PUNYASHLOK AHILYADEVI HOLKAR SOLAPUR UNIVERSITY, SOLAPUR

पुण्यश्लोक अहिल्यादेवी होळकर
सोलापूर विद्यापीठ
।। विद्यया संपन्नता ।।
NAAC Accredited-2022
'B++' Grade (CGPA-2.96)

SYLLABUS

FOR

M.Sc. (Part-I) MATHEMATICS
(Semester I and II)

As per NEP - 2020

WITH EFFECT FROM ACADEMIC YEAR 2026-27

(JUNE-2026).

PUNYASHLOK AHILYADEVI HOLKAR SOLAPUR UNIVERSITY, SOLAPUR

SCHOOL OF COMPUTATIONAL SCIENCES

DEPARTMENT OF MATHEMATICS

Preamble:

M.Sc Mathematics is a two-year postgraduate course that deals with deeper knowledge of Pure and Applied Mathematics. This programme is of 88 credits spreads over four semesters. The program has some unique features such as independent projects, a large number of elective courses, extensive computer training including standard software packages such as LaTeX, SciLab software. This programme provides training in different aspects of Pure Mathematics, equipping with a range of mathematical skills in problem-solving, project work and presentation.

Programme Outcomes:

1. Inculcate critical thinking to carry out scientific investigation objectively without being biased with preconceived notions.
2. Gain the knowledge of software which will be useful in Industry.
3. Communicate Mathematics accurately and effectively in both written and oral form.
4. Prepare students for pursuing research or careers in industry in mathematical sciences and allied fields.
5. Develop abilities for logical thinking and problem solving.
6. Pursue research in reputed institutions and solve the existing mathematical problems using the knowledge of pure and applied mathematics.

Programme Specific Outcomes:

1. Understanding about the fundamental axioms in Mathematics and capability of developing ideas based on them.
2. To imbibe problem-solving and computational skills.
3. To inculcate abstract mathematical thinking.
4. Interpret the knowledge acquired for propagation and popularization of Mathematics in society.
5. Manage software tools as Latex, SCILAB which keep in pace with the technological advancements.
6. Motivation for research studies in Mathematics and related fields with real life applications.
7. Nurturing problem solving skills, thinking, creativity through assignments, project work.
8. Preparing for competitive examinations, like NET, SET, GATE, etc.

Revised Syllabi of M.Sc. I in Mathematics (NEP-2020)

1) **Title of the course:** M.Sc. in Mathematics
2) **Pattern:** Semester and Credit system.
3) **Duration of Course**: 2 years
4) **Strength of the Students:** 40
5) **Eligibility:** For M. Sc. in Mathematics following candidates are eligible.
   (i) B.Sc. with Mathematics as principal level.
   (ii) B.Sc. with any subject as principal and Mathematics at subsidiary level.

M. Sc. program in Mathematics consists of 88 credits. Credits of a course are specified against the title of the course.

M.Sc. I Mathematics Course

Sem	Course Type	Course code	No. of Credits	Course Title
I	Major Mandatory	DSC -1	4	Group and Ring Theory
		DSC- 2	4	Real Analysis
		Lab-1	2	Mathematics Practical -1
		Lab-2	2	Mathematics Practical -2
	Major Elective	DSE- 1 (Any one)	4	(A)Number Theory
				(B)Advanced Calculus
				(C)Introduction to Probability Theory
				(D)NPTEL/SWAYAM MOOC's
		Lab-3	2	Mathematics Practical -3
	Research Methodology	RM	4	Research Methodology
II	Major Mandatory	DSC -3	4	Field Extension Theory
		DSC- 4	4	General Topology
		Lab-4	2	Mathematics Practical-4
		Lab-5	2	Mathematics Practical -5
	Major Elective	DSE- 2 (Any one)	4	(A)Complex Analysis
				(B)Classical Mechanics
				(C)Fuzzy Mathematics
				(D)NPTEL/SWAYAM MOOC's
		Lab-6	2	Mathematics Practical -6
	OJT/FP	OJT/FP	4	OJT/In-house project/ Internship/ Apprenticeship

M.Sc. Mathematics (NEP-2020)
Course Structure M.Sc. Part-I (Mathematics) w.e.f. June 2023

	M.Sc. MATHEMATICS SEMESTER-I											
Paper Code	**Title of the Paper**	**Credits**	**Contact hours/week**			**Distribution of Marks for Examination**					
			Th (L)	**Pr**	**Total**	**Internal**		**External**		**Total**	
						Th	**Pr**	**Th**	**Pr**	**Th**	**Pr**
DSC-1	Group and Ring Theory	4	4	--	4	40	--	60	--	100	--
DSC-2	Real Analysis	4	4	--	4	40	--	60	--	100	--
DSE-1	(A)Number Theory (B)Advanced Calculus (C)Introduction to Probability (D)NPTEL/SWAYAM MOOC's	4	4	--	4	40	--	60	--	100	--
Lab-1	Mathematics Practical -1 (Ordinary Differential Equations-I)	2	--	4	4	--	20	--	30	--	50
Lab-2	Mathematics Practical –2 (Ordinary Differential Equations-II)	2	--	4	4	--	20	--	30	--	50
Lab-3	Mathematics Practical –3 (Basic Latex)	2	--	4	4	--	20	--	30	--	50
RM	Research Methodology in Mathematics	4	4	--	4	40	--	60	--	100	--
Total for Semester-I		**22**	**16**	**12**	**28**	**160**	**30**	**240**	**90**	**400**	**150**
	M.Sc. MATHEMATICS SEMESTER-II										
Paper Code	**Title of the Paper**	**Credits**	**Contact hours/week**			**Distribution of Marks for Examination**					
			Th (L)	**Pr**	**Total**	**Internal**		**External**		**Total**	
						Th	**Pr**	**Th**	**Pr**	**Th**	**Pr**
DSC-3	Field Extension Theory	4	4	--	4	40	--	60	--	100	--
DSC-4	General Topology	4	4	--	4	40	--	60	--	100	--
DSE-2	(A)Complex Analysis (B)Classical Mechanics (C)Fuzzy Mathematics (D)NPTEL/SWAYAM MOOC's	4	4	--	4	40	--	60	--	100	--
Lab-4	Mathematics Practical-4 (Measure Theory-I)	2	--	4	4	--	20	--	30	--	50
Lab-5	Mathematics Practical -5 (Measure Theory-II)	2	--	4	4	--	20	--	30	--	50
Lab-6	Mathematics Practical -6 (Advanced Latex)	2	--	4	4	--	20	--	30	--	50
OJT/FP	OJT/In-house project/ Internship/ Apprenticeship	4	--	8	8	--	40	--	60	--	100
Total for Semester-II		**22**	**12**	**20**	**32**	**120**	**100**	**180**	**150**	**300**	**250**

Evaluation Scheme:

Each theory paper will have 100 marks out of which 60 marks will be for Term End examination and 40 marks for Internal Assessment. The candidate has to appear for internal evaluation of 40 marks and external evaluation (University Examination) of 60 marks for each theory paper.

Each practical paper will have 50 marks out of which 30 marks will be for Term End examination and 20 marks for Internal Assessment. The candidate has to appear for internal evaluation of 20 marks and external evaluation (University Examination) of 30 marks for each practical paper.

Internal Evaluation:

- In case of theory papers internal examinations will be conducted by department / school.
- In case of practical papers 20 marks shall be for internal test, which will be conducted by the Department / school.

External Evaluation (End of Term University Examination):

I) Nature of Theory question paper:

1) Each Theory paper is of 60 marks.

2) Each Theory paper will be of 2.30 hours duration

) There shall be 05 questions each carrying 12 marks.

4) Q.No.1 contains 12 objective type sub-questions each carrying 1 mark.

5) Q.No.2 shall contains 08 short answer type sub-questions each carrying 02 marks, students have to attempt any six questions.

6) Q.No. 3 shall contains 04 short answer type sub-questions each carrying 04 marks, students have to attempt any three questions.

7) Q.No.4 and Q.No. 5 contains 03 long answer type sub-questions each carrying 06 marks , students have to attempt any two questions

II) Nature of Practical question paper: (End of Term Examination)

For Sem-I and II: Practical examination will be conducted for 30 marks and is of two hours duration. There shall be 03 questions each of 10 marks, of which student has to attempt any 02 questions. VIVA will be for 5 marks and 5 marks shall be for day-to-day journal.

Paper Name: Group and Ring Theory	**Course Code: 2317101**
Paper Code: DSC-1	**Credits: 04**

Course objectives: This course is aimed to provide an introduction to the concept of Normal, Subnormal and composition series. Also to study and understand topics like P-subgroups, class equation and polynomial rings.

Course outcomes:

After completing this course, the student will be able to:

1. Explain the concept of solvable groups and nilpotent groups. Jordan Holder theorem.
2. Understand the concept of G-sets, Conjugate class and class equation. Construct the proofs of Sylow theorem's, apply Sylow theorems to solve problems.
3. Grasp the concept of UFD, PID, ED.
4. Study irreducible polynomial, The Eisenstein Criteria, UFD in polynomial rings in detail .

Curriculum Details:

Unit I: Groups (15 L)

Normal and subnormal series, Jordan -Holder Theorem, Composition series, Commutator subgroups, Solvable groups, Nilpotent groups.

Unit II: Sylow theorem (15 L)

Zassenhaus lemma, G- sets, Conjugate classes, P- Subgroups, Sylow theorems, class equation.

Unit III: Ring (15 L)

UFD, PID, Euclidean domain, arithmetic in Euclidean domains

Unit IV: Ring of Polynomial (15 L)

Polynomial ring over the rational field, Division algorithm, irreducible polynomials, The Eisenstein criteria, ideal structure in F[X], Uniqueness of factorization in F[x], UFD in Polynomial rings, Modules, Sub modules.

Recommended Books:

1.J. B. Fraleigh, Basic Algebra, Narosa pub.

Reference Books :-

1. I. N. Herstein . Topics in Algebra. Wiley Eastern Ltd. New Delhi 1975.
2. Joseph A. Gallian, Contemporary Abstract Algebra, Narosa Pub.
3. P.B.Bhattacharya, S.K.Jain and S.R. Nagpaul. Basic Abstract Algebra (2nd Edition) Cambridge University, Press Indian Edition 1997.
4. M. Artin Algebra, Prentice-Hall of India 1991
5. N.Jacobson, Basic Algebra Vols I and II Freeman 1988.
6. S.Lang Algebra 3rd edition. Addison-Westely 1993
7. O.S. Luther and I.B.S. Passi, Algebra Vol. I-Groups. Vol. II-Rings, Narosa Publishing House
8. . D.S.Malik & N.Mordeson and M.K.Sen Fundamentals of Abstract Algebra, Mc. Graw Hill International Edition, 1997.

Paper Name: Real Analysis	**Course code : 2317102**
Paper Code: DSC-2	**Credits: 04**

Course objectives: The mission of this course is to introduce students the concepts of Riemann Integration, Riemann Stieltijies integral. Develop their skills in problem solving. Understand concept of Implicit functions and Extremum problems.

Course outcomes:

After completing this course, the student will be able to:

1. Understand the concept of Refinement of partitions, Darboux's theorem, Integrable function and fundamental theorem of calculus.
2. Acquire knowledge of Mean value theorem, existence of the integral, condition of inerrability.
3. Learn directional derivative, total derivative, partial derivatives, Jacobian matrix with examples.
4. Study Inverse functions theorem and the Implicit function theorem.

Curriculum Details:

Unit I: Riemann Integration: (15 L)

Definition and existence of the integral, Refinement of partitions, Darboux's theorem, Conditions of integrability, Integrability of the Sum and difference of integrable functions, The integral as a limit of sums, Some integrable functions, Integration and differentiation. The fundamental theorem of Calculus, Mean Value theorem of integral Calculus, Second Mean Value theorem.

Unit II: Riemann – Stieltijes integral: (15 L)

The fundamental theorem of Calculus, Mean Value theorem of integral Calculus, Second Mean Value theorem. Definition and existence of the integral, a condition of integrability

Unit III: Multivariable differential calculus: (15 L)

Introduction, the directional derivative, Directional derivatives and continuity, total derivative, the total derivative expressed in terms of partial derivatives, the Jacobian matrix, the chain rule, the mean value theorem, for differentiable functions, Taylors formula for functions from R^n to R^1

Unit IV : Implicit functions and Extremum problems. (15 L)

Functions with nonzero Jacobian determinant, the inverse function theorem, The Implicit function theorem, Extrema of real valued functions of one variable.

Recommended Books :-

1. Mathematical Analysis, 2nd ed., S. C. Malik and Savita Arora, New Age international ltd.
2. Apostol T. M. Mathematical Analysis , (2nd edition) 12.1 – 12.5 , 12.8, 12.9, 12.11, 12.12, 12.14, 13.1, to 13.5 Narosa Pub.

Reference Books :-

1. Burkill and Burkill A second course Mathematical Analysis, Cambridge University Press (1970)
2. Walter Rudin,Principles of Mathematical Analysis(3rd Ed)MC Graw Hill
3. A Basic Course in Real Analysis , Ajit Kumar & S.Kumaresan, CRC press
4. Introduction to Real Analysis.Robert G.Bartle,Donald R,Sherbert, Wiley India Pvt ltd.
5. R. R. Goldberg, Methods of Real Analysis

Paper Name: Number Theory	**Course code : 2317107**
Paper Code: DSE -1(A)	**Credits: 04**

Course objectives:
Introduce students with the basic concepts of number theory like divisibility, congruences, Diophantine equations, number theoretic functions, quadratic residues etc, develop their skills in problem solving , Prepare students for advanced topics in number theory, make students understand the art of proving theorems.

Course outcomes: After completing this course, the student will be able to:
1. Tackle Division Algorithm ,
2. Handle Theory of Congruences.
3. Understand Mobius inversion formula, Euler's theorem.
4. Understand Legendre symbol and can solve problems.

Curriculum Details:

Unit I :

Review of divisibility, the division algorithm, Greatest common divisor, Euclidean algorithm, Diophantine equation ax + by = C, Primes and their distribution, Fundamental Theorem of Arithmetic, the Goldback Conjecture. (15 L)

Unit II:

Congruences, Properties of Congruences, Linear congruences, Special divisibility tests, Fermat's theorem, Fermat's factorization method, Little theorem, Wilsons theorem. (15 L)

Unit III:

Number theoretic functions, the functions τ andσ, The Mobius Inversion formula, the greatest integer function, Eulers Generalization of Fermats theorem, Euler's phi function, Euler's theorem, properties of phi function. (15 L)

Unit IV:

Primitive roots, order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, the theory of Indices. (15 L)

Recommended book:

1. D.M. Burton : Elementary Number Theory, Universal book stall, New Delhi.

Reference Books :

1. S.B.Malik : Basic Number theory Vikas publishing House.
2. George E.Andrews : Number theory, Hindusthan Pub. Corp.(1972)
3. Nisen Zuckerman : An Introduction to theory of numbers.
4. Hari Kishan : Number Theory , Pragati edition.
5. Pundir : Number Theory, Pragati edition.

Paper Name: Advanced Calculus	**Course code : 2317108**
Paper Code: DSE -1(B)	**Credits: 04**

Course objectives: To introduce basic notions of Real Analysis such as limit of function, sequence of functions, infinite series etc so that strong foundation of subsequent analysis can be developed.

Course Outcomes:

1. Understand limit of function alongwith some important theorems.
2. Study Sequence of functions with detail knowledge of point wise convergence, uniform convergence.
3. Study some tests of convergence.
4. Acquire knowledge of Cauchy criterion.

Curriculum Details:

Unit I:

Limit of functions, limit theorems, Continuous functions, Combinations of Continuous functions, Continuous functions on intervals, Uniform Continuity, Monotone and Inverse functions. (15 L)

Unit II:

Sequence of functions: Point wise convergence, uniform convergence, Cauchy criterion for uniform convergence, consequence of uniform convergence, Interchange of limits.

(15 L)

Unit III:

Infinite Series, Absolute convergence, grouping of series, rearrangement of series, Tests for absolute convergence: limit comparison test II, Root Test, Ratio test, Integral test, Raabe's test. (15 L)

Unit IV:

Test for non-absolute convergence: alternating series test, Dirichlet Test, Abel's test, series of functions, tests for uniform convergence, Cauchy criterion, Weierstrass M-Test.

(15 L)

Recommended Books:

1. Introduction to Real Analysis, R.G.Bartle and Donald R. Sherbert, WlLEY India edition, Fourth edition.

Reference Books:

1. Burkill and Burkill A second course Mathematical Analysis, Cambridge University Press
2. Walter Rudin,Principles of Mathematical Analysis(3rd Ed)MC Graw Hill
3. A Basic Course in Real Analysis , Ajit Kumar & S.Kumaresan, CRC press
4. Methods of Real Analysis, Richard R. Goldberg, Oxford & IBH Publication
5. Mathematical Analysis, 2nd ed., S. C. Malik and Savita Arora, New Age international ltd.

Paper Name: Introduction to Probability Theory	**Course code : 2317109**
Paper Code: DSE -1(C)	**Credits: 04**

Course Objective: To study basic knowledge about Probability Theory such as Axioms of Probability, Conditional probability, Random Variables, Distribution functions, types of random variables with examples and their properties, inequalities, modes of convergences, Law of Large Numbers.

Course Outcomes:

1. Solve the problems using Baye's formula and identify independent events.
2. Able to identify the correct distribution to the real life problem .
3. Explain joint distributions and derive the marginal distributions. Find the expectation, variance, MGF of random variables.
4. Apply inequalities and law of large numbers to solve real life problems.

Curriculum Details:

Unit I :

Sets and classes, limit of a sequence of sets, Sample Space and Events, Axioms of Probability, Sample Spaces having Equally Likely Outcomes, Conditional Probabilities, Bayes Formula and Independent Events. (15 L)

Unit II :

Random Variables, Distribution Functions, Discrete Random Variables, Expected Value, Moment Generating Functions, Expectation of a Function of a Random Variable, Variance, Discrete distributions: uniform, binomial, geometric, negative binomial, hyper geometric, Poisson, Continuous distributions, uniform, exponential, gamma, beta, normal : Probability density function (pdf) and expectations. (15 L)

Unit III:

Joint Distribution Functions, Independent Random Variables, Sums of Independent Random Variables, Conditional Distributions: Discrete Case and Continuous Case, Joint Probability Distribution of Functions of Random Variables, Expectation of Sums of Random Variables, Covariance, Variance of Sums, and Correlations, Conditional Expectation, Joint Moment Generating Functions. (15 L)

Unit IV:

Problems on Chebyshev's and other inequalities, Modes of Convergence of random variables, Weak Law of Large Numbers, Strong Law of Large Numbers, Central Limit Theorem.

(15 L)

Recommended Books:

1. Sheldon Ross, A First Course in Probability, PRENTICE HALL India.

2. Vijay k. Rohatgi, a. K. Md. Ehsanes saleh, An Introduction to Probability and Statistics, second edition, Wiley series.

Reference Books:

1. Murray R. Speigel, Schaum's Outline of Probability and Statistics.

2. J.S. Milton & J.C. Arnold, Introduction to Probability and Statistics.

3. H.J. Larson , Introduction to Probability Theory and Statistical Inference.

4. S.M. Ross , Introduction to Probability and Statistics for Engineers and Scientists.

5. P. Halmos , Measure Theory (for algebra of sets)

Paper Code: DSE-1(D)	**Course Code : 2317110**
	Credits: 04

- **Any NPTEL/ SWAYAM MOOCs Course (Selected SWAYAM course should be on PG syllabus with prior approval from department/school)**

Paper Name: Mathematics Practical-1 Ordinary Differential Equations-I	**Course code : 2317104**
Paper Code: Lab-1	**Credits: 02**

Course Objectives:

This course aims to introduce the Linear Differential Equations with constant co-efficients and variable co-efficients and to learn various methods to solve them.

Course Outcomes:

1. Capable with various methods of finding solutions of ordinary differential equations.
2. Identify and solve homogeneous and non-homogeneous differential equations with constant coefficients and variable coefficients.

Curriculum Details:

Unit I: Linear Equations with constant coefficients:

The second order homogeneous equation, initial value problems for second order equations, Linear dependence and independence. A formula for the Wronskian, the non-homogeneous equations of order two, the homogeneous equations of order n, initial value problems for the nth order equations, Equations with real constants, The non-homogeneous equation of order n

Unit II: Linear Equations with variable coefficients:

Initial value problems for the homogeneous equations, solutions of the homogeneous equations, The Wronskian and linear independence, reduction of the order of a homogeneous equation, Homogeneous equations with analytic coefficients.

Practical Assignments 1 to 5 on Unit I and Practical Assignments 6 to 10 on Unit II.

Recommended Books :

1. An introduction to ordinary differential equations. by E.A. Coddington (1974) Prentice Hall of India Pvt.Ltd. New Delhi.

Reference Books :

1. Theory of ordinary differential equations by E.A. Coddington and Levinson (1955) Mc Graw Hill, New York

2. Elementary differential equations by E.D. Rainvills (1964) The Macmillan company, New York.

3. Ordinary Differential equations by G. Birkoff and G.G.Rota John Willey and Sons.

4. Differential Equations with Applications and Historical note by G.F. Simmons (1972) MacGraw Hill, Inc. New York.

5. Ordinary Differential Equations by Somasundaram, Narosa pub.

Paper Name: Mathematics Practical-2 Ordinary Differential Equations-II	**Course code : 2317105**
Paper Code: Lab-2	**Credits: 02**

Course Objectives:

This course aims to study qualitative properties such as existence and uniqueness of solutions of linear differential equations.

Course Outcomes:

1. Use power series methods to solve differential equations about ordinary points and regular singular points.
2. Study the existence and uniqueness of solutions and construct approximate solutions using method of successive approximation.

Curriculum Details:

Unit I: Linear Equations with regular singular points:

The Euler equation, second order equations with regular singular points, second order equations with regular singular points –general case, the Bessel's equation.

Unit II: Existence and uniqueness of solutions:

The method of successive approximations, The Lipschitz condition.

Practical Assignments 1 to 5 on Unit I and Practical Assignments 6 to 10 on Unit II.

Recommended Books :

1. An introduction to ordinary differential equations by E.A. Coddington (1974) Prentice Hall of India Pvt.Ltd. New Delhi.

Reference Books :

1. Theory of ordinary differential equations by E.A. Coddington and Levinson (1955) Mc Graw Hill, New York

2. Elementary differential equations by E.D. Rainvills (1964) The Macmillan company, New York.

3. Ordinary Differential equations by G. Birkoff and G.G.Rota John Willey and Sons.

4. Differential Equations with Applications and Historical note by G.F. Simmons (1972) MacGraw Hill, Inc. New York.

5. Ordinary Differential Equations by Somasundaram, Narosa pub.

Paper Name: Mathematics Practical-3 Basic LaTeX	Course code : 2317106
Paper Code: Lab-3	Credits: 02

Course Objectives:

The main motive is to impart the knowledge and understanding about LaTeX system, explain the procedure of LaTeX typesetting and familiarize the participants with various document formats of LaTeX and enable them to prepare research articles, thesis, books, and presentations with confidence.

Course Outcomes:

1. Understand typesetting of complex mathematical formulae using LaTeX.
2. Use tabular and array environments within LaTeX also use various methods to either create or import graphics into a LaTeX document

Curriculum Details:

Unit I: Introduction to LaTeX, Installation of LaTeX, Layout Design, LaTeX input files, Understanding Latex compilation Basic Syntax, Input file structure, document classes, packages (Geometry, Hyperref, amsmath, amssymb, algorithms, algorithmic graphic, color), page styles.

Unit II: Typesetting Mathematical formulae: fractions, Integrals, sums, products, Fancy Header, tables, Page Layout – Titles, Abstract Chapters, Sections, References, Equation references, citation, Writing equations, Matrix, Tables, arrays, Inline math formulas and displayed equations, Math symbols and fonts, Delimiters, matrices, arrays, Typesetting Producing Mathematical Graphics. Table of contents, index, hypertext, pdf pages, geometry, fancy header and footer, Verbatim, itemize and enumerate, boxes, equation number. Creating Tables, Inserting figures, enumeration list, itemized list, font effects, and inserting equations.

Practical Assignments 1 to 5 on Unit I and Practical Assignments 6 to 10 on Unit II.

Reference Books:

1. LATEX Tutorials A Primer, Indian TEX Users Group, Trivandrum, India, 2003 September.
2. Learning LATEX by Doing, Andre Heck, 2002. 3
3. The Latex companion, M. Carter, B.vanBrunt, second edition, Addison wisely, Pearson Education

Paper Name: Research Methodology in Mathematics	**Course code : 2317103**
Paper Code: RM	**Credits: 04**

Course Objectives:
The main objective of this course is to introduce the basic concepts in research methodology.. Also it provide the students with an introduction to research methods, report writing, manuscript writing, thesis etc.

Course Outcomes:

1. Develop knowledge about the importance of research methodology in research.
2. Ability to write Mathematics article/research paper in a right way.
3. Understand the terms such as i-10 index, h-index, impact factor, science citation index, UGC CARE and scopus indexed journals etc.
4. Acquire the knowledge to type research article in Mathematics using LATEX.

Curriculum Details:

Unit I:

Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India (15 L)

Unit II:

What is a Research Problem? , Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration ,Conclusion .

(10L)

Unit III:

Meaning of Research Design, Need for Research Design , Research Methodology, Features of a Good Design , Important Concepts Relating to Research Design ,Different Research Designs, Basic Principles of Experimental Designs. (20 L)

Unit IV:

Quality indices of research publication: citations, i10 index, impact factor, H- index, science citation index, Using web for literature review: Google Scholar, Scopus, Math Sci Net., Research Journals indexed in UGC CARE, Scopus, SCI etc. (15 L)

Recommended Books

1. Research Methodology, Methods and Techniques by C.R.Kothari, New Age International publisher (Second revised edition)

Reference Books:

1. Stegmann J., How to evaluate journal impact factors, Nature, 390(6660), (1997), 550-555.
2. 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.
3. Garfield E., The evolution of the Science Citation Index, International Microbiology, 10, (2007), 65-69. DOI: 10.2436/20.1501.01.10

M.Sc. I Mathematics SEM II

Paper Name: Field Extension Theory	**Course code : 2317201**
Paper Code: DSC-3	**Credits: 04**

Course Objectives:

The main objective of this course is to introduce Field extension, Group of Automorphism and finite fields.

Course Outcomes:

1. Introduction of the concept of Field extension and its various types.
2. Understand the Galois theory and solve examples of finding Galois group of given polynomial.
3. Establish the connection between the concept of field extensions and Galois Theory.
4. Understand the constructible numbers and solvability by radical.

Curriculum Details:

Unit –I

Introduction to Extension fields, field adjunctions, Algebraic and Transcendental elements, Simple extensions, Finite extensions, Algebraic extensions, Roots of Polynomials, Multiple roots. (15L)

Unit II

Splitting field, Uniqueness of Splitting field, Separable elements, Separable extensions, Perfect field, the elements of Galois theory, Automorphism of Fields, Fixed fields. (15L)

Unit III

Group of Automorphisms of a field K relative to subfield F of K, Normal extension, Galois group, Fundamental theorem of Galois theory. (15L)

Unit IV

Finite fields and its applications, Constructible real numbers, Solvability by radicals. (15 L)

Recommended Books :

1.Herstein I.N. : Topics in Algebra, Wiley Eastern Ltd.,Second ed. 1993.

2.J.B. Fraleigh : A first course in Abstract Algebra, Narosa Pub.Co.

References :

1. P.B.Bhattacharya, S.K.Jain and S.R. Nagpaul. Basic Abstract Algebra (2nd Edition) Cambridge University, Press Indian Edition 1997.

2. M.Artin Algebra, Prentice-Hall of India 1991

3. N.Jacobson, Basic Algebra Vols I and II Freeman 1988 (Kalse Published by Firncustan Publishing Compay.)

4. S.Lang Algebra 3rd edition. Addison-Westely 1993

5. O.S. Luther and I.B.S. Passi, Algebra Vol. I-Groups. Vol. II-Rings, Narosa Publishing House (Vol 1-1996 Vol. II 1- 1999)

6. D.S.Malik & N.Mordeson and M.K.Sen, Fundametnals of Abstract Algebra, Mc. Graw Hill International Edition, 1997

7.Joseph Galian , Contemporary Abstract Algebra.

Paper Name: General Topology	**Course code : 2317202**
Paper Code: DSC-4	**Credits: 04**

Course objectives:

The goal of the course is to provide in depth knowledge of this fundamental core course in mathematics to show various techniques from analysis, set theory, logic that are used in topological spaces.

Course outcomes:

After completing this course, the student will be able to:

1. Explain the concepts of topological spaces ,closed sets, dense sets , Neighbourhood, Interior, Exterior, Boundary, derived sets with examples.
2. Acquire knowledge of Continuous function, homeomorphism, compact and connected sets.
3. Study Separation axioms, To,T1, T2,T3,T4 spaces Their characterization and basic properties.
4. Study First and second countable spaces, Lindeloff spaces, separable spaces, second countability and sepearablity.

Curriculum Details:

Unit –I: (15L)

Definition and examples of topological spaces, closed sets, closure, dense sets, Neighborhood, Interior, Exterior, Boundary, accumulation points, and derived sets, Bases, sub-bases, Relative topology.

Unit –II: (15 L)

Continuous functions and homeomorphism, Compact sets and connected sets,

Unit –III: (15L)

Separation Axioms: To, T1, T2, T3, T 3½, T4 - Their characterizations and basic properties.

Unit IV: (15 L)

First and Second countable spaces, Lindeloff spaces, separable spaces, second countability and seperablility.

Recommended Books :-

1. Perwin W.J.: Foundations of General Topolgoy, Academic Press (1964)

Reference Books :

1. Munkres J. R. :- Topology – A first course, prentice Hall of India (200)

2. Joshi K. D. : Introduction to General Topology – Wiley Eastern (1983)

3. Willard S : General Topology, Adisson Weseley (1970)

Paper Name: Complex Analysis	**Course code : 2317207**
Paper Code: DSE-2(A)	**Credits: 04**

Course objectives:

This course is aimed to provide an introduction to the theories for functions of a complex Variable, Some of the objectives of the course is to study and understand the topics like Open mapping theorem, Cauchy Integral Formula and its applications, Poles and residues, Mobius Transformation.

Course outcomes:

After successful completion of this course, the student will be able to:

1. Compute the region of convergence for power series.
2. Understand Mobius Transformation and mappings of regions under some special transformations.
3. Evaluate complex integration along the curve via Cauchy's theorem and integral formula.
4. Prove the Cauchy residue theorem and apply it to several kinds of real integrals and Compute the Taylor series and Laurent series expansions of complex functions and apply it to for checking the nature of singularities and calculating residues.

Curriculum Details:

Unit I: (15 L)

Power Series, Analytic functions, Power series representation of analytic functions, Mobius transformations, Cross Ratio, Zeros of analytic function, Liouville's theorem.

Unit II: (15 L)

Fundamental theorem of algebra, Index of a closed curve, Cauchy's integral formula, Cauchy's theorem, Morera's theorem, counting zeros of analytic functions, open mapping theorem, Goursat's theorem.

Unit III: (15 L)

Isolated singularities, characterization of isolated singularities, Laurent series expansion, Residue theorem, Evaluation of definite integrals, Argument principle, Rouche's theorem.

Unit IV: (15 L)

Maximum Modulus theorems, Schwarz's lemma, Hurwitz's theorem, Montel theorem, Riemann mapping theorem.

Recommended Books :

1. J.B. Conway -Functions of complex variable (second edition) Narosa (1980)

Reference Books :

1. L.V. Ahliors : Complex Analysis, McGraw Hall (1979)
2. H.Silverman : Complex Variables, Hanton Mifflin (1975)
3. N.Levinson and R M.Redheffer : Complex Variables, Tata McGraw Hill (1980)
4. Remmert : Complex Function Theory, Springer Verlag
5. Dennis G.Zill , Patrik D. Shanahan : A first course in Complex Analysis, Jones and Bartlett Publishers.

Paper Name: Classical Mechanics	Course code : 2317208
Paper Code: DSE-2(B)	Credits: 04

Course objectives:

To emphasis the understanding of Classical Mechanics using Lagrangian and Hamiltonian approach also demonstrate knowledge and understanding of the fundamental concepts in the dynamics of system of particles and motion of rigid body.

Course outcomes:

1. Understand Calculus of variation and solve different problems.
2. Learn D-Alemberts principle and formulate Laganges equation of motion
3. Formulate Hamiltonian equation and understand its physical significance
4. Gain knowledge of Eulerian angles and Cayley Klein parameters.

Curriculum Details:

Unit I : (15 L)

Mechanics of a particle, Mechanics of a system of particles, constraints, Generalized coordinates, D'Alembert's principle, Lagrange's equations of motion, the forms of Lagrange's equation for velocity dependent potential, and dissipative forces, applications of Lagrangian formulation, cyclic co-ordinates and generalized momentum, conservation theorems.

Unit II (15L)

Functionals, basic lemma in calculus of variations, Euler- Lagrange's equations, the case of several dependent variables, the minimum surface of revolutions, the problem of Brachistochrone, Isoperimetric problems, Problem of the maximum enclosed area, shape of a hanging rope .

Unit III (15L)

Hamilton's principle, Lagrange's equations from Hamilton's principle, (holonomic system) Hamilton's equations of motion from a variational principle. The principle of least action cyclic coordinates and Routh's procedure, conservation theorems and physical significance of Hamiltonian.

Unit IV (15 L)

The kinematics of rigid body motion, The independent co-ordinates of a rigid body, orthogonal transformations, properties of transformation matrix, infinitesimal rotations, the Eulerian angles, the Cayley-Klein parameters, Euler's theorem on motion of rigid body. Angular momentum and kinetic energy of motion of a rigid body about a point.

Recommended Books:

1. H.Goldstein: Classical Mechanics (1980) Narosa Publishing House, New Delhi
2. Robert Weinstock : Calculus of variations with applications to Physics and Engineering (International series in Pure and Applied Mathematics) (1952) McGraw-Hill book comp, New York.
3. N.C.Rana and P.S. Joag : Classical Mechanics (1991) Tata McGraw Hill, New Delhi.

Reference Books:

1. E.T.Whittaker :A treatise on the Analytical Dynamics of Particles and rigid bodies (1965) Cambridge University Press.
2. E.A.Desolge : Classical Mechanics , Vol. I and II (1982) John-Wiley and sons, New York.
3. V.Barger and Martin Olsson :Classical Mechanics A Modern Perspective (1995) McGraw Hill, Inc.New York.
4. V.B.Bhatia: Classical Machanics with introduction to Non-linear oscillation and chaos (1997) Narosa Pub.House
5. J. C. Upadhyay: Classical Mechanics , Himalaya Pub.

Paper Name: Fuzzy Mathematics	**Course code : 2317209**
Paper Code: DSE-2(C)	**Credits: 04**

Course objectives:

This course introduces students to the basic concepts of modeling in systems using fuzzy sets. The concepts of fuzzy sets are introduced and their role in applications of semantic interpreters, control systems and reasoning systems.

Course Outcomes :

1. Understand basic knowledge of the fuzzy sets, operations and their properties.
2. Understand the fundamental concepts of Fuzzy functions and Fuzzy logic
3. Apply the concepts of Fuzzy sets in image processing, pattern reorganization and decision making.
4. Acquire the knowledge of Fuzzy Arithmatic.

Curriculum Details:

Unit I:

Motivation. Fuzzy set as a generalization of a characteristic function of a set, Different notations describing a fuzzy set. (15L)

Unit II :

Algebra of fuzzy sets, "Venn diagrams", Level cuts, decomposition theorems, image and inverse image of a fuzzy set under a function. (15L)

Unit III:

Extension principle, Triangular norm and co-norm, their characterization theorems. (15L)

Unit IV:

Fuzzy arithmetic: Fuzzy numbers, their characterizations, their relation-ships with closed intervals of real numbers, Lattice of fuzzy numbers. (15L)

Recommended Books:

1. Klir George J. and Yuan Bo. Fuzzy Sets and Fuzzy Logic, Theory and Applications, Prentice Hall of India Pvt.Ltd, New Delhi 1997

Reference books :

1. Kaufmann A and Gupta M. M. Introduction to Fuzzy Arithmetics, Van Nostrand.
2. Ross Timothy J.,Fuzzy logic with Enginering Applications, McGraw Hill Inc. 1995
3. Lowen R., Fuzzy Set Theory, 1996
4. Zimmerman H.J.,Fuzzy Set Theory and Its Applications 1997.
5. Pedrycz, W. and Gomide F.: An introduction to Fuzzy Sets Analysis and Design. The MIT Press, Massachusetts 1998.

Paper Code: DSE-2(D)	**Course code : 2317210**
	Credits: 04

- **Any NPTEL/ SWAYAM MOOCs Course**

(Selected SWAYAM course should be on PG syllabus with prior approval from department/school)

Paper Name: Mathematics Practical-4 **Measure Theory-I**	**Course code : 2317204**
Paper Code: Lab-4	**Credits: 02**

Course objectives:
This course will help to learn basic elements of measure theory such as outer measure, measurable sets, measurable functions.

Course Outcomes :
After completing this course, the student will be able to:

1. Generalize the concept of length of interval and analyse the properties of Lebesgue measurable sets.
2. Understand the concept of measurable functions and their properties.

Curriculum Details:

Unit I. Lebesgue Measure: Outer measure, G_δ set, F_σ set, Measurable sets, Lebesgue measure, non-measurable sets. (15 L)

Unit II. Measurable functions: Measurable functions and their properties, Littlewood's three principles (statement only), Egoroff's theorem. (15 L)

Practical Assignments 1 to 5 on Unit I and Practical Assignments 6 to 10 on Unit II.

Recommended Books :

1. Royden H.L.: Real Analysis , Printice Hall of India.
2. I.K. Rana : An Introduction to Measure and Integration, Narosa (1997)

Reference Books :

1. Berberian, S.K. Measure and Integration, McMillan N.Y.1965
2. G. De. Barra, Measure and Integration

Paper Name: Mathematics Practical-5 Measure Theory-II	**Course code : 2317205**
Paper Code: Lab-5	**Credits: 02**

Course objectives:

The course introduces the Lebesgue integral and develops the elements of measure theory. Explains the construction of Lebesgue integral and its properties, absolute convergence of integral, integrable functions, Lebesgue theorem on dominated convergence, Lebesgue-Stieltjes integral, Convergence theorems.

Course Outcomes :

1. Understand the concept of Lebesgue integration of measurable functions and convergence in measure.
2. Understand the concept of differentiation of monotone functions and differentiation of an integral.

Curriculum Details:

Unit I. Lebesgue Integral: Lebesgue integral of a bounded function over a set of finite measure, the Lebesgue integral of a non-negative measurable function, Fatou's Lemma, the general Lebesgue integral, convergence in measure. (15L)

Unit II. Differentiation and Integration: Differentiation of monotone functions, function of bounded variation, Differentiation of an integral, Absolute continuity, Convex functions.(15L)

Practical Assignments 1 to 5 on Unit I and Practical Assignments 6 to 10 on Unit II.

Recommended Books :

1. Royden H.L.: Real Analysis , Printice Hall of India.
2. I.K. Rana : An Introduction to Measure and Integration, Narosa (1997)

Reference Books :

1. Berberian, S.K. Measure and Integration, McMillan N.Y.1965
2. G. De. Barra, Measure and Integration

Paper Name: Mathematics Practical-6 **Advanced Latex**	**Course code : 2317206**
Paper Code: Lab-6	**Credits: 02**

Course objectives:

To prepare a Latex document, to make scientific article and project report, book, include figures and tables in a Latex document, make conference proceedings and presentations, the preamble of LaTeX file to define document class and layout options, Use BibTeX to maintain bibliographic information and to generate a bibliography for a particular document and beamer for beautiful presentations.

Course outcomes: After completing this course, the student will be able to:

1. Typesetting of journal articles, technical reports, thesis, books, and slide presentations.
2. Automatic generation of table of contents, bibliographies and indexes.

Curriculum Details:

Unit I : Producing Mathematical Graphics, Table of contents, generating new commands, Figure handling, Numbering, List of figures, List of tables, Generating index, Beamer class (Classes: article, book, report, beamer, slides), beamer theme, frames, slides, pause, overlay, transparent, handout stands presentation mode.

Unit II: Applications to: Writing Resume, Writing question paper, Writing articles/ research papers, Presentation using beamer.

Practical Assignments 1 to 5 on Unit I and Practical Assignments 6 to 10 on Unit II.

Reference Books:

1. LATEX Tutorials A Primer, Indian TEX Users Group, Trivandrum, India, 2003 September.
2. Learning LATEX by Doing, Andre Heck, 2002. 3
3. The Latex companion, M. Carter, B.van Brunt, second edition, Addison wisely, Pearson Education

Paper Name: On Job Training/ In house Project/ Internship/Apprenticeship	**Course code : 2317203**
Paper Code: OJT/FP	**Credits: 04**

On Job training (OJT) is an integral component of the M.Sc. Mathematics program that provides students with a unique opportunity to bridge the gap between theoretical knowledge gained in the classroom and practical application in a real world environment.

By participating in OJT, students are able to apply the concepts and theories learned during their program to real-world scenarios. They gain hands-on experience, problem-solving skills. This practical exposure enhances their competence and confidence, preparing them to tackle the challenges they may encounter in their professional careers.

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

1. Student has to submit final report based on the work carried out during OJT/FP.
2. Student has to make a presentation of the work carried out during OJT/FP in front of university appointed panel of one external and one internal examiner.

- Assessment criteria of In house project shall be based on final report/ dissertation, presentation and oral examinations. University examinations shall be of 60 marks and internal examination of 40 marks. Research project viva will be taken by university appointed external and internal examiners. Internal evaluation will be carried out by internal guide.

Equivalence of Papers of M.Sc. I SEM I

Paper Code	Old Paper	Paper Code	Equivalent paper
HCT 1.1	Algebra I	DSC-1	Group and Ring Theory
HCT 1.2	Real Analysis I	DSC-2	Real Analysis
HCT 1.3	Differential Equations	----	No Equivalence
HCT 1.4	Classical Mechanics	----	No Equivalence
SCT 1.1	Number Theory	DSE-1(A)	Number Theory

Equivalence of Papers of M.Sc.I SEM II

Paper Code	Old Paper	Paper Code	Equivalent paper
HCT 2.1	Algebra II	DSC-3	Field Extension theory
HCT 2.2	Real Analysis II	----	No Equivalence
HCT 2.3	General Topology	DSC-4	General Topology
SCT 2.1	Complex Analysis	DSE-2 (A)	Complex Analysis
OET 2.1	Fundamentals in Mathematics	--	No Equivalence