Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Structure and Curriculum of Two-Year Degree Programme

Postgraduate Programme of Science and Technology

M.Sc. in Mathematics

Board of Studies in Mathematics

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

w.e.f. June, 2024

(In Accordance with NEP-2020)

Academic Year : 2024-25

Review Statement

The NEP Cell reviewed the Curriculum of **M.Sc. Mathematics** Programme to be effective from the **Academic Year 2024-25.** It was found that, the structure is as per the NEP-2020 guidelines of Govt. of Maharashtra.

Date: 13/03/2024

Place: Latur

NEP Cell
Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)

CERTIFICATE

I hereby certify that the documents attached are the Bonafide copies of the Curriculum of **M.Sc. Mathematics** Programme to be effective from the **Academic Year 2024-25.**

Date: 13/03/2024

Place: Latur

Dr. M S Wavare
Chairperson
Board of Studies in Mathematics
Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Members of Board of Studies in the Subject Mathematics

Under the Faculty of Science and Technology

Department of Mathematics

Sr. No.	Name	Designation	In position
1	**Dr. Mahesh S Wavare** Professor and Head, Department of Mathematics, Rajarshi Shahu Mahavidyalaya, Latur (Autonomous)	Chairperson	HoD
2	**Dr. Bhalchandra D. Karande** Head and Associate Professor, Department of Mathematics, Maharashtra Udaygiri Mahavidyalaya, Udaygiri Dist. Latur.	Member	V.C. Nominee
3	**Dr. S. D. Kendre**, Associate Professor, Department of Mathematics, Savitribai Phule Pune University, Pune.	Member	Academic Council Nominee
4	**Dr. M. T. Gophane** Associate Professor,Department of Mathematics Shivaji University, Kolhapur.	Member	Academic Council Nominee
5	**Dr. N. S. Darkunde** School of Mathematical Sciences, S. R. T. M. U Nanded.	Member	Expert from outside for Special Course
6	**Mr. S. S. Ranmal** Sungrace Computers Pvt Ltd, Pune.	Member	Expert from Industry
7	**Prof. S. M. Shinde** Department of Mathematics, Government College of Engineering, Amravati, Dist. Amaravati.	Member	Alumni
8	**Dr. N. S. Pimple**	Member	Faculty Member
9	**Miss. S. D. Shinde**	Member	Faculty Member
10	**Mr. P. D. Bombalge**	Member	Faculty Member
11	**Mr. N. D. Kapale**	Member	Faculty Member
12	**Dr. A. A. Yadav**	Member	Member from the same faculty

From the Desk of the Chairperson…

When Shiv Chhatrapati Shikshan Sanstha started the Science Faculty in Rajarshi Shahu Mahavidyalaya, Latur in 1971, the Department of Mathematics was founded. In the beginning, there was just one instructor for the PUC class and the first year of the B.Sc. B.Sc.-II and B.Sc. III year courses began in 1973 and 1974, respectively, in response to the natural expansion. During the 2017–2018 academic year, the department launched its M.Sc. Mathematics programme with a 30-student entry limit.

The undergraduate degree course in mathematics is a six- or eight-semester course spanned across three- or four-academic years, in accordance with the guidelines of the Undergraduate Curriculum Framework 2022 (UGCF 2022). The teaching and learning process is centered on the learner and includes both theoretical and practical elements. While guaranteeing that the student has a solid foundation in the topic and obtains in-depth knowledge, it provides flexibility in program structure. A student may choose courses from the syllabus that includes Discipline Specific Electives (DSEs), Generic Electives (GEs), Skill Enhancement Courses (SECs), Ability Enhancement Courses (AECs), and Value Addition Courses (VACs) in addition to the Discipline Specific Core (DSC) courses. As a result, the interdisciplinary approach and commitment to creative approaches within the curricular framework are highlighted.

The new National Education Policy (NEP), 2020, which includes significant elements, offers a platform to develop, nurture, grow, encourage, and multiply mathematical thinking. To achieve a balance between the requirement for employment in the twenty-first century and entrepreneurship, which is characterized by lateral, critical, and numerical thinking, the essential changes have been put in place. The NEP acknowledged the importance of mathematical thinking and how necessary it is for the country to become a Vishwa guru. The NEP provides children with the nutrition they require by making mathematics enjoyable and engaging from the very beginning. Because it encourages the development of computer skills and intuitive reasoning, the NEP also requires the adoption of a coding curriculum, which should start in middle school.

The courses for the UG Programme are framed using time tested and internationally popular text books so that the courses are at par with the courses offered by any other reputed universities around the world.

Only those concepts that can be introduced at the UG level are selected and instead of cramming the course with too many ideas the stress is given in doing the selected concepts rigorously. The idea is to make learning mathematics meaningful and an enjoyable activity rather than acquiring manipulative skills and reducing the whole thing an exercise in using thumb rules.

As learning Mathematics is doing Mathematics, to this end, some activities are prescribed to increase student's participation in learning. Duration of the degree Programme shall be six- or-eight semesters distributed in a period of three/four academic years.

(Dr. Mahesh S Wavare)

Chairperson
Board of Studies in Mathematics

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

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Department of Political Science

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Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

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Department of Mathematics

PG Skeleton in Accordance with NEP-2020

Illustrative Credit Distribution Structure for Two Years M.Sc. Degree

Year Level	Sem	Major 24-28(22-26) per Sem 46-56 for two years		RM	OJT/FP	RP	Cum. Cr	Marks	Degree
		Mandatory	**Elective**						
I 6.0	I	Major I 4 Cr Major II 4 Cr Major III 4 Cr	MEC I 4 Cr	RMC 4 Cr	*NA*	*NA*	20 Cr	Theory : 01 Cr. = 25 M. Lab Course (Science): 01 Cr. = 50 M.	PG Diploma (After 03 Year UG Degree)
	II	Major IV 4 Cr Major V 4 Cr Major VI 4 Cr	MEC II 4 Cr	*NA*	OJT I 4 Cr/ FP I 4 Cr	*NA*	20 Cr	OJT/FP : 01 Cr. = 25 M.	
	Total	**Major 24 Cr**	**MEC 08 Cr**	**RMC 04 Cr**	**OJT/FP 04 Cr**	**NA**	**40 Cr**		
	Exit Option: PG Diploma with 40 Credits After 03 Year B.Sc. Degree								
II 6.5	III	Major VII 4 Cr Major VIII 4 Cr Major IX 4 Cr	MEC III 4 Cr	*NA*	*NA*	RPI 4 Cr	**20 Cr**	RP I & RP II: 01 Cr. = 25 M	PG Degree (After 03 Year UG Degree)
	IV	Major X 4 Cr Major XI 4 Cr Major XII 4 Cr	MEC IV 4 Cr	*NA*	*NA*	RPII 6 Cr	**22 Cr**		
	Total	**Major 24 Cr**	**MEC 08 Cr**	**NA**	**NA**	**RP 10 Cr**	**42 Cr**		
Cum. Total of I & II Year		**Major 48 Cr**	**MEC 16 Cr**	**RMC 04 Cr**	**OJT/FP 04 Cr**	**RP 10 Cr**	**40+42 =82 Cr**		**82 Credits**
	Exit Option: Two Years 04 Sem. PG Degree with 82 Credits After 03 Year UG Degree								

Abbreviations:

1. MEC : Major Elective Course
2. RMC : Research Methodology Course
3. OJT : On Job Training (Internship/Apprenticeship)
4. FP : Field Project
5. RP : Research Project
6. Cum. Cr : Cumulative Credit

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur (Autonomous)

Department of Mathematics

M.Sc. Mathematics Skeleton in Accordance with NEP-2020

Illustrative Credit Distribution Structure for Two Years/One Year PG (M.Sc.)

Year & Level	Sem	Major 24-28(22-26) per Sem 46-56 for two years		RM	OJT/FP	RP	Cum. Cr	Marks	Degree
		Mandatory	**Elective**						
II **6.5**	**III**	**Ring Theory** 4 Cr **Functional Analysis** 4 Cr **Classical Mechanics** 4 Cr	Coding Theory 4 Cr or Numerical Linear Algebra 4 Cr or NPTEL/SWAYAM MOOC's Equivalent Courses 4 Cr	*NA*	*NA*	**Research Project I 4 Cr**	**20 Cr**	RP I & RP II: 01 Cr. = 25 M	**PG Degree (After 03 Year UG Degree)**
	IV	**Field Theory** 4 Cr **Linear Integral Equations** 4 Cr **Numerical Analysis** 4 Cr	Fuzzy Mathematics 4 Cr or Fractional Calculus 4 Cr or NPTEL/SWAYAM MOOC's Equivalent Courses 4 Cr	*NA*	*NA*	**Research Project II 6Cr**	**22 Cr**		
	Total	**Major 24 Cr**	**MEC 08 Cr**	**NA**	**NA**	**RP 10 Cr**	**42 Cr**		
Cum. Total of I & II Year		**Major 48 Cr**	**MEC 16 Cr**	**RMC 04 Cr**	**OJT/FP 04 Cr**	**RP 10 Cr**	**40 +4 2= 82**		**82 Credits**
	Exit Option: Two Years 04 Sem. PG Degree with 82 Credits After 03 Year UG Degree								

Programme Outcomes (POs) for M.Sc. Programme	
PO No.	Upon completion of this Programme the students will be able to
PO 1	To Develop their mathematical knowledge, oral, written, and practical skills in a way to enhance confidence and provide satisfaction.
PO 2	To inculcate the confidence by developing a feel for numbers, patterns, and relationships.
PO 3	To advance an ability to consider, solve problems, present and interpret results.
PO 4	To improve Communication and reason using mathematical concepts.
PO 5	To understand mathematical principles and their applications.
PO 6	To foster the abilities to reason logically, to classify, to generalize and to prove.
PO 7	To acquire the foundation, appropriate to their further studies of mathematics and of other disciplines.
PO 8	To do research project in the field of Mathematics.

Programme Specific Outcomes (PSOs) for M.Sc. in Mathematics	
PSO No.	Upon completion of this programme, the students will be able to
PSO 1	Upgrade the knowledge to qualify CSIR-NET/SET/GATE in Mathematical Sciences.
PSO 2	Get tune with further studies of their area of interest.
PSO 3	Be good teacher in Mathematics subject.
PSO 4	Get placed in job of Scientific Computing /Data Analyst etc .
PSO 5	Comprehend and write effective reports and design documentation related to mathematical research and literature, make effective presentations.
PSO 6	Implant in students' inventive qualities, teamwork, and ethical practices in order to achieve society standards.
PSO 7	Provide a high-quality education by incorporating projects, participatory learning, and cutting-edge software tools into successful teaching and learning processes.
PSO 8	Provide a comprehensive curriculum which will educate students towards becoming great scientific professionals.
PSO 9	Inculcate the interest for mathematics in students and to prepare them for potential research.
PSO 10	Promote collaborative learning and application of mathematics to real life situation.

Semester - III

Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)
Department of Mathematics

Course Type : Major-VII
Course Title : Ring Theory
Course Code : 601MAT3101
Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives

LO1 Basic properties of rings, examples of rings,
LO2 ideals, algebra of ideals
LO3 Homomorphism and isomorphism of rings
LO4 Integral domain, UFD, PID's and ED

Course outcomes

After completion of course the student will be able to-
CO1 Different useful types of rings
CO2 Concept of ideals and quotient ring
CO3 Similarities between two rings by means of homomorphism and isomorphisms
CO4 Integral domain, UFD, PID's and ED

Unit No.	Title of Unit & Contents	Hrs.
I	**Rings**	**15**
	1. Terminology, Rings of Continuous Functions, Matrix Rings, Polynomial Rings, Power Series Rings, Laurent Rings, Boolean Rings, Some Special Rings 2. Direct Products 3. Several Variables ring 4. Opposite Rings 5. Characteristic of a Ring.	
	Unit Outcome: UO 1. Classify the various rings with terminology UO 2. Identify Characteristic of Rings	
II	**Ideals**	**15**
	1. Definitions 2.Maximal Ideals, Generators 3.Basic Properties of Ideals 4.Algebra of Ideals 5.Quotient Rings 6.Ideals in Quotient Rings 7.Local Rings	
	Unit Outcome: UO 1. Get concept of Ideals and algebra of ideals UO 2. Evaluate quotient ring and ideals in quotient ring	
III	**Homomorphism of Rings**	**15**
	1. Definitions and Basic Properties 2. Fundamental Theorems Endomorphism Rings	

Unit No.	Title of Unit & Contents	Hrs.
	3. Field of fractions 4. Prime fields	
	Unit Outcomes: UO 1. Get concept of homomorphism of rings UO 2. Find field of fraction and prime fields	
IV	**Factorization in Domains**	**15**
	1. Division in Domains 2. Euclidean Domains 3. Principal Ideal Domains 4. Factorization Domains 5. Unique Factorization Domains 6. Eisenstein's Criterion	
	Unit Outcome: UO 1. Classify domains and it's properties UO 2. Apply Eisenstein's Criterion	

Learning Resources:

1. C. Musili, Introduction to RINGS AND MODULES Second Revised Edition, Narosa Publishing House
2. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, "Basic Abstract Algebra", (Second Ed.) Cambridge Univ. Press (Indian Ed.1995)
3. Joseph A. Gallian, "Contemporary Abstract Algebra", (Fourth Ed.), Narosa, 1999.
4. V.K. Khanna, S.K. Bhambri, "A Course in Abstract Algebra", Vikas Publishing House.
5. David Dummit and Richard Foote, "Abstract Algebra", John Wiley and Sons.

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Mathematics

Course Type : Major-VIII
Course Title : Functional Analysis
Course Code : 601MAT3102
Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives

LO1 To introduce students, the Hahn-Banach Theorem
LO2 To learn Properties of Hilbert spaces
LO3 To familiarize with different operators-such as adjoint, conjugate, normal. Positive, Unitary etc.,
LO4 To develop working knowledge on Projections, eigen value and eigen vectors, eigen space and Spectrum of T.

Course outcomes

After completion of course the student will be able to-

CO1 Identify Normed Linear Space, Banach Space, continuous Linear transformations, Conjugate space, Banach Algebra, Graph of linear transformation, Hahn-Banach Theorem and its applications, Open Mapping and Closed Graph Theorems.
CO2 Analyze Hilbert space, Orthogonal and Orthonormal vectors and sets, Orthogonal Compliments and conjugate space H*., Schwart Lemma, Bessel's Inequality and Riesz representation theorem.
CO3 To Identify, Self adjoint, Normal, Unitary and Positive operators and to analyze the invariant subspace and reducible transformations.
CO4 To Provide information on Eigen Value, Eigen Vectors, Eigen Spaces and Spectrum of T.

Unit No.	Title of Unit & Contents	Hrs.
I	**Banach spaces**	**15**
	1. Normed linear spaces, Banach spaces, Quotient norm spaces 2. Continuous linear transformations, equivalent norms 3. The Hahn-Banach theorem and its consequences. 4. The Natural imbedding of N in N**	
	Unit Outcome: UO 1. To understand basics of Banach Space UO 2. To understand the Hahn-Banach Theorem	
II	**Open Mapping theorem and Orthonormal Sets**	**15**
	1. The open mapping Theorem, the closed graph theorem, 2. The conjugate of an operator, the uniform boundedness principle, 3. orthogonal complements, The projection theorem, orthogonal sets	

Unit No.	Title of Unit & Contents	Hrs.
	4. The Bessel's inequality, Fourier expansion and Perseval's equation, Separable Hilbert spaces	
	Unit Outcome: UO 1. To apply Open mapping theorem and Closed graph theorem UO 2. To study Bessel's inequality , Fourier expansion and Perseval's equation	
III	**Hilbert spaces**	**15**
	1. Definition and examples and simple properties 2. The conjugate space, Riesz's theorem 3. The adjoint of on operators, self adjoint operators 4. Normal and unitary operators, projections, Contraction mapping and Banach fixed point theorem.	
	Unit Outcomes: UO 1. To understand different operators in Banach Spaces. UO 2. To familiarize with the Contraction mapping and BFPT	
IV	**Finite Dimensional Spectral Theory**	**15**
	1. Matrices 2. Determinants and spectrum of an operator 3. The spectral Theorem	
	Unit Outcome: UO 1. To understand the Spectral theory and Spectrum theorem.	

Learning Resources:

1. G.F. Simmons, "Introduction to Topology and Modern Analysis", McGraw-Hill Book Company, International student Edition, New York.
2. B.V. Limaye, "Functional Analysis", Wiley Eastern Ltd.
3. G. Bachman and L. Narici, "Functional Analysis".
4. Erwie Krey zig, "Introductory Functional Analysis with Applications", John Wiley & Sons, New York, 1978Academic Press 1966.
5. J. B. Conway, "A course in functional analysis", Springer-Verlag, New York 1990.
6. S. Ponnusamy, "Foundations of Functional Analysis", Narosa Publishing House

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Mathematics

Course Type : Major-IX
Course Title : Classical Mechanics
Course Code : 601MAT3103
Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives:

LO1 To study D' Alembert's Principle, Lagrange's equations of motion
LO2 To study Euler- Lagrange's equations
LO3 To study Hamiltonian and least action principle
LO4 To study Kinematics of rigid body motion.

Course Outcomes:

After completion of course the student will be able to-
CO1 Understood the mechanics of the system of particles
CO2 Able to apply Euler Lagrange's equation to extremis the functional.
CO3 Well understood The Kinematics of rigid body motion

Unit No.	Title of Unit & Contents	Hrs.
I	**Survey of the Elementary Principles**	**15**
	1. Mechanical of system of particles, Mechanics of system of particles 2. Conservation theorems conservative forces with examples 3. Constraints, Generalized co-ordinates. D. Alembert's principle 4. Lagrange's equations of motion. The forms of Lagrange's equations of motion for non conservative systems and partially conservative and partially non conservative systems 5. Kinetic energy as a homogeneous function of generalized velocities. Simple applications of the Lagranian formulation.	
	Unit Outcomes: UO 1. Acquaint with the basic concepts of system of particle such as constraint, Generalized co-ordinates. D. Alembert's principle UO 2. Able to apply the Lagrange Formula	
II	**Calculus Of Variation**	**15**
	1. Cyclic co-ordinates and generalized momentum conservation Theorems 2. Calculus of variation, Euler Lagrange's equation, First integrals of Euler Lagrange's equation, the case of several dependent variables 3. Geodesics in a plane, the minimum surface of revolution, Brachistochrome problem 4. Isoperimetric problems, problems of maximum enclosed area.	

Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcome: UO 1. To evaluate extremal of the function	
III	**Hamiltonian Equations of Motion**	**15**
	1. Hamiltonian function, Hamilton's canonical equations of motion 2. Derivation of Hamilton's equations from variational principle, Physical significance of Hamiltonian 3. The principle of least action, Jacobi's form of the least action principle 4. Cyclic co-ordinates and Routh's procedure	
	Unit Outcome: UO 1. To understood the Hamilton equation and principle of least action	
IV	**The Rigid Body Equation of Motion**	**15**
	1. The independent co-ordinates of a rigid body 2. Orthogonal transformations, Properties of transformation matrix 3. Infinitesimal rotations, The Eulerian angles, The Calyley-Klein parameters 4. Eulers theorem on motion of rigid body, Angular momentum and kinetic energy of motion of a rigid body about a point	
	Unit Outcome: UO 1. One can Apply Euler's Theorem.	

Learning Resources:

1. Goldstein, H. , "Classical Mechanics". (1980), Narosa Publishing House, New Delhi.
2. Weinstock, "Calculus of Variations with Applications to Physics and Engineering" (International Series in Pure and Applied Mathematics). (1952), Mc Graw Hill Book Company, New York.
3. Whittaker, E. T., "A treatise on the Analytical Dynamics of particles and rigid bodies". (1965), Cambridge University Press.
4. Rana, N.C. and Joag, P. S.," Classical Mechanics". (1991) Tata McGraw Hill, New Delhi.
5. Bhatia, V. B. Classical Mechanics with Introduction to Non-linear Oscillation and Chaos.(1997), Narosa publishing House.
6. Gupta, A. S. Calculus of Variations with Applications (1997), Prentice Hall of India.
7. Gelfand, I. M. and Fomin, S. V. Calculus of Variations (1963), Prentice Hall of India.
8. Mondal, C. R.," Classical Mechanics" (2001), Prentice Hall of India.

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Mathematics

Course Type : MEC-III(A)
Course Title : Coding Theory
Course Code : 601MAT3201
Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives:

LO1 To introduce Error detection, correction and decoding of codes
LO2 To study Finite Fields, to Introduce linear codes, and to acquire knowledge of encoding and decoding using linear codes.
LO3 To Discuss various bounds in coding theory
LO4 To construct linear codes.

Course Outcomes:

After completion of course the student will be able to-
CO1 Detect, correct, and decode given code.
CO2 Construct finite fields and compute minimal polynomial.
CO3 Study Linear codes and some bounds in coding theory.
CO4 Construct Linear Codes.

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction to Error detection, correction and decoding and Finite fields**	**20**
	1. Communication channels, Maximum likelihood decoding 2. Hamming distance, Nearest neighbor/minimum distance decoding 3. Distance of a code 4. Fields, Polynomial rings, Structure of finite fields, Minimal polynomials.	
	Unit Outcomes: UO 1. Knowing about communication Channels, Hamming distance and parameters of code. UO 2. Introduction to finite field and minimal polynomial.	
II	**Linear Codes**	**15**
	1. Vector spaces over finite fields, Linear codes 2. Hamming weight, Bases for linear codes, Generator matrix and parity-check matrix 3. Equivalence of linear codes, Encoding with a linear code 4. Decoding of linear codes (Cosets, Nearest neighbour decoding for linear codes, Syndrome decoding)	

Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcomes: UO 1: To study bases for linear codes UO 2: To encode and decode using Linear codes.	
III	**Bounds in coding theory**	**15**
	1. The main coding theory problem, Lower bounds, Sphere-covering bound 2. Gilbert–Varshamov bound, Hamming bound and perfect codes, Binary Hamming codes 3. q-ary Hamming codes, Golay codes, Some remarks on perfect codes 4. Singleton bound and MDS codes, Plotkin bound.	
	Unit Outcomes: UO1: To study bounds in coding theory UO2: To study perfect codes.	
IV	**Constructions of linear codes**	**10**
	1. Propagation rules 2. Reed–Muller codes 3. Subfield codes.	
	Unit Outcomes: UO1: To study Construction rules for linear codes. UO2: To discuss Reed-Muller Codes and Subfield subcodes.	

Learning Resources:

1. San Ling and Chaoping Xing, Coding Thoery A First Course. Cambridge University Press
2. E.R. Berlekemp, Algebraic Coding Thoery , McGraw-Hill New York(1968) Publishing House.
3. F J MacWilliams and N J A Sloane, The Theory of Error –Correcting Codes, North Holland
4. Lid and Pilz , Applied Abstract Algebra - 2nd Edition.
5. R. Lidl, H. Neiderreiter , Introduction to finite fields and their applications, Cambridge University Press.

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Mathematics

Course Type : MEC-III(B)
Course Title : Fractional Calculus
Course Code : 601MAT3202
Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives

LO1 Mittag-Leffler Functions of one and two parameters
LO2 Fractional derivatives
LO3 Fractional integrals
LO4 To solve fractional differential equations

Course outcomes

After completion of course the student will be able to-
CO1 Discuss about beta and Gamma functions
CO2 Calculate fractional derivatives and fractional integral
CO3 Do geometric and physical interpretation of fractional integral and fractional differentiation.
CO4 Solve fractional differential equation

Unit No.	Title of Unit & Contents	Hrs.
I	**Gamma and Beta Functions**	**15**
	1. Definition of the Gamma and Beta Functions, Some properties of Gamma and Beta Functions 2. Relation between Gamma and Beta Functions 3. Special Function: Definition of Mittag-Leffler Functions of one and two parameters, Relations of Mittag-Leffler Function to some other functions 4. The Laplace transform of Mittag-Leffler Function in two parameters 5. Wright Function, Definition of Wright function	
	Unit Outcomes: **UO1:**Get concepts of Beta and Gamma functions UO2: Able to do problems on special function as Mittag-Leffler and Wright Function.	
II	**Fractional Derivative and Integrals**	**15**
	1. Integral relation and relation to other functions, Grunwald-Letnikov fractional derivatives 2. Riemann-Liouville fractional derivatives,Caputo's fractional derivative	

Unit No.	Title of Unit & Contents	Hrs.
	3. Fractional derivatives of standard functions and their graphical representation by Mathematical softwares Fractional integrals	
	Unit Outcomes: **UO1:**Calculate fractional derivatives and integrals. **UO2:** Understand graphical representation of fractional derivatives of standard function by software.	
III	**Integral transform of fractional derivatives**	**15**
	1. Geometric and physical interpretation of fractional integral and fractional differentiations 2. Left and right fractional derivatives. 3. Laplace transform of fractional derivatives 4. Fourier transform of fractional derivatives and Mellin transform of fractional derivatives	
	Unit Outcomes: **UO1:**Knowledge of Geometric and physical interpretation of fractional integral and fractional differentiations. **UO2:** Compute Integral transform of fractional derivatives.	
IV	**Fractional differential equations**	**15**
	1. Linear fractional differential equations (homogeneous fractional differential equations and non-homogeneous fractional differential equations) 2. Existence and uniqueness theorem as a method of solution, 3. Laplace transform method to solve fractional differential equations	
	Unit Outcomes: **UO1:**Solving homogeneous fractional differential equations and non-homogeneous fractional differential equations **UO2:**Solving fractional differential equations using Laplace Transform.	

Learning Resources:

1. Igor Podlubny - Fractional Differential Equations, Academic press, San Diego, California.
2. Miller K. S. and Ross B. – An Introduction to Fractional Calculus and Fractional Differential Equations, New York, John Wiley, 1993.
3. Oldham K. B. and Spanier J. – The Fractional Calculus, New York, Academic press, 1974.
4. Igor Podlubny - Fractional Differetial Equations, Academic Press, Boston, New York.
5. Anatoly A. Kilbas, Hari M. Shrivastav, Juan J. Trujillo- Theory and Applications of Fractional Differential Equations, Elesevier, New York 2006.
6. Shananu Das – Functional Fractional Calculus, 2011 Springer-Verlag, Berlin Heidelberg.

Semester - IV

Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)
Department of Mathematics

Course Type : Major-X
Course Title : Field Theory
Course Code : 601MAT4101
Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives

LO1 To Know Algorithm for factorization
LO2 To obtain Fields Extension
LO3 To Know Normal and Separable extension
LO4 To Find Galois Group

Course outcomes

After completion of course the student will be able to-
CO1 Apply Schoneman-Eisenstein criterion
CO2 Find degree of extension using tower theorem
CO3 Apply theory of splitting fields
CO4 Find Galois group.

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction**	**15**
	1. Definition and examples of fields 2. Minimal polynomial, adjoining elements 3. Irreducible polynomial, Algorithm for factorization 4. The Schoneman- Eisenstein criterion	
	Unit Outcome: UO1. Determine Irreducibility of polynomials UO2. Able to apply Schoneman-Eisenstein criterion	
II	**Fields Extension**	**15**
	1. Prime radicals 2. The degree of extension 3. Finite Extensions 4. The Tower theorem 5. Algebraic extension	
	Unit Outcome: UO1. Finding Degree of Extension UO2. Know characterisation of finite extension	
III	**Normal and Separable extension**	**15**
	1. Splitting fields Definition and examples	

Unit No.	Title of Unit & Contents	Hrs.
	2. Uniqueness of splitting fields 3. Normal extensions, Separable extension 4. Fields of characteristic zero, Fields of characteristic p 5. Theorem of primitive element.	
	Unit Outcomes: UO1. Finding Splitting field of polynomials UO2. Apply theory of Separable and Normal Extension	
IV	**The Galois Group**	**15**
	1. Definition of the Galois Group 2. Galois group of splitting fields, Permutations of the roots 3. Automorphism of groups and Fixed field, 4. Fundamental theorem of Galois Theory, Fundamental Theorem of Algebra 5. examples of Galois groups, polynomial solvable by radicals	
	Unit Outcome: UO1. Evaluate Galois group of splitting field UO2. Apply theorem of algebra	

Learning Resources:

1. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, "Basic Abstract Algebra", (Second Ed.), Cambridge Univ. Press (Indian Ed.1995).
2. V.K. Khanna, S.K. Bhambri, "A Course in Abstract Algebra", Vikas Publicing House. (Second Edition)
3. David Dummit and Richard Foote, "Abstract Algebra", John Wiley and Sons.
4. David A Cox, "Galois Theory". Second edition,A John Wiley and Sons, INC, publication

Course Type : Major-XI
Course Title : Linear Integral Equations
Course Code : 601MAT4102
Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives

LO1 To study Convolution
LO2 To classify Volterra integral equations of first and second kind
LO3 To learn Laplace Transform applications to solve Volterra integral equations
LO4 To learn Abels singular integral equation

Course outcomes

After completion of course the student will be able to-

CO1 Understand the Relationship between Linear Differential equations and Volterra Integral Equations, and solutions by using resolvent kernels.
CO2 Evaluate Characteristic numbers and Eigen functions and its properties.
CO3 Apply method of successive approximation
CO4 Discuss Eulers Integrals, Abel's problem, Iterated Kernels.
CO5 Apply Laplace Transformation to get the solution of Integro-Differential Equations, Volterra Integral Equation of the First kind

Unit No.	Title of Unit & Contents	Hrs.
I	**Integral equations**	**15**
	1. Definition and classification of integral equations, Special kinds of kernels 2. Convolution integrals, Conversion of an initial value problem into a Volterra integral equation 3. Conversion of a boundary value problem into a Fredholm integral equation, Eigen values and eigen functions 4. Solution of homogeneous Fredholm integral equations of the second kind with separable kernel, Fredholm alternative.	
	Unit Outcome: UO 1. To classify integral equations UO 2. To convert IVP and BVP into FIE and VIE	
II	**Methods of Successive approximation**	**15**
	1. Method of successive approximation, Iterated kernel, Resolvent kernel 2. Solution of Fredholm and Volterra integral equations of the second kind by the method of successive substitutions	

Unit No.	Title of Unit & Contents	Hrs.
	3. Solution of Fredholm and Volterra integral equations of the second kind by the method of successive approximations: Neumann series.	
	Unit Outcome: UO 1. To apply method of successive approximation to solve integral equations.	
III	**Integral Equations with Symmetric Kernels**	**15**
	1. Integral equations with symmetric kernels, Regularity conditions, Complex Hilbert space 2. An orthonormal system of functions, Fundamental properties of eigen values and eigen functions for symmetric kernels. 3. Expansion in eigen functions and bilinear form, Hilbert-Schmidt theorem and some immediate consequences. 4. Singular integral equations, The Abel integral equation examples	
	Unit Outcomes: UO 1. To evaluate kernels of integral equations UO 2. To obtain solutions of Abel's singular integral equations	
IV	**Integral transform method**	**15**
	1. Integral transform method 2. Application of Laplace transform to solve Volterra integral equations with convolution type kernels 3. Application of Fourier transform to solve integral equations, Examples.	
	Unit Outcome: UO 1. To solve Volterra and Fredholm integral equations by using Laplace Transform	

Learning Resources:

1. T R.P. Kanwal, "Linear Integral Equations Theory and Technique", Academic Press, Inc., New York.
2. Dr. M. D. Raisinghania, "Integral Equations and Boundary Value Problems", S. Chand and Company Pvt. Ltd., New Delhi.
3. S.G. Mikhlin, "Linear integral equations" (Translated from Russian), Hindustan Book Agency 1960.
4. B.L. Moiseiwitsch, "Integral Equations", Longman, London & New York.
5. M. Krasnov, A Kiselev, G. Makaregko, "Problems and Exercises in integral equations" (Translated from Russian by George Yankovsky) MIR Publishers Moscow, 1971.

Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)
Department of Mathematics

Course Type : Major-XII
Course Title : Numerical Analysis
Course Code : 601MAT4103
Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives

LO1 To solve algebraic, transcendental, and differential equations, and to calculate derivatives and integrals
LO2 To understand of the elements of error analysis for numerical methods and certain proofs.
LO3 To develop problem solving skills

Course outcomes

After completion of course the student will be able to-
CO1 Solve an algebraic or transcendental equation using an appropriate numerical method
CO2 Approximate a function using an appropriate numerical method
CO3 Solve a differential equation using an appropriate numerical method
CO4 Evaluate a derivative and integration at a value using an appropriate numerical method

Unit No.	Title of Unit & Contents	Hrs.
I	**Solution to Numerical, Algebraic and Transcendental Equation**	**15**
	1. Iterative solutions of nonlinear equation: bisection method 2. Regula falsi method, Fixed-point iteration, Newton's method, secant method 3. Acceleration of convergence 4. Newton's method for two nonlinear equations, polynomial equation methods	
	Unit Outcome: UO 1. Able to find approximate solution of algebraic and transcendental equation. UO 2. To know the rate of convergence of Newton's method, secant method	
II	**Interpolation**	**15**
	1. Polynomial interpolation: interpolation polynomial, , 2. Divided difference interpolation, Aitken's formula 3. Finite difference formulas,	

Unit No.	Title of Unit & Contents	Hrs.
	4. Hermite's interpolation, double interpolation	
	Unit Outcome: UO 1. To Interpolate the polynomial from given tabulated entries	
III	**Simultaneous Linear Algebraic Equation**	**15**
	1. Linear systems of Equations: Gauss Elimination 2. Gauss-Jordan method, LU decomposition 3. Iterative methods: Jacobi Method of Iteration 4. Gauss- Seidel iteration.	
	Unit Outcomes: UO 1. To solve linear system of equation using direct method and iterative method	
IV	**Numerical calculus**	**15**
	1. Numerical Calculus: Numerical differentiation, Errors in numerical differentiation. 2. Numerical Integration, Trapezoidal rule, Simpson's 1/3 - rule, Simpson's 3/8 rule. 3. Error estimates for Trapezoidal rule and Simpson's ule.	
	Unit Outcome: UO 1. To Evaluate the numerical differentiation and integration	

Learning Resources:

1. S. S. Sastry, Introduction Methods of Numerical Analysis (4th Edition) (Prentice-Hall).
2. K .E. Atkinson,: An Introduction to Numerical Analysis
3. J. I. Buchaman and P. R. Turner, Numerical Methods and Analysis.
4. DR. V. N. Vedamurthy, DR. N. Ch. S. N. Iyengar, Numerical Methods

Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)
Department of Mathematics

Course Type : MEC-IV(A)
Course Title : Numerical Linear Algebra
Course Code : 601MAT4201
Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives:

LO1 To review of linear algebra concepts.
LO2 To apply Gram Schmidt orthogonalization process.
LO3 To Compute floating point representation of numbers.
LO4 To Compute condition number of a matrix

Course Outcomes:

After completion of course the student will be able to-
CO1 Analyze the basic operations on vector spaces numerically.
CO2 Introduce MATLAB and compute sign integer representation of numbers.
CO3 Discuss the stability of systems
CO4 To compute condition numbers of matrix

Unit No.	Title of Unit & Contents	Hrs.
I	**Review of Linear Algebra**	**15**
	1. Matrix operations and type of matrices, Determinant of a Matrix 2. Rank of a matrix, Vector Spaces, Linear dependence and independence 3. Bases and Dimensions, Linear Transformation Orthogonal subspaces 4. Row space, column space and null Space, Eigenvalues and Eigenvectors, Diagonalizable Matrices.	
	Unit Outcome: UO 1**:** To review linear algebra	
II	**Orthogonal sets and sign representation of numbers**	**15**
	1. Orthogonal Sets, Gram Schmidt orthogonalization and orthonormal bases 2. Introduction to MATLAB 3. Sign integer representation, Computer representation of numbers.	
	Unit Outcome: UO 1**:** To compute integer sign representation of numbers	

Unit No.	Title of Unit & Contents	Hrs.
III	**Floating point representation**	**15**
	1. Floating point representation, Round-off error 2. Error propagation in computer arithmetic 3. Addition and multiplication of floating point numbers	
	Unit Outcomes: UO 1. To compute error in computer arithmetic UO 2. To do addition and multiplication of floating-points	
IV	**Conditioning and condition numbers**	**15**
	1. Conditioning and condition numbers, Stability of numerical algorithms 2. Vector norms, Matrix Norms, Convergent Matrices 3. Stability of non-linear system Condition number of a matrix and Elementary properties.	
	Unit Outcomes: UO1: To study stability of Numerical Algorithms UO2: To study Convergent matrices and stability of non-linear systems.	

Learning Resources:

1. V. Sundarapandian, Numerical Linear Algebra, PHI, 2008.
2. Biswa Nath Dutta, Numerical Linear Algebra and Applications, SIAM, 2010.
3. Roger A. Horn and Charles R. Johnson, Matrix Analysis, Cambridge University Press,1994
4. William Ford, Numerical Linear Algebra with Applications, Academic Press, 2014.

Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)
Department of Mathematics

Course Type : MEC-IV(B)
Course Title : Fuzzy Mathematics
Course Code :
Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives

LO1 To learn crips and fuzzy set theory and make calculation on fuzzy set theory
LO2 To recognize fuzzy logic membership function
LO3 To make applications on Fuzzy logic membership function and fuzzy inference systems
LO4 To understand applications of semantic interpreters, control systems and reasoning systems

Course outcomes

After completion of course the student will be able to-
CO1 Understand basic knowledge of the fuzzy sets, operations and their properties
CO2 Understand the fundamental concepts of Fuzzy functions and Fuzzy logic.
CO3 Apply the concepts of Fuzzy sets in image processing, pattern reorganization and decision making.
CO4 Identify the applications of fuzzy sets

Unit No.	Title of Unit & Contents	Hrs.
I	**Fuzzy Sets**	**12**
	1. Basic concepts of fuzzy set – t-norm – t-conorms 2. Membership function – α-cut 3. Algebra of fuzzy sets – Distance between fuzzy sets 4. Fuzzy relation	
	Unit Outcome: UO 1. To study algebra of Fuzzy sets and fuzzy relations	
II	**Fuzzy Arithmetic**	**12**
	1. Fuzzy numbers – Arithmetic operations of fuzzy numbers 2. Extension principle 3. Interval arithmetic 4. Defuzzification.	
	Unit Outcome: UO 1. To understand the Interval arithmetic and defuzzification UO 2. To study Fuzzy numbers and fuzzy arithmetic operations.	
III	**Fuzzy Function and Fuzzy Logic**	**24**
	1. Fuzzy valued functions	

Unit No.	Title of Unit & Contents	Hrs.
	2. Fuzzy equations, fuzzy inequalities, system of fuzzy linear equations 3. Maximum and minimum of fuzzy functions. 4. Classical Logic – Multi-valued Logics 5. Fuzzy Propositions – Fuzzy Quantifiers – Linguistic hedges 6. Inference from conditional Fuzzy proposition	
	Unit Outcomes: UO 1. To familiarize with the Fuzzy equations, fuzzy inequalities, system of fuzzy linear equations UO 2. To understand fuzzy propositions and quantifiers.	
IV	**Applications of Fuzzy Set Theory**	**12**
	1. Fuzzy sets in Decision making 2. Optimization in Fuzzy environment 3. Fuzzy set application in image processing 4. Fuzzy set application in pattern recognition	
	Unit Outcome: UO 1. Apply fuzzy theory in optimization problems, image processing and pattern recognition	

Learning Resources:

1. George J. Klir and Bu Yuan, "Fuzzy sets and Fuzzy logic Theory and applications", Prentice Hall of India, New Delhi.
2. Didier Bubois and Henri Prade, "Fuzzy sets and systems", Academic Press.
3. James J Buckley, Esfandiar Eslami, "An Introduction to Fuzzy logic and Fuzzy sets" (Springer).
4. H.J. Zimmernman, "Fuzzy set theory and application" (Allied Publication in Association with KLUWER).

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

PG First Year

Extra Credit Activities

Sr. No.	Course Title	Credits	Hours T/P
1	MOOCs	Min. of 02 credits	Min. of 30 Hrs.
2	Certificate Courses	Min. of 02 credits	Min. of 30 Hrs.
3	IIT Spoken Tutorial Courses	Min. of 02 credits	Min. of 30 Hrs.

Guidelines:

Extra -academic activities

1. All extra credits claimed under this heading will require sufficient academic input/ contribution from the students concerned.
2. Maximum 04 extra credits in each academic year will be allotted.
3. These extra academic activity credits will not be considered for calculation of SGPA/CGPA but will be indicated on the grade card.

Additional Credits for Online Courses:

1. Courses only from SWAYAM and NPTEL platform are eligible for claiming credits.
2. Students should get the consent from the concerned subject Teacher/Mentor/Vice Principal and Principal prior to starting of the course.
3. Students who complete such online courses for additional credits will be examined/verified by the concerned mentor/internal faculty member before awarding credits.
4. Credit allotted to the course by SWAYAM and NPTEL platform will be considered as it is.

Additional Credits for Other Academic Activities:

1. One credit for presentation and publication of paper in International/National/State level seminars/workshops.
2. One credit for measurable research work undertaken and field trips amounting to 30 hours of recorded work.
3. One credit for creating models in sponsored exhibitions/other exhibits, which are approved by the concerned department.
4. One credit for any voluntary social service/Nation building exercise which is in collaboration with the outreach center, equivalent to 30 hours
5. All these credits must be approved by the College Committee.

Additional Credits for Certificate Courses:

1. Students can get additional credits (number of credits will depend on the course duration) from certificate courses offered by the college.
2. The student must successfully complete the course. These credits must be approved by the Course Coordinators.
3. Students who undertake summer projects/ internships/ training in institutions of repute through a national selection process, will get 2 credits for each such activity. This must be done under the supervision of the concerned faculty/mentor.

Note:

1. The respective documents should be submitted within 10 days after completion of Semester End Examination.
2. No credits can be granted for organizing or for serving as office bearers/ volunteers for Inter-Class / Associations / Sports / Social Service activities.
3. The office bearers and volunteers may be given a letter of appreciation by the respective staff coordinators. Besides, no credits can be claimed for any services/activities conducted or attended within the college.
4. All claims for the credits by the students should be made and approved by the mentor in the same academic year of completing the activity.
5. Any grievances of denial/rejection of credits should be addressed to Additional Credits Coordinator in the same academic year.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Examination Framework

Theory:

40% Continuous Assessment Tests (CATs) and 60% Semester End Examination (SEE)

Course	Marks	CAT & Mid Term Theory				CAT Practical		Best Scored CAT & Mid Term	SEE	Total
1	2	3				4		5	6	5 + 6
		Att.	CAT I	Mid Term	CAT II	Att.	CAT			
Major/MEC	100	10	10	20	10	-	-	40	60	100
RP/FP	100	--	--	--	--	-	-	40	60	100
RP	150	--	--	--	--	-	-	60	90	150

Notes:

1. All Internal Exams are compulsory
2. Out of 02 CATs best score will be considered
3. Mid Term Exam will be conducted by the Exam Section
4. Mid Term Exam is of Objective nature (MCQ)
5. Semester End Exam is of descriptive in nature (Long & Short Answer)