Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Structure and Curriculum of Two-Year Degree Programme

Postgraduate Programme of Mathematics

Faculty of Science and Technology

Board of Studies

in

Mathematics

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

[PG I Year]

w.e.f. June, 2026

(In Accordance with NEP-2020)

Review Statement

The NEP Cell reviewed the Curriculum of **M.Sc.-I** to be effective from the **Academic Year 2026-27.** It was found that, the structure is as per the NEP-2020 guidelines of Govt. of Maharashtra.

Date: 11 /04/2026

Place: Latur

NEP CELL

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

CERTIFICATE

I hereby certify that the documents attached are the Bonafide copies of the Curriculum of **M.Sc. I** to be effective from the **Academic Year 2026-27.**

Date:04/05/2026

Place: Latur

Lt. (Prof.) Mahesh S Wavare
Chairperson
Board of Studies in Mathematics
Rajarshi Shahu Mahavidyalaya, Latur
Empowered Autonomous Institution

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Members of Board of Studies in Mathematics

Under the Faculty of Science and Technology

Sr. No.	Name	Designation	In position
1	Lt.(Dr.) Mahesh S Wavare	Chairperson	HoD
2	Dr. V C Borkar, Professor, Department of Mathematics Yeshwant College, Nanded.	Member	V.C. Nominee
3	Dr. M T Gophane ,Professor and Head Department of Mathematics, Shivaji University, Kolhapur .	Member	Academic Council Nominee
4	Dr. Anil Khairnar, Vice-Principal and HoD Department of Mathematics, Aabasaheb Garware College, Pune	Member	Expert from outside for Special Course
5	Dr. Nitin S Darkunde, Associate Professor , School of Mathematical Sciences ,S R T M U Nanded	Member	Expert from outside for Special Course
6	Mr. S S Ranmal ,L & T Technology Services, 7th Floor Amar Madhuban Tech Park Baner Pune (MS)	Member	Expert from Industry
7	Mr. Ajit Vyankatrao Gavhane , Michelin India Pvt Ltd, Pune	Member	P.G. Alumni
8	Dr Nishank S. Pimple	Member	Faculty Member
9	Mrs. Aakanksha S. Mitkari	Member	Faculty Member
10	Miss. Shraddha L. Chidrewar	Member	Faculty Member

From the Desk of the Chairperson…

It gives me immense pleasure to present the curriculum for the First Year M.Sc. (Mathematics) Programme under the framework of the National Education Policy (NEP) 2020 at Rajarshi Shahu Mahavidyalaya. This curriculum, to be implemented from the academic year 2026–27, marks a significant step towards the introduction of a comprehensive two-year postgraduate programme.

The present curriculum has been thoughtfully designed in accordance with NEP-2020 guidelines, aiming to provide a balanced blend of theoretical knowledge, and research orientation. It includes core subjects such as Abstract Algebra, Integral Transforms, Differential Equations, Applied Linear Algebra, Topology, and Partial Differential Equations, along with a wide range of elective courses like Graph Theory, Operations Research, Analytical Number Theory, Numerical Analysis, Advanced Complex Analysis, and Differential Geometry.

A distinctive feature of this programme is its strong emphasis on flexibility, skill enhancement, and interdisciplinary learning. The incorporation of Research Methodology, On-Job Training (OJT), Field Projects, and SWAYAM/NPTEL-based MOOCs provides students with opportunities to explore beyond the classroom and develop practical and employable skills.

The curriculum is also aligned with Programme Outcomes (POs) and Programme Specific Outcomes (PSOs), focusing on developing analytical thinking, problem-solving abilities, research aptitude, and professional competence. It prepares students not only for higher studies and research but also for competitive examinations such as NET, SET, GATE, and NBHM, as well as diverse career opportunities.

I extend my sincere appreciation to all members of the Board of Studies, academic experts, and faculty members whose valuable insights and dedicated efforts have contributed to the formulation of this curriculum.

I am confident that this curriculum will serve as a strong academic foundation and will empower students to achieve excellence in mathematics and its applications in various fields.

Lt (Dr.) Mahesh S Wavare
Chairperson
Board of Studies in Mathematics

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Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Mathematics

Structure for Master Degree Programme in M.Sc.-I

Multiple Entry and Exit (In accordance with NEP-2020)

Year & Level	Sem	Major		Minor	OJT,FP, RP	Credit per Sem.	Cum./Cr. per exit
		DSC	DSE				
1	**2**	**3**		**4**	**5**	**6**	**7**
I 6	I	MMC -I: 04 Cr. MMC-II : 04 Cr. Major -III : 04 Cr. MMC-IV: 02 Cr.	MEC-I 04 Cr.	RMC 04 Cr.		22	44 Cr. PG Diploma (After 03 Year UG Degree)
	II	MMC V-XVII: 04 Cr. MMC-VI : 04 Cr. MMC-VII: 04 Cr. MMC -VIII : 02 Cr.	MEC-II 04 Cr.		OJT 04 Cr / Field Project 04 Cr.	22	
	Cum. Cr.	28	08	04	04	44	

Abbreviations:

1. DSC : Discipline Specific Core (Major)
2. DSE : Discipline Specific Elective (Major)
3. DSM : Discipline Specific Minor
4. MMC : Major Mandatory Course
5. MEC : Mandatory Elective Course
6. RMC : Research Methodology Course
7. OJT : On-the- Job Training
8. FP : Field Project

Shiv Chhatrapati Shikshan Sanstha's

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Empowered Autonomous Institution

Faculty of Science

Program Structure UG IV (Mathematics)

Year & Level	Semester	Course Code	Course Title	Credits	No. of Hrs.
I 6.0	I	601MAT1101	MMC-I: Abstract Algebra	04	60
		601MAT1102	MMC-II: Integral Transform	04	60
		601MAT1103	MMC-III: Differential Equation	04	60
		601MAT1104	MMC-IV: Another BoS (SET/NET/GATE Oriented)	02	30
		601MAT1201 MEC-III	a. Graph Theory b. Advanced Complex Analysis c. Differential Geometry d. SWYAM-NPTEL/ Equivalent MOOCs Courses	04	60
		Minor	Research Methodology	04	60
	Total Credits			**22**	
	II	601MAT2101	MMC-V: Applied Linear Algebra	04	60
		601MAT2102	MMC-VI: Topology	04	60
		601MAT2103	MMC-VII: Partial Differential Equation	04	60
		601MAT2104	Another BoS (SET/NET/GATE Oriented)	02	30
		601MAT2201 MEC-III	a. Operations Research b. Analytical Number Theory c. Numerical Analysis d. SWYAM-NPTEL/ Equivalent MOOCs Courses	04	60
		OJT/FP	On Job Training/ Field Project	04	60
	Total Credits			**22**	
Total Credits (Semester VII & VIII)				**44**	

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Rajarshi Shahu Mahavidyalaya, Latur

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Name of the Programme :M.Sc.(Mathematics)

Programme Outcomes (POs) for B.Sc.(Mathematics)	
After completion of the programme, students will be able to:	
PO 1	**Advanced Mathematical Knowledge**: Apply advanced concepts of algebra, analysis, topology, and applied mathematics to solve complex theoretical and real-world problems.
PO 2	**Analytical and Logical Reasoning:** Demonstrate strong analytical thinking and logical reasoning to construct proofs, validate mathematical statements, and solve abstract problems.
PO 3	**Problem Solving and Modeling:** Formulate and solve interdisciplinary problems using mathematical modeling, numerical methods, and computational techniques.
PO 4	**Research Competency:** Design and execute research projects (Research Project I & II) by applying appropriate methodologies, literature review, and data analysis.
PO 5	**Problem Solving and Modeling:** Formulate and solve interdisciplinary problems using mathematical modeling, numerical methods, and computational techniques.
PO 6	**Computational and Technical Skills:** Utilize modern tools (MATLAB, Python, LaTeX, numerical algorithms) for simulations, coding theory, and linear algebra computations.
PO 7	**Specialization and Domain Expertise:** Acquire expertise in specialized areas such as Functional Analysis, Field Theory, Numerical Linear Algebra, Coding Theory, and Fractional Calculus.
PO 8	**Professional Ethics and Lifelong Learning:** Adhere to ethical research practices and continuously update knowledge through MOOCs (SWAYAM/NPTEL) and emerging mathematical developments.

Programme Specific Outcomes (PSOs) for M.Sc.-I(Mathematics)	
PSO No.	After completion of this programme the students will be able to -
PSO 1	**Core Mathematical Foundations:** Develop strong understanding of core subjects like Abstract Algebra, Differential Equations, Integral Transforms, Linear Algebra, and Topology.
PSO 2	**Mathematical Problem-Solving Skills:** Solve standard and advanced problems involving ODEs, PDEs, transforms, and algebraic structures using systematic approaches.
PSO 3	**Computational and Analytical Techniques:** Apply numerical methods and computational tools to analyze mathematical models and solve real-life problems.
PSO 4	**Interdisciplinary Application Skills:** Apply mathematical concepts in fields such as physics (Classical Mechanics), engineering (Coding Theory), and data science-related areas.
PSO 5	**Research Orientation:** Understand research methodology and develop ability to identify problems, review literature, and initiate small-scale research work.

Semester - I

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Mathematics
PG I Sem I

Course Type: MMC-I
Course Title: Abstract Algebra
Course Code: 601MAT1101
Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives

LO1. To illustrate the foundational properties of semi-groups and groups by interpreting the relationship between generators and cyclic relations.
LO2. To construct quotient groups by distinguishing the role of normal subgroups and conjugacy in group structures.
LO3. To categorize finite groups by decomposing them into normal, solvable, or nilpotent series.
LO4. To categorize finite groups by decomposing them into normal, solvable, or nilpotent series.

Course Outcomes:

After completion of course the student will be able to-

CO 1. Illustrate group properties and homomorphisms by classifying operation-preserving mappings.
CO 2. Construct quotient groups and apply isomorphism theorems to establish mathematical equivalence
CO 3. Analyze group complexity by decomposing structures into solvable, nilpotent, or permutation series.
CO 4. **Appraise** finite group structures by **utilizing** Sylow's Theorems and abelian group invariants.

Unit No.	Title of Unit & Contents	Hrs.
I	**Groups and Homomorphism of groups**	**15**
	1. Groups, semi groups and groups 2. Group Homomorphisms 3. Subgroups and cosets, 4. Cyclic groups, Generators and relations	
	Unit Outcomes: UO 1. Acquaint with the basic concepts of mathematics such as group , homomorphism. UO 2. Able to find structures of different groups.	
II	**Isomorphism of groups**	**15**
	1. Normal subgroup and quotient group 2. Isomorphism theorems, Automorphism 3. Conjugacy and *G*-set	

Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcomes: UO 1. Construct quotient groups and apply isomorphism theorems to establish mathematical equivalence UO 2. Analyze group symmetries by evaluating automorphisms and conjugacy classes within G-sets**.**	
III	**Homomorphism and Isomorphism**	**15**
	1. Normal series ,Solvable groups, Nilpotent groups 2. Fundamental Theorem of Finite Abelian Groups, 3. Permutation Groups, Cyclic decomposition, Alternating group A_n	
	Unit Outcomes: UO 1. Learn to apply isomorphism theorems to find structure of groups. UO 2. Analyze the architecture of symmetric and abelian groups by utilizing cyclic decomposition and the Fundamental Theorem of Finite Abelian Groups	
IV	**Direct Product and Sylow theorems**	**15**
	1. Structure of groups, Direct product, 2. Finitely Generated Abelian Groups, Invariants of a finite abelian group 3. Sylow Theorems and its applications	
	Unit Outcome: UO 1. Learn to apply Sylow theorem.	

Learning Resources:

1. "Algebra-Vol. 1: Groups" Luthar, I. S. and I. B. S. Passi, Narosa, New Delhi, 1996.
2. "A Course in Abstract Algebra" Khanna, V.K., S.K. Bhambri, Vikas Publishing House. (Second Edition).
3. "Abstract Algebra", Dummit, David and Richard Foote John Wiley and Sons
4. "Basic Abstract Algebra", (Second Ed.), Bhattacharya, P. B., S. K. Jain and S. R. Nagpaul, Cambridge Univ. Press (Indian Ed. 1995)
5. "Contemporary Abstract Algebra", Gallian, Joseph A., (Fourth Ed.), Narosa, 1999.

Internal Examination Pattern:

CAT – I Written Theory Test (Based on Unit -I)

CAT – II Assignments PYQ's on IIT-JAM/NET/SET/GATE/NBHM/ Related Competitive Examinations and Seminar by Student on it (Based on Unit-I, II)

Mapping of COs to POs & PSOs

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	2	0	0	1	1	3
CO2	3	1	3	0	1	0	2	1
CO3	3	2	3	2	2	2	1	2
CO4	3	1	3	1	1	1	2	1

COs / PSOs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	0	1	3	0
CO2	1	0	1	0	1
CO3	0	0	1	2	0
CO4	0	0	1	0	3

Scale: 3 = High, 2 = Moderate, 1 = Low, 0 = No Correlation

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Empowered Autonomous Institution

Faculty of Science and Technology

Department of Mathematics

PG I Sem I

Course Type: MMC-II

Course Title: Integral Transforms

Course Code: 601MAT1102

Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives:

LO 1. To provide students with a comprehensive understanding of the theory and properties of Laplace, Fourier, Mellin, and Z-transforms.

LO 2. To develop the mathematical skills required to determine inverse transforms using techniques like partial fractions, convolution, and complex inversion formulas.

LO 3. To enable students to model and solve ordinary differential equations (ODEs), partial differential equations (PDEs), and difference equations using transform methods.

LO 4. To explore the application of integral transforms in evaluating complex integrals and analyzing discrete-time and continuous-time signals.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Classify the different types of integral transforms they come across.

CO 2. Formulate the physical problem under consideration in terms of different types of ordinary and partial differential equations with initial and boundary conditions

CO 3. Solve the initial value problems and boundary value problems using the appropriate integral transform.

CO 4. Analyze the nature of the solution of the initial value problems and boundary value problems.

Unit.	Title of Unit & Content	Hrs.
I	**Laplace Transform**	**17**
	1. Introduction, The Laplace Transform of some typical Functions 2. Basic operational properties. 3. Transforms of more complicated functions, The inverse Laplace Transform 4. Complex Inversion Formula, Additional Topics.	

Unit.	Title of Unit & Content	Hrs.
	Unit Outcomes: UO 1.Compute the Laplace Transform of standard and complex functions using core properties like linearity, shifting, and differentiation. UO 2. Apply the Inverse Laplace Transform through partial fractions, convolution, and the Complex Inversion Formula to solve higher-level mathematical problems.	
II	**Applications of Laplace Transform**	**14**
	1. Applications involving Laplace Transform: Introduction 2. Evaluating integrals, Solutions of ODEs, Solutions of PDEs. The Mellin transform 3. Evaluation of Mellin transform, Complex variable methods, Applications	
	Unit Outcomes: UO 1.Ability to solve ODEs and PDEs by converting differential operations into simpler algebraic forms using Laplace Transforms. UO 2. Evaluate Mellin Transforms using complex variable methods to solve specialized integrals and boundary value problems.	
III	**Fourier Transform**	**16**
	1. Fourier integrals and Fourier Transforms: Introduction 2. Fourier integral representations, Proof of the Fourier integral theorem, Fourier transform pairs 3. Properties of the Fourier Transform, The convolution integrals of Fourier, Transforms involving generalized functions.	
	Unit Outcomes: UO 1.Skill to derive Fourier integral representations and apply the Fourier integral theorem to establish transform pairs for various functions. UO 2. Capability to utilize Fourier properties, convolution integrals, and generalized functions (like the Delta function) to simplify and solve complex signal problems.	
IV	**Z-Transforms:**	**13**
	1. Definition, properties (initial/final value theorems) 2. Applications to difference equations. 3. Inverse Z-Transform 4. Inversion Integral Method	
	Unit Outcomes: UO 1.Aptitude to define and apply the Z-transform to discrete-time signals, utilizing properties like the initial and final value theorems to determine sequence behavior without full inversion.	

Unit.	Title of Unit & Content	Hrs.
	UO 2. Ability to implement Inverse Z-transform techniques, specifically using the Inversion Integral Method (Residue method) to return functions to the time domain and solve linear difference equations.	

Learning Resources:

1. Integral Transforms for Engineers, by Larry C. Andrews, Bhimsen K. Shivamoggi, Prentice Hall of India, New Delhi, 2003.
2. Integral Transforms, by A. R. Vasishtha, Dr. K. L. Gupta, Krishna Prakashan Mandir, Meerut,2016.
3. Integral Transforms, by J. K. Goyal, K. P. Gupta, Pragati Prakashan, Meerut,2019

Internal Examination Pattern:

CAT – I: Written Theory Test (Based on Unit -I)

CAT – II Assignments PYQ's on IIT-JAM/NET/SET/GATE/NBHM/ Related Competitive Examinations and Seminar by Student on it (Based on Unit-I, II)

Mapping of POs, PSOs and COs:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	1	0	1	0	2	1
CO2	2	3	2	0	3	1	2	1
CO3	3	3	2	1	2	1	1	1
CO4	2	2	3	0	3	0	2	1

COs / PSOs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	1	0	1
CO2	2	3	1	1	2
CO3	1	3	1	0	3
CO4	1	2	1	2	2

Scale: 3 = High, 2 = Moderate, 1 = Low, 0 = No Correlation

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Empowered Autonomous Institution

Faculty of Science and Technology

Department of Mathematics

PG I Sem I

Course Type: MMC-III

Course Title: Differential Equations

Course Code: 601MAT1103

Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives:

LO 1. Learn to solve first-order differential equations.
LO 2. Learn to solve linear differential equations of higher-order.
LO 3. Learn to solve a second-order differential equation with constant coefficients.
LO 4. Learn to solve differential equations with variable coefficients

Course Outcomes:

After completion of course the student will be able to-

CO 1. Recognize definition and properties of initial value problems
CO 2. Know definition and properties of linear dependence and independence, Wronskian, singular points, regular singular points, Lipschitz constant
CO 3. Apply power series solution method, method of successive approximation
CO 4. Be familiar with properties of Euler equation and Bessel equation, non – local existence of solutions.

Unit No.	Title of Unit & Contents	Hrs.
I	**Linear Differential equation**	**15**
	1. Linear equations of first order, Initial Value Problem for 2. second order equations Initial value problems, Solutions of the homogeneous equation	
	Unit Outcomes: UO 1. Recognize Linear and non linear Differential equations. UO 2. Able to solve initial value problems	
II	**Non-homogeneous Differential Equation**	**15**
	1. Linear dependence and independence, A formula for the Wronskian. 2. The non-homogeneous equations of order two, The homogeneous equations of order n, Initial Value Problem for nth order equations.	

Unit No.	Title of Unit & Contents	Hrs.
	3. Equations with real constants, The non-homogeneous equations of order-n, A special method for solving the non-homogeneous equation, Algebra of constant coefficient operators.	
	Unit Outcome: UO 1. Able to solve non-homogeneous Differential equations.	
III	**Linear Differential equations with Regular Singular Points**	**15**
	1. Wronskian and linear independence, Reduction of order, Non-homogeneous equations. 2. Legendre equation, Linear Equations with regular singular points: Euler equation, Second order equation with regular singular points, Exceptional cases. 3. The Bessel equation, The Bessel equation (Continued).	
	Unit Outcomes: UO 1. Recognize properties of Eular equation and Bessel equation, non – local existence of solutions.	
IV	**Linear Differential equations with successive approximations**	**15**
	1. Separation of variables, Exact equations, Method of successive approximations 2. Lipchitz condition, Convergence of the successive approximations, Non-local existence of solutions, Approximations to, and uniqueness of solutions, Equations with complex valued functions.	
	Unit Outcomes: UO 1. Apply power series solution method, method of successive approximation	

Learning Resources:

1. A First Course in Differential Equations with Modeling Applications, Dennis G. Zill, Cengage Learning, 12th Edition, 2023.
2. An Introduction to Ordinary Differential Equations, Earl A. Coddington, Dover Publications, Reprint Edition, 1989.
3. Elementary Differential Equations and Boundary Value Problems, William E. Boyce & Richard C. DiPrima, John Wiley & Sons, 12th Edition, 2021.
4. Differential Equations and Boundary Value Problems: Computing and Modeling, C. Henry Edwards & David E. Penney, Pearson, 6th Edition, 2022.
5. Differential Equations and Their Applications, Martin Braun, Springer-Verlag, 4th Edition, 1993.
6. Differential Equations, Shepley L. Ross, John Wiley & Sons, 3rd Edition, 1984.
7. Differential Equations and Linear Algebra, Gilbert Strang, Wellesley-Cambridge, 2nd Edition, 2017.
8. Ordinary and Partial Differential Equations, M.D. Raisinghania, S. Chand Publishing, 21st Edition, 2023.

Internal Examination Pattern :

CAT – I Written Theory Test (Based on Unit -I)

CAT – II Assignments PYQ's on IIT-JAM/NET/SET/GATE/NBHM/ Related Competitive Examinations and Seminar by Student on it (Based on Unit-I, II)

Mapping of POs, PSOs and COs:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	2	0	1	0	1	1
CO2	3	1	3	0	1	0	2	1
CO3	3	2	2	1	2	1	1	1
CO4	3	2	3	0	2	0	2	1

COs / PSOs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	1	0	2
CO2	1	2	2	0	1
CO3	1	3	1	1	2
CO4	1	2	1	1	2

Scale: 3 = High, 2 = Moderate, 1 = Low, 0 = No Correlation

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Faculty of Science and Technology

Department of Mathematics

PG I Sem I

Course Type: MEC-I(A)

Course Title: Graph Theory

Course Code: 601MAT1201

Credits: 4 **Max. Marks: 100** **Lectures:60 Hrs.**

Learning Objectives:

LO 1. To introduce fundamental concepts, terminology, and representations of graphs.

LO 2. To develop understanding of structural properties such as trees, connectivity, paths, and cycles.

LO 3. To explore matching theory and its applications in real-world problems.

LO 4. To apply graph theory techniques to solve optimization and network-based problems.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Apply fundamental concepts of graph theory such as graphs, subgraphs, paths, cycles, and matrix representations to model and analyze real-world problems.

CO 2. Analyze properties of trees and connectivity, including spanning trees, shortest path problems, and identification of bridges and cut vertices in graphs.

CO 3. Evaluate and solve traversal and optimization problems involving Euler tours, Hamiltonian cycles, the Travelling Salesman Problem, and the Chinese Postman Problem.

CO 4. Apply matching theory and optimization techniques to solve problems such as bipartite matching and assignment problems using appropriate algorithms.

Unit No.	Title of Unit & Contents	Hrs.
I	**An introduction to Graphs**	**14**
	1. The definition of a Graph 2. Graphs as Models 3. More Definitions 4 Vertex Degrees 5 Subgraphs 6 Paths and Cycles 7 The Matrix representation of Graphs	

Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcomes: UO1: Explain basic graph concepts, terminology, and different types of graphs. UO2: Analyze graphs using vertex degrees, subgraphs, paths, cycles, and matrix representations.	
II	**Trees and Connectivity**	**16**
	1 . Definition and Simple Properties 2. Bridges 3. Spanning Trees 4. Connector Problems	
	Unit Outcomes: UO1: Describe properties of trees, bridges, and connectivity in graphs. UO2: Construct spanning trees and apply them to solve connectivity-related problems.	
III	**Eulers Tours and Hamiltonian Cycles**	**15**
	1. Euler Tours 2. The Chinese Postman Problem 3. Hamiltonian Graphs 4. The Travelling Salesman Problem	
	Unit Outcomes: UO1: Identify Eulerian and Hamiltonian graphs and explain their properties. UO2: Apply graph theory concepts to solve routing and optimization problems such as the Chinese Postman and Travelling Salesman problems.	
IV	**Matching**	**15**
	1Matching and Augmenting Paths 2 The Marriage Problem 3 The Personal Assignment Problem 4 The Optimal Assignment Problem 5 The Chinese Postman Problem Post Script	
	Unit Outcomes: UO1: Explain matching, augmenting paths, and solve problems related to bipartite graphs. UO2: Apply matching concepts to solve real-world problems such as marriage, assignment, and optimization problems.	

Learning Resources:

1. A first look at Graph Theory, John Clark and Derek Holton. Allied Publisher Ltd with World Scientific,1991.
2. Discrete Mathematics and Its Applications, Kenneth H. Rosen McGraw-Hill Education Edition: 7th Edition, 2012
3. Graph Theory with Applications, J.A. Bondy and U.S.R. Murty, North-Holland / Elsevier 1976 (Reprinted Edition)
4. Graph Theory, Frank Harary Addison-Wesley Publishing Company 1969
5. Graph Theory, J.A. Bondy and U.S.R. Murty, Springer Graduate Texts in Mathematics, 2008 (Reprint)
6. Introduction to Graph Theory, Douglas B. West, Prentice Hall of India / Pearson Education 2nd Edition, 2001
7. Introduction to Graph Theory, Richard J. Trudeau, Dover Publications, Reprint Edition, 1993

Internal Examination Pattern :

CAT–I: Written Theory Test based on Unit–I.

CAT–II: Assignments based on previous year questions (PYQs) from competitive examinations such as IIT-JAM, NET, SET, GATE, NBHM, along with a student seminar presentation, covering Unit–I and Unit–II.

Mapping of POs, PSOs and COs:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	1	3	2	2	1
CO2	3	2	3	1	2	2	1	1
CO3	2	3	2	2	3	3	2	1
CO4	2	3	2	2	3	3	2	1

COs / PSOs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	0	3	1	0
CO2	1	1	2	2	1
CO3	0	1	2	1	0
CO4	2	0	2	1	1

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Faculty of Science and Technology

Department of Mathematics

PG I Sem I

Course Type: MEC-I(B)

Course Title: Advanced Complex Analysis

Course Code: 601MAT1201

Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives:

LO 1. To study Complex Field, Algebra of complex numbers.
LO 2. To study Stereographic Projection, Transformation & Mapping Properties.
LO 3. To Discuss Analyticity, Harmonic Functions
LO 4. To evaluate Line Integrals using Cauchy's Theorems

Course Outcomes:

After completion of course the student will be able to-

CO 1. Understand how complex numbers provide a satisfying extension of the real numbers
CO 2. Recognize the condition(s) for a complex variable function to be analytic and/or harmonic.
CO 3. Evaluate a contour integral using parameterization, fundamental theorem of calculus and Cauchy's integral formula.
CO 4. Compute the residue of a function and use the residue theory to evaluate a contour integral or an integral over the real line

Unit No.	Title of Unit & Contents	Hrs.
I	**Complex Field and Mappings**	**15**
	1. Complex Field, Modulus, Argument and Conjugate of complex numbers, Algebra of complex numbers 2. Rectangular and Polar representation of Complex numbers, Point sets in the plane, Sequences. Stereographic Projection, Linear Fractional, Transformation, Other Mappings, The Exponential Function, Mapping Properties	
	Unit Outcomes: UO 1. Understand how complex numbers provide a satisfying extension of the real numbers	
II	**Analyticity and Power Series**	**15**
	1. The Logarithmic Function, Complex Exponents, Power series, Analytic functions, Analyticity, Harmonic Functions, 2. Sequences of Functions, Uniform Convergence, Maclaurin and	

Unit No.	Title of Unit & Contents	Hrs.
	Taylor Series, Operations on Power series. Taylor's Theorem, Cauchy's Estimate, Zeros of an analytic function, Louville's Theorem, Fundamental Theorem of Algebra, Maximum Modulus Theorem.	
	Unit Outcome: UO 1. Appreciate how throwing problems into a more general context may enlighten one about a specific context	
III	**Line Integrals**	**15**
	1. Curves, Parameterizations, Line Integrals, Cauchy's Theorems. Index of a closed curve, Cauchy's Theorem, Cauchy's Integral Formula, Morera's Theorem. **2.** The Homotopic version of Cauchy's Theorem and simple connectivity, Counting of Zeros, The Open mapping Theorem, Goursat's theorem	
	Unit Outcome: UO 1. Learn techniques of complex analysis that make practical problems easy	
IV	**Laurents Series and the Residue Theorem**	**15**
	1. Singularities, Classification of Singularities, Laurent's Series, Casorati-Weierstrass Theorem, Residues, Cauchy's Residue Theorem, Evaluation of Integrals, Meromorphic functions 2. The Argument Principle, Rouche' Theorem, Schwartz Lemma. Convex Functions and Hadamard's three Circles Theorem, The Riemann mapping Theorem	
	Unit Outcome: UO 1. Compute the residue of a function and use the residue theory to evaluate a contour integral or an integral over the real line.	

Learning Resources:

1. Complex Analysis, Lars V. Ahlofors, McGraw Hill Co. 1979
2. Complex Analysis, Silverman Herb,2006
3. Complex Variables with Applications, S. Ponnusamy and Herb Silverman,
4. Birkhauser Publication 2006.
5. Foundations of Complex Analysis, S. Ponnusamy, Narosa Publishing House 2011.
6. Function of one complex variable, John B. Convey, Narosa Pub. House , 1980.

Internal Examination Pattern :

CAT–I: Written Theory Test based on Unit–I.

CAT–II: Assignments based on previous year questions (PYQs) from competitive examinations such as IIT-JAM, NET, SET, GATE, NBHM, along with a student seminar presentation, covering Unit–I and Unit–II.

Mapping of POs, PSOs and COs:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	3	0	1	0	1	1
CO2	3	2	3	0	2	0	2	1
CO3	3	2	2	0	1	0	1	1
CO4	2	2	1	2	1	1	1	1

COs / PSOs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	0	1	1
CO2	1	3	0	1	2
CO3	1	3	0	0	3
CO4	0	3	0	0	3

Scale: 3 = High, 2 = Moderate, 1 = Low, 0 = No Correlation

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Department of Mathematics

PG I Sem I

Course Type: MEC-I (C)

Course Title: Differential Geometry

Course Code: 601MAT1201

Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives:

LO 1. To develop understanding of vector spaces, Euclidean spaces, matrices, and linear transformations.

LO 2. To apply concepts of differential calculus to study curves, including tangent vectors, arc length, and directional derivatives.

LO 3. To analyze geometric properties of curves and surfaces using curvature, torsion, and Frenet formulas.

LO 4. To evaluate and construct geometric transformations and special curves such as helices and spherical curves in space.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Explain and apply fundamental concepts of vector spaces, Euclidean spaces, matrices, and linear transformations, and analyze metric and topological spaces.

CO 2. Apply and analyze Parametric representation of curves, tangent vectors, directional derivatives, and arc length to evaluate the geometric behavior of curves in R^3

CO 3. Apply and analyze curvature, torsion, and Frenet formulas to evaluate geometric properties of curves and their behavior on surfaces.

CO 4. Analyze, evaluate, and construct geometric properties of curves using transformations, isometries, and fundamental theorems, including special curves such as helices and spherical curves.

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction**	**15**
	1. Vector space, Euclidean Space, Matrices and Group, Vectors in R^3 and R and their Algebra, Orientation in R^3 and R , 2. Real and Vector-valued Functions and their calculus, Metric Spaces and Topological Spaces, 3. Linear Mappings and Transformations, Dual of a vector space	
	Unit Outcomes: UO 1. Explain operations on vectors and matrices in R^n UO 2.Analyze the structure of metric and topological spaces.	
II	**Curves in Space**	**15**
	1 Differentiable curve and its parametric representation, answers to some Questions related to the nature of a Curve, 2 Tangent vectors and Vector Fields in R^3, Directional Derivatives, Arc Length and tangent Vector.	
	Unit Outcomes: UO 1:Examine and interpret geometric properties of curves. UO 2 :Evaluate the nature and behavior of curves using calculus tools	
III	**Theory of Surfaces and Curves on Surfaces**	**15**
	1. Osculating plane and the circle, curvature vector, principal normal vector, torsion 2. Frenet formulae, Frenet approximate of curves and its projections, piecewise regularity of curves 3. Singular points and their classification due to gauss, Frenet formulae for an arbitrary curve	
	Unit Outcomes: UO 1:Apply Frenet formulas to determine geometric properties of curves. UO 2 :Evaluate curve behavior on surfaces using curvature and torsion	
IV	**Geometry of Curves**	**15**
	1. Translation, Rotation and Isometries in R , mapping F* induced from F, Fundamental Theroem on curves in R^3, 2. Congruent curves, Content between two curves, curve and a plane or a surface 3. Generalized helixes and spherical curves	
	Unit Outcomes: UO 1:Evaluate special types of curves such as helices and spherical curves. UO 2 :Construct and interpret curves using fundamental theorems of space curves.	

Learning Resources:

1. An Introduction to Differential Geometry, Dr. Kailash Sinha and Jagdish Prasad, Shalini Prakashan Meerut,1970
2. Differential Geometry an integrated Approach, Prakash ,Nirmala Tata McGraw-Hill Company Limited ,1981.
3. Differential Geometry: Curves , Surfaces , Manifolds", Wolfgang Kuhnel, American Mathematical Society, 2002
4. Elementry Topics in Differential Geometry , John A Thorpe , Springer ,2004

Internal Examination Pattern:

CAT – I Written Theory Test (Based on Unit -I)

CAT – II Assignments PYQ's on IIT-JAM/NET/SET/GATE/NBHM/ Related Competitive Examinations and Seminar by Student on it (Based on Unit-I, II)

Mapping of POs, PSOs and COs:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	3	0	1	0	1	1
CO2	3	2	3	0	2	0	2	1
CO3	3	2	2	0	1	0	1	1
CO4	2	2	1	2	1	1	1	1

COs / PSOs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	3	0	1
CO2	3	3	1	1	2
CO3	3	2	1	2	2
CO4	3	1	1	1	2

Scale: 3 = High, 2 = Moderate, 1 = Low, 0 = No Correlation

Semester - II

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PG I Sem II

Course Type: MEC-V

Course Title: Applied Linear Algebra

Course Code: 601MAT2101

Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives:

LO 1. To explain fundamental concepts of vector spaces, subspaces, and basis.

LO 2. To describe linear transformations and their matrix representations.

LO 3. To relate matrix methods and eigen concepts in linear algebra.

LO 4. To interpret inner product spaces and canonical forms of matrices.

Course outcomes:

After completion of course the student will be able to-

CO 1. Explain the structure of vector spaces, subspaces, and concepts of basis and dimension.

CO 2. Describe linear transformations, their properties, and matrix representations.

CO 3. Apply concepts of matrices, eigenvalues, and eigenvectors in studying linear systems and transformations.

CO 4. Interpret inner product spaces, orthogonality, and canonical forms of matrices.

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction To Vector Spaces**	**15**
	1. Introduction, Vector spaces, subspaces, Quotient Spaces 2. Linear combinations and system of linear equations 3. linear dependence and independence 4. Bases and dimension, Maximal Linear Independent Subsets.	
	Unit Outcomes: UO1**:** Explain vector spaces, subspaces, and linear combinations. UO2**:** Describe concepts of linear dependence, basis, and dimension.	
II	**Linear Transformation**	**15**
	1.Linear Transformations, Null spaces, Range spaces 2.The matrix representation of a linear transformation, Composition of linear transformations	

Unit No.	Title of Unit & Contents	Hrs.
	3.Invertibility and Isomorphism, The change of Co-ordinate matrix, Dual spaces.	
	Unit Outcomes: UO1**:** Explain linear transformations, null space, and range space. UO2**:** Apply concepts of linear transformations to describe isomorphism and coordinate changes.	
III	**Matrix Operation And System of Linear Equation**	**15**
	1.Elementary Matrix Operations and elementary matrices, The rank of a matrix 2.System of linear Equations-Theoretical Aspects, System of linear equations-Computational Aspects 3.Eigen values and Eigen vectors, Diagonalizability, Triangulable Operators 4. Invariant Subspaces, Cayley-Hamilton Theorem.	
	Unit Outcomes: UO1**:** Explain elementary matrix operations, rank, and systems of linear equations. UO2**:** Describe eigenvalues, eigenvectors, and concepts of diagonalizability.	
IV	**Inner Products and Norms**	**15**
	1. Inner products and Norm 2. The Gram-Schmidt Orthogonalization process and orthogonal complements 3. The adjoint of a linear operator, Bilinear forms, Quadratic forms. 4.Jordan Canonical form-I, Jordan Canonical form-II, The Minimal Polynomial, Rational Canonical form.	
	Unit Outcomes: UO1**:** Explain inner product spaces, norms, and orthogonality. UO2**:** Describe canonical forms including Jordan canonical form and related concepts.	

Learning Resources:

1. "Geometrical approach to Linear Algebra", S.Kumaresan,
2. "Introduction to Linear algebra", S. Lang, Springer International Edition,2nd Edition.
3. "Linear Algebra" Vivek Sahai and Vikas Bist, Narosa Publishing House,2nd Edition.
4. "Linear Algebra", K.Hoffman, R.Kunze, Prentice Hall of India.
5. "Linear Algebra", S.H. Friedberg, A.J. Insel, L.E. Spence, Prentice-Hall, International, Inc., 3rd Edition.

Internal Examination Pattern :

CAT – I: Written Theory Test (Based on Unit -I)

CAT – II Assignments PYQ's on IIT-JAM/NET/SET/GATE/NBHM/ Related Competitive Examinations and Seminar by Student on it (Based on Unit-I, II)

Mapping of POs, PSOs and COs:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	2	0	1	0	2	1
CO2	3	2	2	1	1	1	1	1
CO3	3	3	3	1	2	2	1	1
CO4	3	1	3	0	1	0	1	1

COs / PSOs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	3	0	1
CO2	2	1	3	0	1
CO3	1	1	3	1	1
CO4	3	1	3	0	1

Scale: 3 = High, 2 = Moderate, 1 = Low, 0 = No Correlation

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Department of Mathematics

PG I Sem II

Course Type: MMC-VI

Course Title: Topology

Course Code: 601MAT2102

Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives:

LO 1. To introduce the concepts of countability, axiom of choice, and well-ordered sets as a foundation for topological structures.

LO 2. To provide a deep understanding of basic topological concepts, including bases, subspaces, product topologies, and metric topologies.

LO 3. To explore the global properties of topological spaces, specifically connectedness and compactness.

LO 4. To familiarize students with separation axioms and fundamental theorems like Urysohn's Lemma and the Tychonoff's Extension Theorem.

Course outcomes:

After completion of course the student will be able to-

CO 1. State and define fundamental terms such as countable sets, basis for a topology, limit points, and various separation axioms.

CO 2. Explain the relationship between different topologies (order, product, metric) and the significance of the Axiom of Choice in set theory

CO 3. Solve problems by constructing topologies on given sets and demonstrating continuity between topological spaces.

CO 4. Distinguish between connected and disconnected spaces, and analyze the properties of compact subspaces within the real line.

Unit No.	Title of Unit & Contents	Hrs.
I	**Countability of Sets**	**20**
	1. Cartesian Products, Finite Sets 2. Countable and Uncountable Sets 3. Infinite Sets and Axiom of Choice, Well Ordered Sets.	
	Unit Outcome: UO 1. Students will be able to classify sets as finite, countable, or uncountable and apply the Well-Ordering Theorem.	
II	**Introduction to Topology**	**14**
	1. Basis for a topology, Order topology 2. Subspace Topology, Product topology 3.Closed sets and limit points, Continuous functions, Metric Topology.	

Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcome: UO 1. Students will be able to illustrate how a basis generates a topology and identify closed sets and limit points	
III	**Connectedness and compactness**	**14**
	1. Connected spaces, Connected Subspaces of Real Line 2. Components and Local Connectedness 3. Compact spaces, Compact Subspaces of the Real Line 4. Limit point compactness, Local Compactness.	
	Unit Outcome: UO 1. Students will be able to determine if a space is locally connected or locally compact.	
IV	**Separation Axioms**	**12**
	1. Countability Axioms, Separation axioms 2. Normal Spaces, Urysohn's Lemma, Tietze Extension Theorem 3. Metrization Theorem, Tychonoff's Theorem.	
	Unit Outcome: UO 1. Students will be able to apply the Tychonoff's Theorem to extend continuous functions from closed subsets.	

Learning Resources:

1. Elements of general topology by S. T. Hu, Holden day Inc. 1965.
2. Foundations of general topology by W. J. Pervin, academic press Inc. N.Y. H 1964
3. General Topology by Stephen Willard, Addison-Wesley Publishing Company, 1970
4. Topology by J. Dugundji Allya and Bacon. reprinted: Prentice Hall of India, 1966
5. Topology by J.R. Munkres, Prentice Hall of India, Second Edition,2021

Internal Examination Pattern :

CAT – I Written Theory Test (Based on Unit -I)

CAT – II Assignments PYQ's on IIT-JAM/NET/SET/GATE/NBHM/ Related Competitive Examinations and Seminar by Student on it (Based on Unit-I, II)

Mapping of POs, PSOs and COs:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	2	0	0	0	2	1
CO2	3	1	3	0	1	0	1	1
CO3	3	2	3	0	1	1	2	1
CO4	3	1	3	0	1	0	2	1

COs / PSOs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	0	0	1
CO2	3	0	0	0	1
CO3	3	2	0	0	1
CO4	3	1	0	0	1

Scale: 3 = High, 2 = Moderate, 1 = Low, 0 = No Correlation

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Department of Mathematics

PG I Sem II

Course Type: MMC-VII

Course Title: Partial Differential equation

Course Code: 601MAT2103

Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives:

LO 1. To describe the fundamental concepts of first and second-order partial differential equations (PDEs) and their classifications.
LO 2. To demonstrate various analytical methods, such as Charpit's, Jacobi's, and the separation of variables, to solve diverse PDE problems.
LO 3. To examine physical phenomena like wave motion and heat conduction by formulating them into mathematical PDE models.
LO 4. To integrate special functions (Bessel, Legendre) and theorems (Kelvin's Inversion, Harnack's) into the solution process of complex boundary value problems.

Course outcomes:

After completion of course students will be able to-

CO 1. Recall and state the standard forms of linear, quasi-linear, and non-linear PDEs, as well as properties of Bessel and Legendre functions
CO 2. Explain the principles behind the method of separation of variables and the classification of second-order PDEs into elliptic, parabolic, and hyperbolic types
CO 3. Solve first-order PDEs using Charpit's and Jacobi's methods and determine general solutions for higher-order PDEs with constant coefficients
CO 4. Differentiate between Dirichlet and Neumann boundary conditions and analyze their impact on the stability and uniqueness of solutions

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction to PDE**	**25**
	1.Introduction, Linear Equation of first order, Charpit's Method, Jacobi's Method 2.Quasi-Linear Equations, Non-Linear First Order P.D.E 3.General solution of higher order PDE's with constant coefficients 4.Special Functions - Bessel's function, Legendre's function.	
	Unit Outcomes: UO 1. To identify linear, quasi linear and non-linear PDEs	

Unit No.	Title of Unit & Contents	Hrs.
	UO 2.To acquire knowledge about some special functions like Bessel's function, Legendre function, etc.	
II	**Second order PDE**	**15**
	1.Introduction, Method of separation of variables 2.Classification of Second order PDE, One Dimensional Wave Equation 3. Laplace Equation, Boundary Value Problems, the Cauchy's Problem,	
	Unit Outcome: UO 1. To acquire knowledge about different solving techniques of PDE	
III	**Some special problems in PDE**	**10**
	1.Dirichlet and Neumann Problem for different regions 2. Harnack's Theorem, Heat Conduction Problem, Duhamel's Principle	
	Unit Outcome: UO 1. To study Dirichlet and Neumann problems for different regions.	
IV	**Families of Surfaces and inversion theorem**	**10**
	1. Classification of P.D.E. in the case of n-variables 2. Families of Equipotential Surfaces, Kelvin's Inversion Theorem.	
	Unit Outcome: UO 1. To study Kelvin's Inversion theorem.	

Learning Resources:

1. "Advanced Engineering Mathematics" by H.K. Dass, S. Chand & Co. Ltd, 2007.
2. "An Elementary Course in Partial Differential Equations", by T. Amarnath, (2nd edition),(Narosa Publishing House), 2003
3. "Elements of partial differential equations", by I.N. Sneddon, (Mc-GrawHill Book Company), 2006.
4. "Introduction to partial differential equation" by K. Sankara Rao, 3rd edition, 2017
5. "Partial differential equations" by E. T. Copson, (Cambridge university press),1975
6. "Partial Differential equations" by W. E. Williams, (Clarendon press oxford), 1980

Internal Examination Pattern :

CAT – I Written Theory Test (Based on Unit -I)

CAT – II Assignments PYQ's on IIT-JAM/NET/SET/GATE/NBHM/ Related Competitive Examinations and Seminar by Student on it (Based on Unit-I, II)

Mapping of POs, PSOs and COs:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	0	1	0	1	1
CO2	3	2	2	0	2	1	1	1
CO3	3	3	2	1	2	1	1	1
CO4	2	3	3	0	3	0	2	1

COs / PSOs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	1	0	2
CO2	2	3	1	0	2
CO3	1	3	1	0	3
CO4	2	3	1	0	2

Scale: 3 = High, 2 = Moderate, 1 = Low, 0 = No Correlation

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PG I Sem II

Course Type: MEC-II(A)

Course Title: Operations Research

Course Code: 601MAT2201

Credits: 4 **Max. Marks: 100** **Lectures:60 Hrs.**

Learning Objectives:

LO 1. To introduce the fundamental concepts, scope, and methodology of Operations Research in scientific decision-making.

LO 2. To develop the ability to formulate real-life problems as Linear Programming Problems and solve them using graphical and simplex methods.

LO 3. To understand and apply optimization techniques for transportation problems.

LO 4. To analyze and solve assignment problems for efficient resource allocation.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Understand the fundamental concepts of Operations Research, formulate real-life problems into linear programming models, and solve them using graphical methods.

CO 2. Apply the Simplex Method, including artificial variables and degeneracy handling, to obtain optimal solutions of linear programming problems and related computational procedures.

CO 3. Analyze and solve Transportation Problems using appropriate methods, including formulation, feasibility conditions, and optimization techniques.

CO 4. Formulate and solve Assignment Problems using standard algorithms while addressing special cases and practical applications.

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction to OR, Mathematical Formulation and Graphical Solution Method:**	**15**
	1. Origin of Operations Research, Scientific Method in Operation Research.	

Unit No.	Title of Unit & Contents	Hrs.
	2. Methodology of Operations Research, Operations Research and Decision Making. 3. Linear Programming Problem and Mathematical Formulation of LPPs and Illustrations on Mathematical Formulation of LPPs. 4. Graphical Solution Method, Some Exceptional Cases, 5. General Linear Programming Problem, Canonical and Standard Form of LPP.	
	Unit Outcomes: UO1**:**Explain the origin, methodology, and role of Operations Research in decision-making. UO2**:**Formulate Linear Programming Problems and solve them using the graphical method, including special cases.	
II	**Simplex Method**	**15**
	1. Introduction, Fundamental Properties of Solutions 2. The Computational Procedure, Use of Artificial Variables 3. Degeneracy in Linear Programming, Solution of Simultaneous Linear Equations. 4. Inverting a Matrix using Simplex Method 5. Applications of Simplex Method.	
	Unit Outcomes: UO 1. Understand the fundamental properties and computational procedure of the simplex method. UO 2. Solve Linear Programming Problems using simplex method, including cases with artificial variables and degeneracy.	
III	**Transportation Problem:**	**15**
	1. Introduction, LP Formulation of the Transportation Problem, 2.Existence of Solution in T.P., Duality in Transportation Problem 3. The Transportation Table, Loops in Transportation Tables.	
	Unit Outcomes: UO1:Formulate transportation problems and analyze their feasibility and optimality. UO2:Solve transportation problems using transportation tables and interpret duality concepts.	
IV	**Assignment Problem:**	
	1. Introduction, Mathematical Formulation of the Problem 2. Solution Methods of Assignment Problem. 3.Special Cases in Assignment Problems. 4. A Typical Assignment Problem.	
	Unit Outcomes: UO1:Understand the structure and mathematical formulation of assignment problems. UO2**:**Solve assignment problems using standard methods and handle special cases effectively.	

Learning Resources:

1. Introduction to Operations Research, Frederick S. Hillier and Gerald J. Lieberman, McGraw-Hill Education, 2015.
2. Linear Programming and Operations Research, Kanti Swarup, P.K. Gupta and Man Mohan, Sultan Chand & Sons, 2005.
3. Operations Research, Kanti Swarup, P.K. Gupta and Man Mohan, Fourteenth Thoroughly Revised Edition, S. Chand & Sons, New Delhi, 2017.
4. Operations Research, Prem Kumar Gupta and D.S. Hira, S. Chand & Company Ltd., 2014.
5. Operations Research: An Introduction, H.A. Taha, Pearson Education, 2017.
6. Operations Research: Theory and Applications, J.K. Sharma, Macmillan Publishers India, 2017.

Internal Examination Pattern :

CAT – I Written Theory Test (Based on Unit -I)

CAT – II Assignments PYQ's on IIT-JAM/NET/SET/GATE/NBHM/ Related Competitive Examinations and Seminar by Student on it (Based on Unit-I, II)

Mapping of POs, PSOs and COs:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	2	1	3	2	2	1
CO2	2	3	2	2	3	3	1	1
CO3	2	3	2	1	3	2	2	1
CO4	2	3	2	1	3	3	2	1

COs / PSOs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1	2	1	1
CO2	0	1	3	1	0
CO3	0	1	3	1	0
CO4	2	1	3	1	1

Scale: 3 = High, 2 = Moderate, 1 = Low, 0 = No Correlation

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Department of Mathematics

PG I Sem II

Course Type: MMC-II(B)

Course Title: Analytical Number Theory

Course Code: 601MAT2201

Credits: 4 **Max. Marks: 100** **Lectures:60 Hrs.**

Learning Objectives:

LO 1. To develop a strong foundation in arithmetic functions and their applications in number theory.

LO 2. To understand modular arithmetic concepts including Euler's theorem and phi-function.

LO 3. To analyze primitive roots, indices, and their role in number-theoretic computations.

LO 4. To explore quadratic residues and the law of quadratic reciprocity with problem-solving skills.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Apply number-theoretic functions such as divisor functions and Möbius inversion in solving problems.

CO 2. Use Euler's theorem and properties of the phi-function in modular arithmetic.

CO 3. Analyze primitive roots, orders, and indices for solving congruences.

CO 4. Solve quadratic congruences using Legendre symbols and quadratic reciprocity law.

Unit No.	Title of Unit & Contents	Hrs.
I	**Number-Theoretic Functions**	**14**
	1. The Sum and Number of Divisors 2. The Möbius Inversion Formula 3. The Greatest Integer Function 4. An Application to the Calendar	
	Unit Outcomes: UO1:Understand divisor functions, Möbius inversion, and greatest integer function.	

Unit No.	Title of Unit & Contents	Hrs.
	UO2:Apply number theory concepts to practical problems like calendar computations.	
II	Euler's Generalization of Fermat's Theorem	**12**
	1. Leonhard Euler and Euler's Phi-Function 2. Euler's Theorem 3. Some Properties of the Phi-Function	
	Unit Outcomes: UO1:Understand Euler's phi-function and its properties. UO2:Apply Euler's theorem in solving modular arithmetic problems.	
III	Primitive Roots and Indices	**17**
	1. The Order of an Integer Modulo n 2. Primitive Roots for Primes 3. Composite Numbers Having Primitive Roots 4. The Theory of Indices	
	Unit Outcomes: UO1:Determine the order of integers modulo n and identify primitive roots. UO2:Apply index theory to simplify exponential congruences.	
IV	The Quadratic Reciprocity Law	**17**
	1. Euler's Criterion 2. The Legendre Symbol and Its Properties 3. Quadratic Reciprocity 4. Quadratic Congruences with Composite	
	Unit Outcomes: UO1: Evaluate quadratic residues using Euler's criterion and Legendre symbol. UO2:Solve quadratic congruences using the law of quadratic reciprocity.	

Learning Resources:

1. A Classical Introduction to Modern Number Theory, Kenneth Ireland and Michael Rosen, Springer, 1990.
2. An Introduction to Number Theory, Ivan Niven, Herbert S. Zuckerman and Hugh L. Montgomery, Wiley, 2008.
3. An Introduction to the Theory of Numbers, G.H. Hardy and E.M. Wright, Oxford University Press, 2008.
4. Elementary Number Theory, David M. Burton, McGraw-Hill Education, 2010.
5. Elementary Number Theory, Gareth A. Jones and J. Mary Jones, Springer, 1998.

Internal Examination Pattern :

CAT – I Written Theory Test (Based on Unit -I)

CAT – II Assignments PYQ's on IIT-JAM/NET/SET/GATE/NBHM/ Related Competitive Examinations and Seminar by Student on it (Based on Unit-I, II)

Mapping of POs, PSOs and COs:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	3	1	1	1	1	1
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CO3	3	1	3	1	0	0	1	1
CO4	3	1	3	0	0	0	1	1

COs / PSOs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	3	2	1
CO2	1	2	1	1	0
CO3	1	1	2	1	2
CO4	2	3	1	0	3

Scale: 3 = High, 2 = Moderate, 1 = Low, 0 = No Correlation

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Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Mathematics

PG I Sem II

Course Type: MEC-II(C)

Course Title: Numerical Analysis

Course Code: 601MAT2201

Credits: 04 **Max. Marks: 100** **Lectures: 60 Hrs.**

Learning Objectives:

LO 1. To provide students with foundational knowledge of iterative methods for finding approximate solutions to non-linear algebraic and transcendental equations.

LO 2. To develop proficiency in interpolation techniques, including finite differences and polynomial approximations, to estimate values between known data points.

LO 3. To enable students to solve systems of linear equations using both direct elimination methods and iterative computational algorithms.

LO 4. To equip students with the skills to perform numerical differentiation and integration (Quadrature) using rules like Trapezoidal and Simpson's to handle complex mathematical functions.

Course outcomes:

After completion of course the student will be able to-

CO 1. Solve an algebraic or transcendental equation using an appropriate numerical method .

CO 2. Approximate a function using an appropriate numerical method.

CO 3. Solve a differential equation using an appropriate numerical method.

CO 4. 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 Outcomes: 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	

Unit No.	Title of Unit & Contents	Hrs.
II	**Interpolation**	**15**
	1. Polynomial interpolation: interpolation polynomial, 2. Divided difference interpolation, Aitken's formula 3. Finite difference formulas, 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 Outcome: 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. An Introduction to Numerical Analysis by K .E. Atkinson, (Second Edition), 2008.
2. Introduction Methods of Numerical Analysis, by S. S. Sastry, (4th Edition) (Prentice-Hall), 2005.
3. Numerical Methods and Analysis by J. I. Buchaman and P. R. Turner, 2022
4. Numerical Methods by DR. V. N. Vedamurthy, DR. N. Ch. S. N. Iyengar, (First Addition), 1998.

Internal Examination Pattern:

CAT – I: Written Theory Test (Based on Unit -I)

CAT – II Assignments PYQ's on IIT-JAM/NET/SET/GATE/NBHM/ Related Competitive Examinations and Seminar by Student on it (Based on Unit-I, II)

Mapping of POs, PSOs and COs:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	2	3	2	3	1	1
CO2	2	2	2	3	2	3	1	1
CO3	2	3	2	3	3	3	1	1
CO4	2	2	2	3	2	3	1	1

COs / PSOs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	2	3	1
CO2	1	3	2	3	2
CO3	1	3	2	3	3
CO4	1	3	1	2	3

Scale: 3 = High, 2 = Moderate, 1 = Low, 0 = No Correlation

Shiv Chhatrapati Shikshan Sanstha's

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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 English 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.
6. Students having a shortage of additional credits at the end of the third year can meet the Additional Credits Coordinator, who will provide the right advice on the activities that can help them earn credits required for graduation.

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Examination Framework

Theory:

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

Practical:

50% Continuous Assessment Tests (CATs) and 50% Semester End Examination (SEE)

Course	Marks	CAT & Mid Term Theory				CAT Practical		Best Scored CAT I and II & CAT-III	SEE	Total
1	2	3				4		5	6	5 + 6
		Att.	CAT I	CAT-II	CAT III	Att.	CAT			
MMC/MEC/RMC	100	10	10	20	10	-	-	40	60	100
OJT/FP	100					-	-	40	60	100

Note:

1. All Internal Exams are compulsory
2. Out of 02 CATs best score will be considered
3. CAT-III will be conducted by the Exam Section which is of Objective Type on 75% syllabus
4. Semester End Exam is of descriptive in nature (Long & Short Answer)
5. Separate Assessment guideline/criteria will be shared by NEP-Cell of the college.