K. C. E. Society's
Moolji Jaitha College
An 'Autonomous College' Affiliated to
K.B.C. North Maharashtra University, Jalgaon.
NAAC Reaccredited Grade - A (CGPA : 3.15 - 3rd Cycle)
UGC honoured "College of Excellence" (2014-2019)
DST(FIST) Assisted College

KNOWLEDGE IS POWER
ESTD. 1945

के. सी. ई. सोसायटीचे
मूळजी जेठा महाविद्यालय
क.ब.चौ. उत्तर महाराष्ट्र विद्यापीठ, जळगाव संलग्नित
'स्वायत्त महाविद्यालय'
नॅकद्वारा पुनर्मानांकित श्रेणी – 'ए' (सी.जी.पी.ए. : ३.१५ – तिसरी फेरी)
विद्यापीठ अनुदान आयोगाद्वारा घोषित 'कॉलेज ऑफ एक्सलन्स' (२०१४-२०१९)
डी.एस.टी. (फीस्ट) अंतर्गत अर्थसहाय्य प्राप्त

Date :- 01/08/2024

NOTIFICATION

Sub :- CBCS Syllabi of M. Sc. in Mathematics (Sem. III & IV)

Ref. :- Decision of the Academic Council at its meeting held on 27/07/2024.

The Syllabi of M. Sc. in Mathematics (Third and Fourth Semesters) as per **NATIONAL EDUCATION POLICY – 2020 (2023 Pattern)** and approved by the Academic Council as referred above are hereby notified for implementation with effect from the academic year 2024-25.

Copy of the Syllabi Shall be downloaded from the College Website (www.kcesmjcollege.in)

Sd/-
Chairman,
Board of Studies

To :

1) The Head of the Dept., M. J. College, Jalgaon.
2) The office of the COE, M. J. College, Jalgaon.
3) The office of the Registrar, M. J. College, Jalgaon.

Near Samarth Colony, Jalgaon - 425 002. (Maharashtra, India) | Ph. : +91 257 - 2237363, 2234281 | e-mail : mjcollege@kces.in | Website : mjcollege.kces.in
समर्थ कॉलनी जवळ, जळगांव – ४२५ ००२. (महाराष्ट्र, भारत) । दूरध्वनी क्र. : +९१ २५७–२२३७३६३, २२३४२८१ । ई–मेलः mjcollege@kces.in । वेबसाईटः mjcollege.kces.in

Khandesh College Education Society's

Moolji Jaitha College, Jalgaon

An "Autonomous College"

Affiliated to

KavayitriBahinabaiChaudhari

North Maharashtra University, Jalgaon-425001

STRUCTURE AND SYLLABUS

M.Sc. Honours with Research (S.Y.M.Sc. Mathematics)

Under Choice Based Credit System (CBCS)

and

as per NEP-2020 Guidelines

[w.e.f.AcademicYear:2024-25]

Preface

The Moolji Jaitha College (Autonomous) has adopted a department-specific model as per the guidelines of UGC, NEP-2020 and the Government of Maharashtra. The Board of Studies in Mathematics of the college has prepared the syllabus for the second-year postgraduate of Mathematics. The syllabus cultivates theoretical knowledge and applications of different fields of Mathematics. The contents of the syllabus have been prepared to accommodate the fundamental aspects of various disciplines of Mathematics and to build the foundation for various applied sectors of Mathematics. The program will be enlightened the students with the advanced knowledge of Mathematics, which will help to enhance student's employability.

The overall curriculum of two year covers pure mathematics, applied mathematics and computational mathematics with programming. The syllabus is structured to cater the knowledge and skills required in the research field, Industrial Sector and Entrepreneurship etc.. The detailed syllabus of each paper is appended with a list of suggested readings.

Programme Outcomes (PO) for M.Sc. MathematicsHonours with Research

Upon successful completion of thisProgramme, student will be able to:

PO No.	PO
1	Critical Thinking: Inculcate critical thinking to carry out scientific investigation objectively without being biased with preconceived notions.
2	Knowledge Skill: Equip the student with skills to analyse problems, formulate an hypothesis, evaluate and validate results, and draw reasonable conclusions thereof.
3	Scientific Communication Skills: Imbibe effective scientific and / or technical communication in both oral and writing. Ability to show the importance of the subject as precursor to various scientific developments since the beginning of the civilization.
4	Ethics: Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in Mathematics.
5	Enlightened Citizenship: Create awareness to become an enlightened citizen with commitment to deliver one's responsibilities within the scope of bestowed rights and privileges.
6	Research Skills: Prepare students for pursuing research or careers in industry in Mathematical sciences. Capability to use appropriate software to solve various problems and to apply programming concepts of C++ , python etc… to various scientific investigations , problem solving and interpretation.

Programme Specific Outcome (PSO)for M.Sc. MathematicsHonours with Research:

After completion of this course, students are expected to:

PSO No.	PSO
1	Demonstrate an understanding of concepts involved in mathematical analysis, algebra and applied mathematics
2	Gain proficiency in mathematical techniques of both pure and applied mathematics and be able to apply the necessary mathematical methods to any scientific problem.
3	Acquire significant knowledge on various aspects related to Linear algebra, Topology, Numerical methods and Differential equations.
4	Learn to work independently as well as a team to formulate appropriate mathematical methods.
5	Develop the ability to understand and practice the morality and ethics regarding scientific Research.
6	Realize the scope of mathematics in enlightening of the society and plan to pursue research which is beneficial to the society.

Credit distribution structure for two years/one-year PG MSc programme

Level	Sem	Major (Core) Subjects		Minor Subjects	OJT/Int, RP	Cumulative Credits/Sem	Degree/ Cumulative Cr.
		Mandatory (DSC)	Elective (DSE)				
6.0	I	DSC-1 (4T) DSC-2 (4T) DSC-3 (4T) DSC-4 (2P)	DSE-1(2T) A/B DSE-2(2P) A/B	RM (4T)		22	First year PG OR One year PG diploma after 3year UG
	II	DSC-6 (4T) DSC-6 (4T) DSC-7 (4T) DSC-8 (2P)	DSE-3(2T) A/B DSE-4(2P) A/B		OJT/Int (4)	22	
	Cum. Cr.	28	8	4	4	44	
	Exit option: PG diploma (44 Credits) after three year UG degree						
6.5	III	DSC-9 (4T) DSC-10 (4T) DSC-11 (4T) DSC-12 (2P)	DSE-6(2T) A/B DSE-6(2P) A/B	--	RP (4)	22	Second year PG after 3 year UG OR PG degree after 4 year UG
	IV	DSC-13 (4T) DSC-14 (4T) DSC-15 (2P) DSC-16 (2P)	DSE-7(2T) A/B DSE-8 (2P) A/B	...	RP (6)	22	
	Cum. Cr.	54	16		4+10	88	
2 Years-4 Sem. PG Degree (80-88 credits) after Three Year UG Degree or 1 Year-2 Sem PG Degree (40-44 credits) after Four Year UG Degree							

Sem- Semester, **DSC**- Department Specific Course, **DSE**- Department Specific Elective, **T**- Theory, **P**- Practical, **RM**- Research Methodology, **OJT**- On Job Training, **Int**- Internship, **RP**- Research Project, **Cum. Cr.**:Cumulative Credits

Multiple Entry and Multiple Exit options:

The multiple entry and exit options with the award of UG certificate/ UG diploma/ or three-year degree depending upon the number of credits secured;

Levels	Qualification Title	Credit Requirements		Semester	Year
		Minimum	Maximum		
6.0	One-year PG Diploma program after 3 Yr Degree	40	44	2	1
6.5	Two-year master's Degree program After 3-Yr UG Or PG Degree after 4-Yr UG	80	88	4	2

S.Y.M. Sc. Mathematics Course Structure

Semester	Course Module	Credit	Hours/ week	TH/ PR	Code	Title
III	DSC	4	4	TH	MTH-DSC-611	Functional Analysis
	DSC	4	4	TH	MTH-DSC-612	Field Theory
	DSC	4	4	TH	MTH-DSC-613	Advanced Numerical Methods
	DSE	2	2	TH	MTH-DSE-614(A)	Combinatorics
	DSE	2	2	TH	MTH-DSE-614(B)	Lattice Theory
	DSC	2	4	PR	MTH-DSC-615	Practical Course on MTH-DSC-612 and MTH-DSC-613
	DSC	4	8	RP	MTH-RP-616	Research Project-I
IV	DSC	4	4	TH	MTH-DSC-621	Linear Integral Equations
	DSC	4	4	TH	MTH-DSC-622	Commutative Algebra
	DSC	4	4	TH	MTH-DSC-623	Advanced Ring Theory
	DSE	2	2	TH	MTH-DSE-624(A)	Graph Theory
	DSE	2	2	TH	MTH-DSE-624(B)	Algebraic Topology
	DSC	6	12	RP	MTH-RP-625	Research Project-II

DSC	**:**	Department-Specific Core course
DSE	**:**	Department-Specific elective
TH	**:**	Theory
PR	**:**	Practical

Examination Pattern for MSc

Theory Question Paper Pattern:

- **60 (External) +40 (Internal) for 4 credits**
  - External examination will be of three hours duration
  - There shall be 5 questions, each carrying equal marks (12 marks each), while the tentative pattern of question papers shall be as follows;
  - Q1 Attempt any 3 out of 4 sub-questions; each 4 marks
  - Q 2, Q3, Q4 and Q5 Attempt any 2 out of 3 sub-question; each 6 marks.
- **30 (External) +20 (Internal) for 2 credits**
  - External examination will be of 1½ hours duration
  - There shall be 3 questions Q1 carrying 6 marks and Q2, Q3 carrying 12 marks each. while the tentative pattern of question papers shall be as follows;
  - Q1 Attempt any 2 out of 3 sub-questions; each 3 marks
  - Q 2 and Q3 Attempt any 2 out of 3 sub-question; each 6 marks.

Rules of Continuous Internal Evaluation:

The Continuous Internal Evaluation for theory papers shall consist of two methods:

1. Continuous & Comprehensive Evaluation (CCE): CCE will carry a maximum of 30% weightage (30/15 marks) of the total marks for a course. Before the start of the academic session in each semester, the subject teacher should choose any three assessment methods from the following list, with each

method carrying 10/5 marks:

i. Individual Assignments
ii. Seminars/Classroom Presentations/Quizzes
iii. Group Discussions/Class Discussion/Group Assignments
iv. Case studies/Case lets
v. Participatory & Industry-Integrated Learning/Field visits
vi. Practical activities/Problem Solving Exercises
vii. Participation in Seminars/Academic Events/Symposia, etc.
viii. Mini Projects/Capstone Projects
ix. Book review/Article review/Article preparation
x. Any other academic activity
xi. Each chosen CCE method shall be based on a particular unit of the syllabus, ensuring that three units of the syllabus are mapped to the CCEs.

2. Internal Assessment Tests (IAT): IAT will carry a maximum of 10% weightage (10/5 marks) of the total marks for a course. IAT shall be conducted at the end of the semester and will assess the remaining unit of the syllabus that was not covered by the CCEs. The subject teacher can decide which units will be assessed using CCEs and which unit will be assessed based on IAT.

The overall weightage of Continuous Internal Evaluation (CCE + IAT) shall be 40% of the total marks for the course. The remaining 60% of the marks shall be allocated to the semester-end examinations.

The subject teachers must communicate the chosen CCE methods and the corresponding syllabus units to the students at the beginning of the semester to ensure clarity and proper preparation.

Practical Examination Credit 2: Pattern (30+20)

External Practical Examination (30 marks):

- Practical examination shall be conducted by the respective department at the end of the semester.
- Practical examination will be of 3 hours and shall be conducted as scheduled.
- There shall be 05 marks for journal and viva voce. A certified journal is compulsory to appear for practical examination.
- The practical examination will be of a minimum of 3 hours duration and shall be conducted as per schedule for 2 consecutive days in case of practical where incubation conditions and allied aspects are essential.

Internal Practical Examination (20 marks):

- Internal practical examination of 10 marks will be conducted by the department as per the schedule given.
- For internal practical examination, students must produce the laboratory journal of practicals completed along with the completion certificate signed by the concerned teacher and department head.
- There shall be continuous assessment of 30 marks based on student performance throughout the semester. This assessment can include quizzes, group discussions, presentations and other activities the faculty assigns during regular practicals. For details, refer to internal theory examination guidelines.
- Finally, 40 (10+30) students' performance will be converted into 20 marks.

SEMESTER-III

S.Y.M.Sc.(Mathematics)
SEMESTER-III
MTH-DSC-611: Functional Analysis

Total Hours: 60 **Credits: 4**

Course objectives	• To know the fundamental knowledge of normed linear spaces. • To study Banach spaces, inner product spaces and Hilbert spaces. • To study the properties and applications of linear operators. • To know important theorems of Functional analysis and their applications.	
Course outcomes	After successful completion of this course, students are expected to: • Understand normed linear spaces, Banach spaces, inner product spaces and Hilbert spaces. • Evaluate and interpret the behavior of linear operators on various function spaces. • Explain the concept and applications of Functional analysis. • Learn the concept of Functional analysis to develop mathematical skills.	
Unit	**Content**	**Hours**
Unit I	Normed linear spaces, Banach Spaces, Quotient spaces, Continuous linear Transformations, The Hahn-Banach theorem and its consequences, conjugate space and separability, Second conjugate space, The natural embedding of normed linear space and its second conjugate space, Weak* Topology on conjugate space.	**15**
Unit II	The open mapping theorem, Projection on Banach space, The closed graph theorem, the conjugate of an operator, The uniform boundedness theorem (Banach-Steinhauss theorem), Inner Product spaces, Hilbert space, Schwartz's inequality, Orthogonal complements, Projection theorem, Orthogonal sets, The Bessel's inequality.	**15**
Unit III	Fourier expansion and Parseval's equations, Gram-Schmidt orthogonalization process, Separable Hilbert space, The conjugate space, Riesz-Representation theorem, Operators and their adjoints on a Hilbert space, self adjoint operators, Normal and unitary operators.	**15**
Unit IV	Finite dimensional spectral theory, Determinants and spectrum of an operator, The spectral theorem, Fixed points, Definition and examples, Banach contraction mapping theorem, Brouwer's fixed point theorem, Schauder's fixed point theorem.	**15**
Study Resources	• Simmon, G. F. *Introduction to Topology and Modern Analysis*. Tata Mc Graw Hill. (Chapter-9: Art 46 to 51; Chapter-10: Art 52 to 59; Chapter-11: Art 61 to 62; Appendix one) • Limaye, B. V. (1996). *Functional Analysis*. New Age International (P) Ltd. Publishers second editions. (Chapter-6: Art 21 to 24; Appendix-A) • Bachman, G and Narici, L. *Functional Analysis*. Academic Press. • Berberian, S. K. *Functional Analysis and Operator theory*. McMillan New York. • Kreyszig, Erwin (1978). *Introductory Functional Analysis with Applications*. John Wiley and Sons. • Siddique, A. H. *Functional Analysis with applications*. Wiley- Eastern Limited. • Chaudhary, B. and Nanda, Sudarshan (1989). *Functional Analysis with applications*. Wiley- Eastern.	

S.Y.M.Sc.(Mathematics)
SEMESTER-III
MTH-DSC-612: Field Theory

Total Hours: 60 **Credits: 4**

Course objectives	• To know the concept and applications of Field theory. • To understand and construct splitting fields for polynomials. • To study basic and advanced concepts of solving polynomial equations. • To know concept of Galois theory and its applications.	
Course outcomes	After successful completion of this course, students are expected to: • Understand the concept of finite and algebraic extensions, splitting field, normal extensions, separable extensions. • Explain the finite fields and roots of unity • Learn the important theorems in Galois theory and their applications • Understand the geometric constructions.	
Unit	**Content**	**Hours**
Unit I	Field extensions, Finite extensions, Algebraic extensions, Simple extensions, Algebraic closure, Algebraically closed field, Splitting field, Normal extension, Conjugate elements.	**15**
Unit II	Separable polynomial, Separable extension, Purely inseparable elements, inseparable extensions, Perfect fields, Finite fields.	**15**
Unit III	Galois extension, Galois group, Artin's theorem, Fundamental theorem of Galois theory, primitive n^th roots of unity, Cyclic extensions.	**15**
Unit IV	Simple radical extension, Radical extension, Galois group of a polynomial, Constructible number, Radical extension of type 2, Geometric constructions, Algebraically independent set, finitely generated extension, Transcendental basis, Transcendental extension, Purely transcendental extension.	**15**
Study Resources	• Gopalakrishnan, N. S. (2018). *University Algebra*. Wiley Eastern Limited, New Delhi. (Sec. 1.10, 1.12, 1.13, 1.14, Sec. 2.10, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16). • Jacobson, N. (2012). *Basic Algebra-I*. (2nd ed.). Hindustan Publishing Corporation. • Nagata, M. (1977), *Field Theory*. Marcel-Dekker Inc. • Gopalakrishnan, N. S. (2016). *Commutative Algebra*. Universities Press (India) Pvt. Ltd. (Sec. 3.1). • Herstein, I. N. (1975). *Topics in Algebra*. John Wiley and Sons, New Delhi. • Fraleigh, J. B. (2003). *A first Course in Abstract Algebra*. Pearson.	

S.Y.M.Sc.(Mathematics)
SEMESTER-III
MTH-DSC-613: Advanced Numerical Methods

Total Hours: 60 **Credits: 4**

Course objectives	• To know the concept and applications of Numerical methods. • To study basic and advanced concepts of solving linear equations. • To explore advanced methods for numerically solving ODE and PDE. • To know concept of Numerical methods to develop mathematical skills in solving various scientific problems.	
Course outcomes	Upon successful completion of this course the student will be able to: • Understand the concept of Queuing Numerical differentiation and Integration. • Explain important principles and techniques of solving ODE by numerical methods. • Learn important principles and techniques of solving PDE by numerical methods. • Use advanced numerical techquies to address and solve real-world problems in various fields.	
Unit	**Content**	**Hours**
Unit I	**System of Linear Equations** Methods of triangularization – Do little algorithm, Crout's method, inverse of a matrix by Crout's method, Gauss Jordan method for system of linear equations, Iterative methods of Jacobi and Gauss–Seidal, Relaxation method, convergence.	**15**
Unit II	**Numerical Differentiation and Integration** Numerical differentiation using Forward, Backward, Central differences, Error analysis, higher derivatives of continuous and tabulated functions, maximum and minimum values of a function, difference tables and Richardson's extrapolation. Newton–Cotes Integration formulas, Trapezoidal rule, Simpson's 1/3-rule, Error Analysis, Romberg integration, Numerical Double integration by trapezoidal and Simpson's rules.	**15**
Unit III	**Numerical Solution of ODE (IVP and BVP)** Initial value problems, Numerical Solution of O.D.E using Picard, Taylor series, Modified Euler and Runge-Kutta fourth order methods, Predictor corrector methods. Linear BVP, shooting method, alternative method, Finite difference method of linear second order problems, derivative boundary condition, solution of tri-diagonal system.	**15**
Unit IV	**Numerical Solution of PDE (BVP)** Introduction, deriving difference equations; numerical solution of elliptic equations, Leibnitz's iteration method for Laplace equation and Poisson's equation; Solution of Heat equation; Bendor-Schmidt method, Crank-Nicholson method; Hyperbolic equations, finite difference method and starting values.	**15**
Study resources	• Jain, M. K. Iyengar, S. R. K. and Jain, R. K. (2014). *Numerical methods for Scientific and Engineering Computation*. New Age international Publishers.(Chapter-5: Art 5.10 to Art 5.11; Chapter-6: Art 6.7; Chapter-7: Art 7.1 to Art 7.4). • Vedamurthy, V. N. and Iyengar, N. Ch. S. N. (1998). *Numerical methods*, Vikash Publishing House. (Chapter-4: Art 4.5 to 4.11; Chapter-9: Art 9.1 to Art 9.3, Art 9.6 to Art 9.9 and Art 9.13; Chapter-11: Art 11.5 to Art 11.9, Art 11.12, Art 11.15, Art 11.18; Chapter-12: Art 12.4 to Art 12.9) • Sastry, S. S. (2012). *Introductory methods of Numerical Analysis*, Prentice Hall India. New Delhi.	

S.Y.M.Sc.(Mathematics)
SEMESTER-III
MTH-DSE-614(A): Combinatorics

Total Hours: 30 **Credits: 2**

Course objectives	• To know the concept and applications of combination and permutation. • To study extremization problems using generating function and recurrence relations • To know relation between Graph Theory and Combinatorics. • To learn about combinatorial designs including block designs, latin squares and applications in experimental designs.	
Course outcomes	After successful completion of this course, students are expected to: • Understand the fundamental concepts of combination and permutation. • Explain the important theorems and their applications of inclusion-exclusion. • Learn the problems using generating function and recurrence relations. • Develop and implement combinatorial algorithms to solve complex problems.	
Unit	**Content**	**Hours**
Unit I	**Generating Counting Methods** Counting principles, Arrangements and selections, Arrangements and selection with repetition, Distributions, Binomial identities.	**15**
Unit II	**Generating functions** Generating function models, Calculating coefficients of generating functions, Partitions, exponential generating functions, A summation method.	**15**
Unit III	**Recurrence Relations** Recurrence relation models, Divide and conquer relations, Solution of linear and inhomogeneous recurrence relation, Solution with generating functions.	**15**
Unit IV	**Inclusion-exclusion** Counting with Venn diagrams, Inclusion – exclusion formula, Restricted positions and Rook polynomials.	**15**
Study Resources	• Tucker, Alan (1995). *Applied Combinatorics* (Sixth Edition). John Wiley & sons New York. (Chapter-5: Art-5.1-5.5; Chapter-6: Art-6.1-6.5; Chapter-7: Art-7.1-7.4; Chapter-8: Art-8.1-8.3). • Krishnamurthy, V. (1989). *Combinatorial Theory and Applications.* East West Press. New Delhi. • Joshi, K. D. (1989). *Foundations of discrete mathematics*. John Wiley & Sons. • Hall, Marshall (1988). *Combinatorial theory*. John Wiley & Sons.	

S.Y.M.Sc.(Mathematics)
SEMESTER-III
MTH-DSE-614(B): Lattice Theory

Total Hours: 30 **Credits: 2**

Course objectives	• To know the concept and applications of Lattice Theory. • To know Birkhoff's characterization, Stone's theorem, Nabchin theorem and Hashimoto's theorem. • To know the concept of Distributive, Standard and Neutral elements. • To know Lattice-ordered Groups and related concepts.	
Course outcomes	After successful completion of this course, students are expected to: • Understand the fundamental concepts of Lattice Theory and Lattice-ordered Groups. • Understand the concept of Birkhoff's characterization, Stone's theorem, Nabchin theorem and Hashimoto's theorem.. • Solve the problems related to Distributive, Standard and Neutral elements. • Learn the beauty of Lattice-ordered Groups and related concepts.	
Unit	**Content**	**Hours**
Unit I	**Introductory Concepts of Lattices** Introduction to Posets, Semi-lattice, Two definitions of lattices, Hasse Diagrams, Homomorphism, Isotone maps, Ideals, Congruence relations, Congruence lattice, Convex Lattice, The homomorphism theorem, Product of lattices, Complete lattices, Ideal lattice, Distributive and Modular Inequalities and Identities, Complements.	**15**
Unit II	**Distributive Lattices** Characterization theorem for modular and distributive lattice, Dedekind's characterization of modular lattice, Birkhoff's characterization of distributive lattices, Representation of distributive lattices, Stone's theorem, Nabchin theorem, Statement of Hashimoto's theorem.	**15**
Unit III	**Elements of Lattice** Distributive, Standard and Neutral elements.	**15**
Unit IV	**Lattice-Ordered Groups** Introduction to Lattice-ordered groups, Definition of the l-group, Calculations in l-group, Riesz Decomposition Theorem, Basic facts, Definition of Convex l-subgroup, Prime Subgroup, Polar.	**15**
Study Resources	• Gratzer, George (1978). *General Lattice Theory*. BirkhauserVerlag Basel. (Chapter-1: Art.-1, 2, 3, 4; Chapter-2: Art.-1; Chapter-3: Art.-2). • Kopytov, V. M. and Medvedev, N. Y. (1994). *The Theory of Lattice-Ordered Groups*. Springer-Science. (Chapter-1: Art.-1, 2, 3; Chapter-2: Art.-1, 2, 3; Chapter-3: Art.-1, 3, 4) • Birkhoff, G. (1948). *Lattice Theory*. American Mathematical Society. New York. • Crawley, Peter and Dilworth, Robert P. (1973). *Algebraic Theory of Lattices*. Prentice-Hall. • Davey, B. A. and Priestly, H. A. (2002). *Introduction to Lattices and Order*. Cambridge University Press . • Jingjing, Ma (2013). *Lecture notes on Algebraic Structure of Lattice-Ordered rings*. World scientific.	

S.Y.M.Sc.(Mathematics)
SEMESTER-III
MTH-DSC-615: Practical Course on MTH-DSC-612 and MTH-DSC-613

Total Hours: 60 **Credits: 2**

Course objectives	• To know the concept and applications of Field theory. • To know concept of Galois theory and its applications. • To know the applications of Numerical methods. • To study advanced concepts of solving linear equations.
Course outcomes	Upon successful completion of this course the student will be able to: • Understand the concept of finite and algebraic extensions, splitting field, normal extensions, separable extensions. • Explain the finite fields and roots of unity • Understand the concept of Queuing Numerical differentiation and Integration. • Explain techniques of solving ODE and PDE by numerical methods.
Practical No.	**Content**
1	**Practical No.1: Field extensions** Finite extensions, Algebraic extensions, Simple extensions, Algebraic closure, Algebraically closed field, Splitting field, Normal extension, Conjugate elements
2	**Practical No.2:Separable extensions** Separable polynomial, Separable extension, Purely inseparable elements, inseparable extensions, Perfect fields, Finite fields.
3	**Practical No.3:Galois extension** Galois extension, Galois group, Artin's theorem, Fundamental theorem of Galois theory, primitive n^{th} roots of unity, Cyclic extensions.
4	**Practical No.4:Solvability by radicals** Simple radical extension, Radical extension, Galois group of a polynomial, Constructible number, Radical extension of type 2, Geometric constructions, Algebraically independent set, finitely generated extension, Transcendental basis, Transcendental extension, Purely transcendental extension.
5	**Practical No. 5: System of Linear Equations** Methods of triangularization – Do little algorithm, Crout's method, inverse of a matrix by Crout's method, Gauss Jordan method for system of linear equations, Iterative methods of Jacobi and Gauss–Seidal, Relaxation method, convergence.
6	**Practical No. 6:Numerical Differentiation and Integration** Numerical differentiation using Forward, Backward, Central differences, Error analysis, higher derivatives of continuous and tabulated functions, maximum and minimum values of a function, difference tables and Richardson's extrapolation. Newton–Cotes Integration formulas, Trapezoidal rule, Simpson's 1/3-rule, Error Analysis, Romberg integration, Numerical Double integration by trapezoidal and Simpson's rules.
7	**Practical No. 7:Numerical Solution of ODE (IVP and BVP)** Initial value problems, Numerical Solution of O.D.E using Picard, Taylor series, Modified Euler and Runge-Kutta fourth order methods, Predictor corrector methods. Linear BVP, shooting method, alternative method, Finite difference method of linear second order problems, derivative boundary condition, solution of tri-diagonal system.
8	**Practical No. 8:Numerical Solution of PDE (BVP)** Introduction, deriving difference equations; numerical solution of elliptic equations, Leibnitz's iteration method for Laplace equation and Poisson's equation; Solution of

	Heat equation; Bendor-Schmidt method, Crank-Nicholson method; Hyperbolic equations, finitedifference method and starting values.
Study Resources	• Gopalakrishnan, N. S. (2018).*University Algebra*. Wiley Eastern Limited. New Delhi. • Jacobson, N. (2012).*Basic Algebra-I* (Second Edition). Hindustan Publishing Corporation. • Nagata, M. (1977).*Field Theory*. Marcel-Dekker Inc. • Herstein, I. N. (1975).*Topics in Algebra*. John Wiley and Sons. New Delhi. • Fraleigh, J. B. (2003).*A first Course in Abstract Algebra*. Pearson. • Jain, M. K. Iyengar, S. R. K. and Jain, R. K. (2014).*Numerical methods for Scientific and Engineering Computation*. New Age international Publishers. • Vedamurthy, V. N. and Iyengar, N. Ch. S. N. (1998).*Numerical methods*. Vikash Publishing House. • Balagurswamy, E. (2017).*Numerical Methods*. Tata McGraw-Hill. • Sastry, S. S. (2012).*Introductory methods of Numerical Analysis.* Prentice Hall India. New Delhi.

S.Y.M.Sc.(Mathematics)
SEMESTER-III
MTH-RP-616: Research Project-I

Total Hours: 120 **Credits: 4**

Course Objectives

1. To give exposure to the students to research culture and technology
2. To introduce students to how to select a research topic, plan, perform experiments, collect and analyze the data
3. To foster self-confidence and self-reliance in the students as they learn to work and think independently

Course outcomes

After successful completion of this course, students are expected to:

- Conceive a problem based on published research and conduct a comprehensive literature survey.
- Plan and carry out the tasks in the given framework of the dissertation and present the work in writing and viva.
- Learn handling of instruments, use of chemicals and how to conduct the experiments
- Learn how to present the project in PowerPoint and answer the queries to examiners and the science of writing.

Credit distribution (1 credit for each unit)

- Identification of a research topic, formulation of research problem, objectives, sample size and hypothesis, etc
- Preparation of Outline
- Review of literature
- Bibliography

The systematic approach towards the execution of the project should be as follows: (Wherever applicable)

1. The complete tenure of the research project should be one year. It should be allotted during the third semester and completed in the fourth semester.
2. Weekly 8 hours should be allotted to the research project in a regular timetable.
3. In the third semester, students will be evaluated based on a credit distribution mentioned above. In the fourth semester, students should perform further research work, collect and analyze the data, compile the results and prepare and submit the final dissertation.
4. Students may be given an opportunity to participate in ongoing research activities in the respective Departments/Schools/Supervisors' laboratories. This will familiarize them with the literature survey and give them a fundamental understanding of designing and executing a research project.
5. Students may work individually or in groups (not more than 3 students) to be decided by the concerned department/supervisor.
6. Each research group should have a different research topic with some possible level of novelty.
7. The student should select the topic relevant to priority areas of concern or allied subjects with the guidance of supervisor/ head of the department.
8. Students are encouraged to work on multidisciplinary and applied projects, but it is not mandatory criteria.
9. At the beginning, students should submit the outline of the research work to be carried out in the project. (Writing in order: Title, Aim and objectives, Literature to be collected, Experimental plan or method design, expected outcome etc.)

10. Write and submit a Literature Review Report and Research outline

Tentative order for review: Title of the Project, Certificates, Acknowledgment, Abstract and Keywords, Contents, Introduction, Literature Review, Aim of the Project, Materials and Methods, Bibliography/reference etc.

Tentative order for research outline: Title page, introduction, background and significance of study, problems to be investigated, objective, hypothesis, chapter scheme, bibliography.

11. At the end of the third semester, each student should submit a detailed Literature Review Report and research outline.
12. An appropriate and essential conclusive statement must be drawn at the end of the study.
13. Students should maintain lab notebooks, and the Supervisor may ask them to submit the mid-semester progress report.
14. For documents related to project submission: Font- Times New Roman, Heading Font Size-14, Normal Text Size-12, spacing-1.5, both sides justified and 1 inch margin on all side, both side printing on A-4 size.
15. Three copies of the Literature Review Report, research outline should be prepared (one copy for each department, guide, and student).
16. At the end of the semester, the candidate should prepare and present research work using a PowerPoint presentation with modern ICT tools and present the same in front of his/ her respective department during the Internal Examination.
17. For external examination the candidate will have to present the research work and face viva voce.
18. Students may present their research work in Avishkar/Webinars/Conferences.
19. Students should note that plagiarism is strictly prohibited.

Internal examination (40 marks): Components of continuous internal assessment:

- Draft Research Outline (10 marks)
- Draft Review of literature (10 marks)
- Working Bibliography (10 marks)
- PowerPoint presentation, and oral examination (10 marks)

External examination (60 marks) and Components of external assessment:

- Final submitted review report, research outline in bound form at the time of examination **(40 marks)**
- Overall presentation reflecting the contribution of work, response to questions **(20 marks)**

SEMESTER-IV

S.Y.M.Sc.(Mathematics)
SEMESTER-IV
MTH-DSC-621: Linear Integral Equations

Total Hours: 60 **Credits: 4**

Course objectives	• To learn about different types od linear differential equations. • To know concept and applications of Integral Equations. • To study bilinear forms. • To know the Integral Equations and related concepts.	
Course outcomes	After successful completion of this course, students are expected to: • Understand the concept of linear integral equations, Volterra Integro-Differential Equations, Volterra-Fredholm Integro-Differential Equations. • Explain the origins of Integral Equations, Methods of solutions to Linear integral equations. • Learn the fundamental properties of eigen values and eigen functions for symmetric kernels. • Uderstand the role and properties of kernel functions in integral equations	
Unit	**Content**	**Hours**
Unit I	**Introductory Concepts of Integral Equations** Types of Integral equations, Types of linear integral equations: First kind, Second kind, Third kind, Homogeneous, Non-homogeneous, Types of kernels: Symmetric kernel, Separable kernel or Degenerate kernel, Iterated kernel, Resolvent kernel or Reciprocal kernel, Classification of Integral Equations: Fredholm integral equation, Volterra integral equation, Volterra-Fredholm integral equation, Singular integral equation, Definition and Classification of Integro-Differential Equations: Fredholm Integro-Differential Equations, Volterra Integro-Differential Equations, Volterra-Fredholm Integro-Differential Equations, Eigen value and Eigen function.	**15**
Unit II	**Origins of Integral Equations** Leibnitz Rule for Differentiation of Integrals, Reducing Multiple Integrals to Single Integrals, Converting IVP to Volterra Integral Equation, Converting Volterra Integral Equation to IVP, Converting BVP to Fredholm Integral Equation, Converting Fredholm Integral Equation to BVP, Solution of an Integral Equation, Conversion to a Volterra equation of the first kind to second kind.	**15**
Unit III	**Methods of solutions to Linear integral equations** Adomian decomposition, Modified Decomposition, Successive Approximations, Neumann Series, Successive Substitution, The Laplace Transform Methods, The Direct Computation Method, Resolvent kernel of Fredholm equations and its properties.	**15**
Unit IV	**Symmetric Kernels** Fundamental properties of Eigenvalues and Eigenfunctions for symmetric kernels, Expansion in Eigenfunctions and Bilinear form, Hilbert Schmidt Theorem and its consequences, Solution of symmetric integral equations.	**15**
Study Resources	• Wazwaz, A. M. (2011).*Linear and Nonlinear Integral Equations-Methods and Applications*. Springer. (Chapter-1: Art-1.3-1.5, Chapter-2: Art-2.1-2.7, Chapter-3: Art-3.1, 3.2(3.2.1-3.2.2, 3.2.5-3.2.6), 3.3(3.3.2-3.3.3), Chapter-4: Art-4.1, 4.2(4.2.1-4.2.2, 4.2.5-4.2.6), 4.3, Chapter-5: Art-5.1, 5.2(5.2.1,	

	5.2.3)) • Kanwal, R. P. (1971).*Linear Integral Equation-Theory and Technique*. Academic Press. (Chapter-7: Art-7.1-7.5) • Jerri, A. J. (1999).*Introduction to Integral Equations with Applications*. Wiley-Interscience. • Krasnov, M. L., Kiselev, A. I., Makarenko, G. I. and Yankovsky, George. (1971).*Problems and exercises in Integral equations*. Mir Publishers. • Cochran, J. A. (1972).*The Analysis of Linear Integral Equations*. McGraw Hill Pub. • Green, C. D. (1969).*Integral Equation Methods*. Thomas Nelson and sons.	

S.Y.M.Sc.(Mathematics)
SEMESTER-IV
MTH-DSC-622: Commutative Algebra

Total Hours: 60 **Credits: 4**

Course objectives	• To know concept of sequence of modules and R-module homomorphisms. • To know Tensor products. • To study ring extensions. • To know the concepts of integral extensions and valuation domain.	
Course outcomes	After successful completion of this course, students are expected to: • Understand the concept of exact sequences, projective and flat modules. • Explain the concepts of Noetherian modules and primary decomposition theorem. • Learn the Valuation rings and Discrete valuation rings.	
Unit	**Content**	**Hours**
Unit I	Exact sequences, Projective modules, Finitely generated modules, Shanuel's lemma, Tensor product, Tensor product w. r. t. exact sequences, flat modules, Faithfully flat modules.	**15**
Unit II	Local rings, Nakayama lemma, multiplicatively closed set, Localisation, Localisation and exact sequence, localisation and tensor product, Noetherian modules, Primary submodules, Primary decomposition.	**15**
Unit III	Artinian modules, Structure theorem of Artinian rings, Integral elements, Integral closure, Integral extensions.	**15**
Unit IV	Going up theorem, Integrally closed domain, Going down theorem, Valuation rings, Ordered group, valuation on a field, Discrete valuation rings.	**15**
Study Resources	• Gopalakrishnan, N. S.(2016).*Commutative Algebra*. Universities Press (India) Pvt. Ltd. (Chapter- I: Art.-1.2 to 1.4, Chapter-II: Art.- 2.2 to 2.3, Chapter-III: Art.- 3.1 to 3.3, Chapter-IV: Art.-4.1 to 4.3, Chapter-V: Art- 5.1 to 5.2). • Atiyah, M. F. and Donald, Mac. (2007).*Introduction to Commutative Algebra*, Sarat Book House. • Eisenbud, David. (1995).*Commutative Algebra with a view toward Algebraic Geometry*. Springer Verlag, New York. • Jacobson, N. (1980).*Basic Algebra Vol.-I & II*. Hindustan Publishing Corporation (India). • Zarski, O. and Samuel, P. (1975).*Commutative Algebra*. Springer. • Rowen, L. (1988).*Ring theory Vol.-I & II*. Academic Press.	

S.Y.M.Sc.(Mathematics)
SEMESTER-IV
MTH-DSC-623: Advanced Ring Theory

Total Hours: 60 **Credits: 4**

Course objectives	• To know concept of ideal theory in commutative rings. • To study radical theory. • To know the concepts of direct sum of rings and primary decomposition theorem.	
Course outcomes	After successful completion of this course, students are expected to: • Understand the concept of maximal ideals, prime ideals, nil radical of an ideal, semiprime ideals and primary ideals. • Explain the concepts of Jacobson radical of a ring, Prime radical of a ring, Quasi-regular element, J-radical and J-semisimple ring. • Learn the Prime avoidance theorem, Cohen's theorem and Krull's intersection theorem.	
Unit	**Content**	**Hours**
Unit I	**Ideal Theory** Basic concepts of maximal ideals, prime ideals and nil radical of an ideal, semiprime ideals, primary ideals, Prime avoidance theorem.	**15**
Unit II	**Certain Radicals of a Ring** Jacobson radical of a ring, Semisimple ring, Prime radical of a ring, Quasi-regular element, J-radical, J-semisimple ring, Regular ring.	**15**
Unit III	**Direct sum of rings** Direct sum of rings, Subdirectly reducible and irreducible rings.	**15**
Unit IV	**Primary decomposition in rings** Introduction of irreducible ideals, irredundant primary representation, Cohen's theorem, Krull's intersection theorem.	**15**
Study Resources	• Burton, D. M. (1970).*A first course in ring and ideals*. Addison-Wisley Publishing Company Inc. (Chapter-V: Art.-5.1 to 5.16, Chapter-VIII: Art.-8.1 to 8.21, Chapter-IX: Art.-9.4 to 9.6, Chapter-X: Art- 10.1 to 10.6, Chapter-XII: Art.-12.1 to 12.11). • Jacobson, N. (1980).*Basic Algebra Vol.-I & II*. Hindustan Publishing Corporation (India). • Dummit, D. S. and Foote, R. M. (2008).*Abstract Algebra*. Wiley student Edition, Wiley India Pvt. Ltd.	

S.Y.M.Sc.(Mathematics)
SEMESTER-IV
MTH-DSE-624(A): Graph Theory

Total Hours: 30 **Credits: 2**

Course objectives	• To know the concept and applications of Graph theory. • To study basic concepts of Graphs, trees and connectivity, Eulerian and Hamiltonian graphs. • To know the matching, coloring of graphs and Cayley graphs.	
Course outcomes	After successful completion of this course, students are expected to: • Understand the algorithms: Kruskal's Algorithm, Prim's Algorithm, Breadth First Search (BFS) algorithm, Backtracing algorithm, Dijkstra's Algorithm, Hungarian algorithm. • Explain the well known theorems: Cayley's Theorem, Dirac theorem, Bondy and Chavatal theorem, Travelling salesman problem. • Learn the Planar graphs and Coloring of graphs.	
Unit	**Content**	**Hours**
Unit I	Definition and examples, graphs as models, subgraphs, Operations on graphs, Matrix representation of graphs, walks, Trails, Paths and Cycles, Connectedness and connectedness algorithm, Definition and simple properties of a tree, Bridges, Spanning Trees, Cayley's Theorem, Kruskal's Algorithm, Prim's Algorithm.	**15**
Unit II	Shortest path problems, The Breadth First Search (BFS) algorithm, The Backtracing algorithm, Dijkstra's Algorithm, Cut vertices, Connectivity, Eulerian trails, Eulerian and semi Eulerian graphs, Fleury's algorithm, The Chinese Postman Problem, Hamiltonian graphs, Dirac theorem, Closure of a graph, Bondy and Chavatal theorem, Travelling salesman problem.	**15**
Unit III	Matching and augmenting paths, Berge theorem, The Hall's marriage problem, the personnel assignment problem and matching algorithm for bipartite graphs, The Hungarian algorithm, Plane and Planar graphs, Euler's Formula.	**15**
Unit IV	Vertex coloring, Critical graphs, Cliques and edge coloring of graphs, Definition of Cayley graph, Groups and graphs, Symmetry and regularity of graphs.	**15**
Study Resources	• Clark, John. and Holton, Derek Allan. (1991).*A First Look At Graph Theory*. World Scientific.(Chapter-1: Art 1.1 to Art 1.8; Chapter-2: Art 2.1 to Art. 2.; Chapter-3: Art 3.1 to Art 3.4; Chapter-4: Art 4.1 to Art 4.5; Chapter-5: Art 5.1 to Art 5.2). • Elena,Konstantinova. (2012).*Lecture notes on some problems on Cayley graphs*. Koper.(Chapter-2: Art 2.1 to Art 2.3). • Bhave, N. S. and Raghunathan, T. T. (1990).*Elements of Graph Theory*. Goal Publications. • Harary, F. (1969).*Graph Theory*. Addison-Wesley Publishing Company. • Parthsarathi, K. R. (1994).*Basic Graph Theory.* Tata McGraw-Hill, New York.	

S.Y.M.Sc.(Mathematics)
SEMESTER-IV
MTH-DSE-624(B): Algebraic Topology

Total Hours: 30 **Credits: 2**

Course objectives	• To know the concept of Geometric complexes and simplicial homology. • To study simplicial approximations. • To know the homotopic paths and fundamental group.	
Course outcomes	After successful completion of this course, students are expected to: • Understand the fundamental concepts and methods in algebraic topology. • Explain the well known theorems: The Euler-Poincare theorem, Euler's theorem, Brouwer's fixed point theorem. • Learn the relation between first homology group and fundamental group.	
Unit	**Content**	**Hours**
Unit I	**Geometric Complexes and Polyhedra** Geometric complexes, polyhedron, orientation of Geometric complexes.	**15**
Unit II	**Simplicial Homology Groups** Chains, Cycles, Boundaries, Homology groups, Examples and structure of homology groups, The Euler-Poincare theorem, Euler's theorem, Pseudo-manifolds, Fundamental group of S^n.	**15**
Unit III	**Simplicial Approximation** Simplicial approximation, Induced homomorphism on the homology groups, The Brouwer's fixed point theorem.	**15**
Unit IV	**The Fundamental Group** Homotopic paths and Fundamental groups, Covering homotopy property for S^1, Examples of fundamental groups, Relation between first homology group and fundamental group.	**15**
Study Resources	• Croom, F. H. (1978).*Basic Concepts of Algebraic Topology*. Springer under graduate text. (Chapter-I: Art- 1.1 to 1.4, Chapter-II: Art-2.1 to 2.5, Chapter-III: Art-3.1 to 3.4, and Chapter-IV: Art-4.1 to 4.4.) • Deo, Satya. (2003).*Algebraic Topology-A primer*. Hindustan Book Agency. • Singer, I. M. and Thorpe, J. A. (1976).*Lecture Notes on Elementary Topology and Differential Geometry*. Springer Verlag, New York. • Spanier, E. H. (1994).*Algebraic Topology*. Third Edition, Springer Verlag New York Inc.	

S.Y.M.Sc.(Mathematics)
SEMESTER-IV
MTH-RP-625: Research Project-II

Hours: 180 **Credits: 6**

Course Objectives

1. To give exposure to the students to research culture and technology
2. To introduce students to how to select a research topic, plan, perform experiments, collect data and analyze the data
3. To foster self-confidence and self-reliance in the students as they learn to work and think independently

Course outcomes

After successful completion of this course, students are expected to:

1. Conceive a problem based on published research and conduct a comprehensive literature survey.
2. Plan and carry out the tasks in the given framework of the dissertation and present the work in writing and viva.
3. Learn handling of instruments, use of chemicals and how to conduct the experiments
4. Learn how to present the project in PowerPoint and answer the queries to examiners and the science of writing.

The systematic approach towards the execution of the project should be as follows:
(Wherever applicable)

1. The complete tenure of the research project should be one academic year. It should be allotted during the third semester and completed in the fourth semester.
2. Weekly 12 hours should be allotted to the research project in a regular timetable.
3. In the fourth semester, students should perform further experimental work, analyze the data and compile the results.
4. Students may be given an opportunity to participate in ongoing research activities in the respective Departments/Schools/Supervisors' laboratories. This will familiarize them with the literature survey and give them a fundamental understanding of designing and executing a research project.
5. Students may work individually or in groups (not more than 3 students) to be decided by the concerned department/supervisor.
6. Each research group should have a different research topic with some possible level of novelty.
7. The student should select the topic relevant to priority areas of concern or allied subjects.
8. Students are encouraged to work on multidisciplinary and applied projects, but it is not mandatory criteria.
9. Students are expected to work in line with the research outline and literature review, which was submitted in the third semester.
10. Students are expected to learn how to execute the research work systematically and overcome the hurdles. Students will get the opportunity to learn about practical aspects of many characterization techniques or models and further how to effectively employ them in the research work. Students should be able to critically evaluate the literature on the topic, identify the research gaps, plan and perform the experiments, interpret the results, understand the limitations of the work and draw conclusions.
11. At the end of the semester, each student should submit a detailed Research Report.
12. The format of the final research report shall be as per the guidelines of respective department. (**Example**: Title of the Project, Certificates, Acknowledgment, Abstract and Keywords, Contents, Introduction, Literature Review, Aim and objective, Materials and Methods, Result, Data analysis and Discussions, conclusion, limitations, suggestion, future scope, Bibliography, Appendix etc.)

13. An appropriate and essential conclusive statement must be drawn at the end of the study.
14. Students should maintain lab notebooks, and the supervisor may ask them to submit the mid-semester progress report.
15. For documents related to project submission: Font- Times New Roman, Heading Font Size-14, Normal Text Size-12, spacing-1.5, both sides justified and 1 inch margin on all side, both side printing on A-4 size.
16. Three copies of the dissertation should be prepared (one copy for each department, guide, and student).
17. At the end of the semester, the candidate should prepare and present research using a PowerPoint presentation using modern ICT tools during the Internal and External Examination.
18. Besides writing a dissertation, students are encouraged to write a manuscript/patent if the results obtained are worthy of publication.
19. Students may present their research work in Avishkar/Webinars/Conferences.
20. Students should note that plagiarism is strictly prohibited.

Internal examination (60 marks): Components of continuous internal assessment:

- Literature collected, methodological planning, analysis of data, design and work, progress reports etc (30 marks)
- Presentation in Webinars/Conferences/publication and departmental presentation etc (20 marks)
- Oral examination (10 marks)

External examination (90 marks) and Components of external assessment:

- Evaluation of dissertation submitted in bound form at the time of examination **(60 marks)**
- Presentation (PPT format) **(15 marks)**
- Overall presentation reflecting the contribution of work, Response to questions **(15 marks)**