :

1.S.Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House.

2. Alfors L. V.: Complex Analysis, McGraw 1979.

3. Churchill and Brown, Complex Variables and applications, MacGraw Hill(India). (8^{th} Edition, 2014)

4. Serge Lang, Complex Analysis, Springer.

5. Steven G. Krantz, Complex Analysis, A Geometric view Point, The Carus Mathematical Monographs.

6. T. W. Gamelin, Complex Analysis, Springer.

M. Sc. Mathematics (Part I) (Level-6.0) (Semester II)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: Topology
Subject Code: MJ-MMT23-202
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:
1. built foundations for future study in analysis, in geometry, and in algebraic topology.
2. introduce the fundamental concepts in topological spaces.
3. acquire demonstrable knowledge of topological spaces, product spaces, and continuous functions on topological spaces.
4. identify compact and connected sets in topological spaces.
5. use Separation and countability axioms, Urysohn lemma, Urysohn metrization.

Unit I: Topological Spaces, Basis and Subbasis for a Topology, The Order Topology, The Product Topology on $X \times Y$, The Subspace Topology. **(15 Lectures)**

Unit II: Closed Sets , Closure and Interior of a Set, Limit Points, Hausdorff Spaces, Continuity of Functions, Homeomorphisms, The Product Topology, The Metric Topology. **(15 Lectures)**

Unit III: Connected Spaces, Connected Subspaces of the Real Line, Components and Local Connectedness, Compact Spaces, Compact Subspaces of the Real Line. **(15 Lectures)**

Unit IV: The Countability Axioms, The Separation Axioms, Normal Spaces, The Urysohn Lemma, The Urysohn Metrization Theorem (Only statement and its importance), The Tietze Extension Theorem (Only statement and its importance). **(15 Lectures)**

Seminars, Tutorials, Problem solving session and group discussions on above four units

Recommended Book:

1. J. R. Munkers, Topology, Second Edition, Pearson Education (Singapore), 2000.

Reference Books:

1. W. J. Pervin, Foundations of General Topology, Academic Press, New York, 1964.
2. J. L. Kelley, General Topology, Springer-Verlag, New York, 1955.
3. S. Willard, General Topology, Addison-Wesley Publishing Company, 1970.
4. K. D. Joshi, Introduction to General Topology, New Age International, 1983.
   G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Book Company, New Delhi, 1963.

M. Sc. Mathematics (Part I) (Level-6.0) (Semester II)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: Advanced Calculus
Subject Code: MJ-MMT23-203
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:
(i) analyze convergence of sequences and series, double sequences and double series
(ii) analyze convergence of sequences and series of functions
(iii) check differentiability of functions of several variables
(iv) apply inverse and implicit function theorems for functions of several variables

Unit I : Sequences and series of functions: Pointwise convergence of sequences of functions, Examples of sequences 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

15 Lectures

Unit II: Rearrangement of series, subseries, Double sequences, Double series, rearrangement of double series, sufficient condition for equality of iterated series, multiplication of series, Cesaro summability, sufficient conditions for uniform convergence of series, uniform convergence and double sequences, mean convergence, Taylor series generated by a function, Bernstein's theorem, binomial series.

15 Lectures

Unit III: Multivariable differential Calculus: The Directional derivatives, directional derivatives and continuity, total derivative, total derivatives expressed in terms of partial derivatives, The matrix of linear function, mean value theorem for differentiable functions, A sufficient condition for differentiability, sufficient condition for equality of mixed partial derivatives, Taylor's formula for functions from R^n to R^1

15 Lectures

Unit IV: Implicit functions: Functions of several variables, Linear transformations, Differentiation, Contraction principle, The inverse function theorem, The implicit function theorem and their applications.

15 Lectures

Seminars, Tutorials, Problem solving session and group discussions on above four units

Recommended books:

1. Mathematical Analysis, Apostal, Second Edition, Narosa Publishing House.1974

Reference books:

1. Principles of mathematical Analysis, Walter Rudin, third Edition, McGraw Hill book company
2. Calculus Vol. I , Vol II, Tom M. Apostol, Second EditionWiley India Pvt. Ltd.
3. W.Fleming, Functions of several Variables,2nd Edition ,Springer Verlag, 1977.

M. Sc. Mathematics (Part I) (Level-6.0) (Semester II)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: Numerical Analysis - II
Subject Code: MJ-MMT23-204
Total Credits: 02

Course Outcomes: Upon successful completion of this course, the student will be able to:

1) apply the methods to solve linear and nonlinear equations.
2) find numerical integration and analyze error in computation.
3) solve differential equations using various numerical methods.
4) determine eigen values and eigen vectors of a square matrix.
5) construct LU decomposition of a square matrix.

Unit I: Interpolation, differentiation and integration: Lagrange and Newton interpolations, Truncation error bounds, Newtons divided difference interpolation, finite difference operators, numerical differentiation, methods based on interpolation, numerical integration, methods based on interpolation, error analysis, Newton-Cotes methods, Error estimates for trapezoidal and Simpson's rule.

15 Lectures

Unit II: Numerical solution of differential equations: Euler method, analysis of Euler method, Backward Euler method, mid-point method, order of a method, Taylor series method, Explicit Runge-Kutta methods of order two and four, convergence and stability of numerical methods, Truncation error, error analysis.

15 Lectures

Seminars, Tutorials, Problem solving session and group discussions on above four units

Recommended Books:

1. M. K. Jain, S. R. K. Iyengar, R. K. Jain, Numerical methods for scientific and Engineering Computation (Fifth Edition), New Age International Publishers 2007.

Reference Books:

1. S. S. Sastry, Introductory methods of Numerical Analysis (Fifth Edition), PHI learning Private Limited, New Delhi 2012.
2. D. Kincaid, W. Cheney, Numerical Analysis Mathematics of Scientific Computing (Third Edition), American Mathematical Society.
3. J.C. Butcher, Numerical methods for ordinary differential equations (Second Edition), John Wiley & Sons Ltd, 2008.
4. Kendall E. Atkinson, An Introduction to Numerical Analysis (Second Edition), John Wiley & Sons 1988.

M. Sc. Mathematics (Part I) (Level-6.0) (Semester I)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: Combinatorics
Subject Code: GE-MMT23-205
Total Credits: 04

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. describe Pigeonhole principle and use it to solve problems.
2. use definitions and theorems from memory to construct solutions to problems
3. use Burnside Frobenius Theorem in counting's.
4. use various counting techniques to solve various problems.
5. apply combinatorial ideas to practical problems.
6. improve mathematical verbal communication skills.

Unit I: The sum rule and product rule, permutations and combinations, the Pigeonhole principle, Ramsay numbers, Catalan numbers, sterling numbers. **15 Lectures**

Unit II: Further basic tools, generalized permutations and combinations sequences and selections, the inclusion and exclusion principle, systems of distinct representatives, solved problems derangements and other constrain derangements. **15 Lectures**

Unit III: Combinatorial number theory, the permanent of a matrix, Rook polynomials and Hit polynomials, SDR and coverings, (Sperners theorem and Symmetric chain decomposition, posets and Dilworth's theorem) statements. **15 Lectures**

Unit IV: Generating functions and recurrence relations, ordinary and exponential generating functions, partitions of a positive integer, recurrence relations, algebraic solutions of linear recurrence relations with constant coefficients and solutions of recurrence relations using generating functions. **15 Lectures**

Seminars, Tutorials, Problem solving session and group discussions on above four units

Recommended Books:

1. V. K. Balkrishnan: Combiactorics, Shaums Outlines Series, Mc Grow Hill Inc.

Reference Books:

1. Richard Brualdi – Introductory Combinatosics North Holland.
2. V. Krishnamurthy: Combinatorics, E. W. Press
3. A. Tucker: Combinatorics, John Wiley & Sons, Inc
4. C. Vasudev, Theory and Problems of Combinatorics, New Age International.

M. Sc. Mathematics (Part I) (Level-6.0) (Semester II)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: Difference Equations
Subject Code: GE-MMT23-206
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:
1. understand difference calculus
2. to solve linear difference equations
3. use Z-transform to slove difference equations
4. investigate stability theory

Unit I: The Difference Operator, Shift operator, Falling factorial power, binomial coefficient, Summation, General properties of indefinite sums, Generating Functions and Approximate Summation, Bernoulli polynomials and numbers, Euler Summation formula, First order equations, General results for linear equations

15 Lectures

Unit II: Solving linear equations, Solving System of linear equations with constant coefficients, Method of Variation of parameters, Applications, Equations with variable coefficients, Nonlinear equations that can be linearized.

15 Lectures

Unit III: The Z-transform: Properties, initial and final value theorem, partial sum theorem, convolution theorem, Inverse Z-transforms, Solution of difference equation with constant coefficients by Z-transforms, Stability Theory: Initial Value Problems for linear systems, the Putzer algorithm, Stability of linear systems **15 Lectures**

Unit IV: Phase plane analysis for linear systems, Fundamental matrices and floquet theory, Discrete Floquet theorem, Floquet Multipliers, Stability theorem for Floquet systems stability of nonlinear system **15 Lectures**

Seminars, Tutorials, Problem solving session and group discussions on above four units

Recommended Book:

1. Walter Kelley and Allan Peterson, Difference Equations, An Introduction with Applications, Academic Press (1991)

Reference Books:

2. Calvin Ahlbrant and Allan Peterson, Discrete Hamiltonian Systems, Difference Equations, Continued Fractions and Riccati Equations, Kluwer (1996).
3. Saber Elaydi, An Introduction to Difference Equations, Springer (1999).

M. Sc. Mathematics (Part I) (Level-6.0) (Semester II)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: Algebraic Automata Theory
Subject Code: GE-MMT23-207
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:

1. understand semigroup relation.
2. explain Mealy machine.
3. derive orthogonal partitions.
4. describe admissible subset system decomposition.

Unit I: Semigroup Relation, semigroup, group, permutation group, products and homomorphisms. **15 Lectures**

Unit II: Machine and semigroup: State machines, their semigroups, homomorphisms, quotients, Coverings, Mealy machine. **15 Lectures**

Unit III: Decompositions: Orthogonal Partitions, admissible partitions, permutation reset machines, group machines . **15 Lectures**

Unit IV: Connected transformation semigroups, automorphism decompositions, Admissible subset system decomposition. **15 Lectures**

Seminars, Tutorials, Problem solving session and group discussions on above four units

Recommended Book:

1. Holcombe M. L.: Algebraic Automata Theory, Cambridge University Press.

Reference Books:

1. Arbib M. A.: Theory of abstract automata, PrenticeHall
2. Eilenberg, S.: Automata, Languages and machine
3. Ginburg A.: Algebraic theory of automata, Academic press.

M. Sc. Mathematics (Part I) (Level-6.0) (Semester II)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Title of Course: On job Training / Field project
Total Credits: 04

Nature of the Theory Question Papers

(I) Nature of the Theory Question Papers for courses of 4 credits:

1. There shall be 7questions each carrying16 marks
2. Question No.1 is compulsory. It consists of objective type questions.
3. Students have to attempt any four questions from Question No.2 to Question No.7.
4. QuestionNo.2 to Question No.7 shall consist of short/descriptive-answer type sub-questions.
5. Duration of university theory examination of 80 marks shall be of 3 hours.

(II) Nature of the Theory Question Papers for courses of 2 credits:

1. There shall be 4 questions.
2. Question No.1 is compulsory of objective type questions carrying 8 marks.
3. Students have to attempt any two questions from Question No.2 to Question No.4. Each question carries 16 marks.
4. Duration of university theory examination of 40 marks shall be of 2 hours.

(III) Assessment criteria of OJT/FP shall be based on final report, presentation and oral examination.

(IV) Assessment criteria of Research project of 4 credits shall be based on final report / dissertation, presentation and oral examination.

(V) Assessment criteria of Research project of 6 credits shall be based on dissertation, presentation and oral examination.