



Anekant Education Society's
Tuljaram Chaturchand College of Arts, Science & Commerce,
Baramati
(Empowered Autonomous)

Three/Four Year Honours/Honours with Research B.Sc. Degree
Program in Mathematics
(Faculty of Science)

CBCS Syllabus
T.Y.B.Sc. (Mathematics)
For Department of Mathematics

NEP-1.0
Choice Based Credit System Syllabus
(2023 Pattern)

(As Per NEP-2020)

To be implemented from Academic Year 2025-26

Title of the Programme: B.Sc. (Mathematics)**Preamble**

AES's Tuljaram Chaturchand College has made the decision to change the syllabus of across various faculties from June, 2023 by incorporating the guidelines and provisions outlined in the National Education Policy (NEP), 2020. The NEP envisions making education more holistic and effective and to lay emphasis on the integration of general (academic) education, vocational education and experiential learning. The NEP introduces holistic and multidisciplinary education that would help to develop intellectual, scientific, social, physical, emotional, ethical and moral capacities of the students. The NEP 2020 envisages flexible curricular structures and learning based outcome approach for the development of the students. By establishing a nationally accepted and internationally comparable credit structure and courses framework, the NEP 2020 aims to promote educational excellence, facilitate seamless academic mobility, and enhance the global competitiveness of Indian students. It fosters a system where educational achievements can be recognized and valued not only within the country but also in the international arena, expanding opportunities and opening doors for students to pursue their aspirations on a global scale.

In response to the rapid advancements in science and technology and the evolving approaches in various domains of Mathematics and related subjects, the Board of Studies in Mathematics at Tuljaram Chaturchand College, Baramati - Pune, has developed the curriculum for the sixth semester of T.Y.B.Sc. (Mathematics), which goes beyond traditional academic boundaries. The syllabus is aligned with the NEP 2020 guidelines to ensure that students receive an education that prepares them for the challenges and opportunities of the 21st century. This syllabus has been designed under the framework of the Choice Based Credit System (CBCS), taking into consideration the guidelines set forth by the National Education Policy (NEP) 2020, LOCF (UGC), NCrf, NHEQF, Prof. R. D. Kulkarni's Report, Government of Maharashtra's General Resolution dated 20th April and 16th May 2023, and 13th March, 2024 and Circular of SPPU, Pune dated 31st May 2023.

A Mathematics degree equips students with the knowledge and skills necessary for a diverse range of fulfilling career paths. Graduates in Mathematics find opportunities in various fields, including Financial Planner, Market Research Analyst, Data Scientist, teaching, Insurance underwriter, operations research analyst, software developer, and many other domains. After graduating with a degree in mathematics, students can embark on a multitude

of rewarding and diverse career paths. The analytical and problem-solving skills honed during their studies equip them with a strong foundation for success in various fields. Many graduates choose to pursue careers in academia and research, where they can contribute to the advancement of mathematical knowledge through teaching, publishing papers, and conducting ground breaking research. Others may opt for careers in the financial sector, such as investment banking or actuarial science, utilizing their expertise in mathematical modelling and statistical analysis to make informed decisions and manage risks. Additionally, the field of data science offers abundant opportunities for mathematics graduates, as they possess the ability to extract meaningful insights from complex data sets and develop algorithms that drive innovation in industries like technology, healthcare, and marketing. Moreover, mathematics graduates can find fulfilling careers in engineering, cryptography, software development, and operations research, to name just a few areas where their mathematical skills are highly sought after. Overall, a degree in mathematics opens doors to a wide range of intellectually stimulating and financially rewarding professions, allowing graduates to make significant contributions to society and thrive in a rapidly evolving world.

Overall, revising the Mathematics syllabus in accordance with the NEP 2020 ensures that students receive an education that is relevant, comprehensive, and prepares them to navigate the dynamic and interconnected world of today. It equips them with the knowledge, skills, and competencies needed to contribute meaningfully to society and pursue their academic and professional goals in a rapidly changing global landscape.

Credit Distribution Structure for T.Y.B.Sc. as per NEP 2020 (for NEP 1.0 2023 Pattern)

Level	Sem.	Major		Minor	OE	VSC, SEC, (VSEC)	AEC, VEC, IKS	OJT, FP, CEP, CC, RP	Cum. Cr/Sem	Degree /Cum. Cr.
		Mandatory	Electives							
5.5	V	MAT-301-MJM: Metrics Spaces and Introduction to Topology (2 Credit) MAT-302-MJM: Fundamentals of Mathematical Analysis (2 Credit) MAT-303-MJM: Introduction to Group Theory (2 Credit) MAT-304-MJM: Elementary Number Theory (2 Credit) MAT-305-MJM: Practical on Analysis and Algebra – I (2 Credit)	MAT-306-MJE(A): Partial Differential Equations (2 Credit) MAT-306-MJE(B): Fundamentals of Graph Theory (2 Credit) MAT-306-MJE(C): Introduction to Numerical Analysis (2 Credit) (Any Two)	MAT-311-MN: Basic Abstract Algebra (2 Credit) MAT-312-MN: Practical based on Numerical Methods (2 Credit)	--	MAT-321-VSC: Practical Applications of LaTeX in Mathematical Documentation (2 Credit)	--	FP (2 Credit)	22	UG Degree 44 credits
	VI	MAT-351-MJM: Basic Course in Complex Analysis (2 Credit) MAT-352-MJM: Introduction to Ring Theory (2 Credit) MAT-353-MJM: Riemann Integration and Series of Functions (2 Credit) MAT-354-MJM: Lebesgue Integration (2 Credit) MAT-355-MJM: Practical on Analysis and Algebra – II (2 Credit)	MAT-356-MJE(A): Optimization Techniques (2 Credit) MAT-356-MJE(B): Computational Geometry (2 Credit) MAT-356-MJE(C): Introduction to Lattice Theory (2 Credit) (Any Two)	MAT-311-MN: Mathematical Analysis (2 Credit) MAT-312-MN: Practical based on Laplace Transform and Fourier Series (2 Credit)	--	--	--	OJT (4 Credit)	22	
	Cum Cr.	20	08	08	--	02	--	06	44	

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 NEP-1.0

Course Structure for F.Y.B.Sc. (2023 Pattern as per NEP-2020)

Sem	Course Type	Course Code	Course Title	Theory / Practical	Credits
I	Major Mandatory	MAT-101-MJM	Algebra	Theory	02
	Major Mandatory	MAT-102-MJM	Calculus	Theory	02
	Major Mandatory	MAT-103-MJM	Mathematics Practical I	Practical	02
	Open Elective (OE)	MAT-116-OE	Basic Mathematics I	Theory	02
	Open Elective (OE)	MAT-117-OE	Applied Mathematics I	Practical	02
	Vocational Skill Course (VSC)	MAT-121-VSC	Logical Methods	Theory	02
	Skill Enhancement Course (SEC)	MAT-126-SEC	Scilab and Maxima Software I	Practical	02
	Ability Enhancement Course (AEC)	ENG-131-AEC	Functional English-I	Theory	02
	Value Education Course (VEC)	MAT-135-VEC	Mathematics for Environmental Science	Theory	02
	Indian Knowledge System (IKS)	MAT-137-IKS	Vedic Mathematics	Theory	02
	Co-curricular Course (CC)	--	To be selected from the Basket	Theory	02
	Total Credits Semester-I				22
II	Major Mandatory	MAT-151-MJM	Geometry	Theory	02
	Major Mandatory	MAT-152-MJM	Calculus and Differential Equations	Theory	02
	Major Mandatory	MAT-153-MJM	Mathematics Practical II	Practical	02
	Minor	MAT-161-MN	Fundamentals of Mathematics	Theory	02
	Open Elective (OE)	MAT-166-OE	Basic Mathematics II	Theory	02
	Open Elective (OE)	MAT-167-OE	Applied Mathematics II	Practical	02
	Vocational Skill Course (VSC)	MAT-171-VSC	Geogebra Software	Practical	02
	Skill Enhancement Course (SEC)	MAT-176-SEC	Scilab and Maxima Software II	Practical	02
	Ability Enhancement Course (AEC)	ENG-181-AEC	Functional English-II	Theory	02
	Value Education Course (VEC)	MAT-185-VEC	Mathematical Solutions for Environmental Challenges	Theory	02
	Co-curricular Course (CC)	--	To be selected from the Basket	Theory	02
	Total Credits Semester-II				22
	Cumulative Credits Semester I + Semester II				44

Course Structure for S.Y.B.Sc. Mathematics (2023 Pattern as per NEP-2020)

Sem	Course Type	Course Code	Course Title	Theory / Practical	Credits	
III	Major Mandatory	MAT-201-MJM	Calculus of Several Variables	Theory	02	
	Major Mandatory	MAT-202-MJM	Laplace Transform & Fourier Series	Theory	02	
	Major Mandatory	MAT-203-MJM	Ordinary Differential Equations	Theory	02	
	Major Mandatory	MAT-204-MJM	Mathematics Practical III	Practical	02	
	Minor	MAT-211-MN	Foundations of Linear Algebra	Theory	02	
	Minor	MAT-212-MN	Practical based on Ordinary Differential Equations	Practical	02	
	Open Elective (OE)	MAT-216-OE	Intermediate Mathematics	Theory	02	
	Vocational Skill Course (VSC)	MAT-221-VSC	Financial Mathematics	Theory	02	
	Ability Enhancement Course (AEC)	MAR-231-AEC HIN-231-AEC SAN-231-AEC	भाषिक उपयोजन व लेखन कौशल्ये हिंदी भाषा: श्रुजन कौशल प्राथमिक संभाषणकौशल्यम्	Theory	02	
	Field Project (FP)	MAT-235-FP	Field Project	Practical	02	
	Co-curricular Course (CC)	YOG/PES/CUL /NSS/NCC-239-CC	To be selected from the Basket	Theory	02	
	Generic IKS Course (IKS)	GEN-245-IKS		Theory	02	
	Total Credits Semester-III					24
IV	Major Mandatory	MAT-251-MJM	Vector Calculus	Theory	02	
	Major Mandatory	MAT-252-MJM	Linear Algebra	Theory	02	
	Major Mandatory	MAT-253-MJM	Operations Research	Theory	02	
	Major Mandatory	MAT-254-MJM	Mathematics Practical IV	Practical	02	
	Minor	MAT-261-MN	Multivariable Calculus	Theory	02	
	Minor	MAT-262-MN	Practical based on Partial Differential Equations	Practical	02	
	Open Elective (OE)	MAT-266-OE	Mathematical Methods	Practical	02	
	Skill Enhancement Course (SEC)	MAT-276-SEC	Geogebra Software	Practical	02	
	Ability Enhancement Course (AEC)	MAR-281-AEC HIN-281-AEC SAN-281-AEC	लेखन निर्मिती व परीक्षण कौशल्ये हिंदी भाषा: संप्रेषण कौशल प्रगत संभाषणकौशल्यम्	Theory	02	
	Community Engagement Project (CEP)	MAT-285-CEP	Community Engagement Project	Practical	02	
	Co-curricular Course (CC)	YOG/PES/CUL /NSS/NCC-289-CC	To be selected from the Basket	Theory	02	
	Total Credits Semester-IV					22
	Cumulative Credits Semester III + Semester IV					46

Course Structure for T.Y.B.Sc. Mathematics (2023 Pattern as per NEP-2020)

Sem	Course Type	Course Code	Course Title	Theory / Practical	Credits
V	Major Mandatory	MAT-301-MJM	Metric Spaces and Introduction to Topology	Theory	02
	Major Mandatory	MAT-302-MJM	Fundamentals of Mathematical Analysis	Theory	02
	Major Mandatory	MAT-303-MJM	Introduction to Group Theory	Theory	02
	Major Mandatory	MAT-304-MJM	Elementary Number Theory	Theory	02
	Major Mandatory	MAT-305-MJM	Practical on Analysis and Algebra – I	Practical	02
	Major Elective	MAT-306-MJE (A)	Partial Differential Equations	Theory (Any Two)	02
		MAT-306-MJE (B)	Fundamentals of Graph Theory		
		MAT-306-MJE (C)	Introduction to Numerical Analysis		
	Minor	MAT-311-MN	Basic Abstract Algebra	Theory	02
	Minor	MAT-312-MN	Practical based on Numerical Methods	Practical	02
	Vocational Skill Course (VSC)	MAT-321-VSC	Practical Applications of LaTeX in Mathematical Documentation	Practical	02
	Field Project (FP)	MAT-335-FP	Field Project	Practical	02
Total Credits Semester-V					22
VI	Major Mandatory	MAT-351-MJM	Basic Course in Complex Analysis	Theory	02
	Major Mandatory	MAT-352-MJM	Introduction to Ring Theory	Theory	02
	Major Mandatory	MAT-353-MJM	Riemann Integration and Series of Functions	Theory	02
	Major Mandatory	MAT-354-MJM	Lebesgue Integration	Theory	02
	Major Mandatory	MAT-355-MJM	Practical on Analysis and Algebra – II	Practical	02
	Major Elective	MAT-356-MJE (A)	Optimization Techniques	Theory (Any Two)	02
		MAT-356-MJE (B)	Computational Geometry		
		MAT-356-MJE (C)	Introduction to Lattice Theory		
	Minor	MAT-361-MN	Mathematical Analysis	Theory	02
	Minor	MAT-362-MN	Practical based on Laplace Transforms and Fourier Series	Practical	02
	On Job Training (OJT)	MAT-385-OJT	On Job Training	Practical	04
Total Credits Semester-VI					22
Cumulative Credits Semester V + Semester VI					44

Programme Specific Outcomes (PSOs)

PSO 1-Proficiency in Mathematical Concepts: Graduates will have a deep understanding of fundamental mathematical concepts and theories across various branches of mathematics, including calculus, algebra, geometry, probability, and statistics.

PSO 2-Problem-Solving Skills: Graduates will possess strong problem-solving skills and the ability to apply mathematical principles to real-world situations. They can analyze complex problems, develop logical reasoning, and devise creative strategies to find solutions.

PSO 3-Mathematical Modeling: Graduates will be proficient in mathematical modeling, which involves using mathematical techniques to describe and analyze real-world phenomena. They can formulate and solve mathematical models to address problems in diverse fields, including physics, economics, engineering, and social sciences.

PSO4-Computational and Analytical Skills: Graduates will be skilled in using computational tools and software, such as programming languages, statistical software, and mathematical modeling software. They can leverage these tools to perform numerical analysis, data visualization, and simulations.

PSO 5-Communication and Presentation: Graduates will possess effective communication skills, both written and oral, to convey complex mathematical ideas and results to both technical and non-technical audiences. They can present mathematical arguments, proofs, and findings in a clear and concise manner.

PSO 6-Research and Inquiry: Graduates will have the ability to engage in mathematical research and inquiry. They can critically evaluate existing mathematical theories, develop new mathematical models, and contribute to the advancement of mathematical knowledge through independent research or collaborative projects.

PSO 7-Interdisciplinary Collaboration: Graduates will be adept at collaborating with professionals from other disciplines, such as scientists, engineers, economists, and computer scientists. They can effectively communicate and work in multidisciplinary teams to solve complex problems that require mathematical expertise.

PSO 8-Lifelong Learning: Graduates will have developed a strong foundation for lifelong learning in mathematics. They will have the skills to stay abreast of new developments in the field, adapt to emerging technologies and methodologies, and continue their professional growth through self-directed study or advanced academic pursuits.

PSO 9-Advanced Mathematical Techniques: Graduates will have a command of advanced

mathematical techniques, such as differential equations, mathematical analysis, linear algebra, number theory, and optimization. They can apply these advanced mathematical tools to solve complex problems and contribute to specialized areas of research.

PSO 10-Mathematical Software Development: Graduates will possess programming skills and the ability to develop mathematical software or algorithms. They can design, implement, and optimize software applications that facilitate mathematical calculations, simulations, data analysis, and modeling.

PSO 11-Mathematical Education and Teaching: Graduates interested in pursuing a career in education will have the necessary skills to teach mathematics at various levels. They can design and deliver effective lessons, develop curriculum materials, and assess student progress in mathematics. They can also inspire and motivate students to develop an appreciation for the subject.

PSO 12-Mathematical Finance and Risk Analysis: Graduates with an interest in finance and economics will have specialized knowledge in mathematical finance and risk analysis. They can apply mathematical models, stochastic calculus, and statistical methods to analyze financial markets, manage investment portfolios, assess risk, and make informed financial decisions.

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	: B.Sc. Mathematics
Program Code	: USMT
Class	: T.Y.B.Sc.
Semester	: VI
Course Type	: Major Mandatory
Course Name	: Basic Course in Complex Analysis
Course Code	: MAT-351-MJM
No. of Teaching Hours	: 30
No. of Credits	: 2

Course Objectives:

1. To understand the algebraic properties, operations, and geometric interpretations of complex numbers, including sums, products, and roots.
2. To learn the concepts of limits, continuity, and differentiability in the context of complex functions, with an emphasis on Cauchy-Riemann equations and harmonic functions.
3. To analyze the properties and applications of exponential, logarithmic, trigonometric, and hyperbolic functions in the complex domain.
4. To gain proficiency in computing contour integrals, understanding the implications of Cauchy-Goursat's Theorem, and applying the Cauchy integral formula in different contexts.
5. To study the convergence of sequences and series, and apply Taylor and Laurent series to represent complex functions.
6. To learn to identify isolated singular points and calculate residues, and use these concepts to evaluate complex integrals via the residue theorem.
7. To develop the ability to apply complex analysis concepts to solve problems in physics, engineering, and applied mathematics.

Course Outcomes:

CO1: Students will be able to perform algebraic operations with complex numbers and represent them geometrically in the complex plane.

CO2: Students will demonstrate the ability to analyze limits, continuity, and differentiate functions of a complex variable using Cauchy-Riemann equations.

CO3: Students will be able to manipulate and apply exponential, logarithmic, and trigonometric functions in complex scenarios.

CO4: Students will be skilled in evaluating contour integrals, understanding the significance of Cauchy's theorems, and applying these to complex problems.

CO5: Students will be able to determine the convergence of series and represent functions using Taylor and Laurent series.

CO6: Students will be able to identify singular points, compute residues, and apply the residue theorem to solve complex integrals.

CO7: Students will apply their knowledge of complex analysis to solve practical problems in various fields such as physics and engineering.

Topics and Learning Points	
Unit 1: Complex Numbers	Teaching Hours 05
1.1 Sums and products, Basic algebraic properties GCD, LCM	
1.2 Vectors and Moduli, Complex Conjugates	
1.3 Exponential Form, Products and powers in exponential form	
1.4 Arguments of products and quotients, Roots of complex numbers	
1.5 Regions in the complex plane	
Unit 2: Analytic functions	07
2.1 Functions of Complex Variables, Limits, Theorems on limits	
2.2 Limits involving the point at infinity, Continuity, Derivatives	
2.3 Differentiation formulas, Cauchy- Riemann Equations, Sufficient Conditions for differentiability, Polar coordinates, Analytic functions, Harmonic functions	
Unit 3: Elementary Functions	04
3.1 The Exponential functions, The Logarithmic function	
3.2 Branches and derivatives of logarithms, Complex exponents	
3.3 Trigonometric functions, Hyperbolic functions	
Unit 4: Integrals	07
4.1 Derivatives of functions, Definite integrals of functions, Contours	
4.2 Contour integral, Upper bounds for Moduli of contour integrals, Anti-derivatives, Cauchy-Goursat's Theorem	
4.3 Simply and multiply connected domains, Cauchy integral formula	
4.4 Derivatives of analytic functions	
4.5 Liouville's Theorem and Fundamental Theorem of Algebra	
Unit 5: Series	03
5.1 Convergence of sequences and series	
5.2 Taylor's series, Laurent series, examples	
Unit 6: Residues and Poles	04
6.1 Isolated singular points, Residues, Cauchy residue theorem	
6.2 Residue at infinity, types of isolated singular points, residues at poles	
6.3 Zeros of analytic functions, zeros and poles	

Text Book:

J. W. Brown and R. V. Churchill, *Complex Variables and Applications*, International Student Edition, 2009. (8th Edition).

Unit 1: Sections 1 to 11,

Unit 2: Sections 12, 15 to 26,

Unit 3: Sections 29 to 35,

Unit 4: Sections 37 to 53,

Unit 5: Sections 55 to 62,

Unit 6: Sections 68 to 76.

Reference Books:

1. S. Ponnusamy, *Complex Analysis*, Narosa Publication.
2. John B. Conway, *Functions of One Complex Variables*, Springer International Student Edition.
3. Serge Lang, *Complex Analysis*, Springer.
4. Elias M. Stein and Rami Shakrchi, *Complex Analysis*, Princeton University Press.
5. John M. Howie, *Complex Analysis*, Springer.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	1	2	2	3	2	3	3
PO03	1	1	1	1	1	1	2
PO04	2	3	3	3	3	3	3
PO05	2	3	3	3	3	3	3
PO06	1	1	1	1	1	1	2
PO07	1	2	2	2	3	3	3
PO08	2	2	2	2	2	2	3
PO09	1	1	1	1	1	1	2
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	1	2	2	2	2	2	3
PO13	1	1	1	1	1	1	2

Justification for the mapping

PO1: Comprehensive knowledge and understanding - Strong relation with all COs as the course builds fundamental to advanced theoretical knowledge in complex analysis.

PO2: Practical, professional, and procedural knowledge - Moderate to strong relations as COs involve procedural knowledge in complex operations, differentiation, integration, and series applications.

PO3: Entrepreneurial mindset and knowledge - Weak relations as complex analysis is primarily theoretical with limited direct entrepreneurial applications.

PO4: Specialized skills and competencies - Strong relations with most COs as the course develops specialized mathematical skills in complex variable theory.

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning - Strong relations as all COs require analytical reasoning and application of complex analysis concepts to solve problems.

PO6: Communication skills and collaboration - Weak relations as the course focuses more on individual mathematical proficiency than collaborative communication.

PO7: Research-related skills - Moderate to strong relations as advanced COs involve series analysis, residue theorems, and research-applicable mathematical tools.

PO8: Learning how to learn skills - Moderate relations as the course builds autonomous learning capabilities in advanced mathematics.

PO9: Digital and technological skills - Weak relations with limited emphasis on technological applications except in practical problem-solving contexts.

PO10: Multicultural competence, inclusive spirit, and empathy - Weak relations as the content is primarily mathematical with limited cultural dimensions.

PO11: Value inculcation and environmental awareness - Weak relations as complex analysis has minimal direct environmental connections.

PO12: Autonomy, responsibility, and accountability - Moderate relations as students develop independent problem-solving capabilities, especially in advanced applications.

PO13: Community engagement and service - Weak to moderate relations with potential for applying mathematical knowledge to community-relevant problems in CO7.

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	: B.Sc. Mathematics
Program Code	: USMT
Class	: T.Y.B.Sc.
Semester	: VI
Course Type	: Major Mandatory
Course Name	: Introduction to Ring Theory
Course Code	: MAT-352-MJM
No. of Teaching Hours	: 30
No. of Credits	: 2

Course Objectives:

1. To introduce students to the fundamental concepts of ring theory, including the definition and examples of rings and subrings.
2. To develop a deep understanding of integral domains, their properties, and their relationship to fields and characteristics of rings.
3. To analyze the structure and properties of ideals and factor rings, including prime and maximal ideals.
4. To understand the concept of ring homomorphisms, their properties, and the field of quotients.
5. To investigate polynomial rings, focusing on their structure, division algorithm, and related consequences.
6. To study the methods for testing the reducibility and irreducibility of polynomials and understand the concept of unique factorization in $\mathbb{Z}[x]$.
7. To analyze the concepts of irreducibles, primes, unique factorization domains, and Euclidean domains within the context of divisibility in integral domains.

Course Outcomes:

CO1: Students will be able to identify and describe the properties of rings and subrings in various mathematical contexts.

CO2: Students will demonstrate the ability to classify integral domains and distinguish them from other algebraic structures, such as fields and rings.

CO3: Students will be able to construct and analyze ideals and factor rings, and apply the concepts of prime and maximal ideals to solve problems.

CO4: Students will understand and apply ring homomorphisms in different algebraic contexts, including the construction of fields of quotients.

CO5: Students will gain proficiency in working with polynomial rings, including performing operations and understanding the division algorithm.

CO6: Students will be able to apply factorization techniques to polynomials, identify irreducible polynomials, and explain the concept of unique factorization in $\mathbb{Z}[x]$.

CO7: Students will demonstrate the ability to analyze divisibility in integral domains, including understanding the roles of irreducibles, primes, and unique factorization domains.

Topics and Learning Points	
Unit 1: Introduction to Ring	Teaching Hours 05
1.1 Definition and examples	
1.2 Properties of Ring	
1.3 Subring	
Unit 2: Integral Domains	05
2.1 Definition and examples	
2.2 Field	
2.3 Characteristics of Ring	
Unit 3: Ideals and Factor Rings	05
3.1 Ideals	
3.2 Factor Ring	
3.3 Prime Ideals and Maximal Ideals	
Unit 4: Homomorphism of Rings	05
4.1 Definition and examples	
4.2 Properties of Ring Homomorphism	
4.3 The field of Quotients	
Unit 5: Polynomial Ring	05
5.1 Definition and Examples	
5.2 The Division Algorithm	
5.3 Consequences	
Unit 6: Factorization of Polynomial	05
6.1 Reducibility Tests	
6.2 Irreducibility Tests	
6.3 Unique Factorization in $\mathbb{Z}[x]$	
6.4 Unique Factorization Domains	
6.5 Euclidean Domains	

Text Book:

Joseph, A. Gallian, *Contemporary Abstract Algebra*, Narosa Publishing House (4th Edition).

Chapter Numbers: 12, 13, 14, 15, 16, 17 and 18.

Reference Books:

1. John B. Fraleigh, *First course in Abstract Algebra*, Pearson Education, 7th Edition.
2. David S. Dummit and Richard M. Foote, *Abstract Algebra*, Wiley, 3rd Edition.
3. N. S. Gopalkrishnan, *University of Algebra*, New Age International Publishers.
4. I. N. Herstein, *Abstract Algebra*, Wiley, 3rd Edition.
5. C. Musili, *Introduction to Rings and Modules*, Narosa Publishing House.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
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PO01	3	3	3	3	3	3	3
PO02	2	2	2	2	3	3	3
PO03	1	1	1	1	1	1	1
PO04	2	2	3	3	3	3	3
PO05	2	2	3	3	3	3	3
PO06	1	1	1	1	1	1	1
PO07	2	2	2	2	2	2	2
PO08	2	2	2	2	2	2	2
PO09	2	2	2	2	2	2	2
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	2	2	2	2	2	2	2
PO13	1	1	1	1	1	1	1

Justification for the mapping

PO1: Comprehensive knowledge and understanding - The entire course is dedicated to building a comprehensive understanding of functions of several variables, limits, continuity, partial derivatives, and their applications.

PO2: Practical, professional, and procedural knowledge - The course provides procedural knowledge for calculating derivatives (CO1-CO4). This becomes strongly practical (Weightage 3) when applied to tangent planes, approximations, and error estimation (CO5-CO7), which are key engineering tools.

PO3: Entrepreneurial mindset and knowledge - The content is highly technical and foundational, with no direct link to business or entrepreneurial concepts.

PO4: Specialized skills and competencies - Skills like computing partial derivatives are moderate. Analyzing limits and continuity (CO3) and applying the chain rule or implicit differentiation (CO4, CO5) represent strong, specialized competencies in calculus.

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning - The course is heavily focused on problem-solving. While basic derivative computation is moderate, solving complex optimization problems, analyzing limit existence, and applying concepts to real-world scenarios like error estimation (CO5-CO7) demonstrate strong analytical reasoning.

PO6: Communication skills and collaboration - The course, as presented, is primarily individual and theoretical, with no inherent focus on collaborative work or formal communication skills.

PO7: Research-related skills - The process of exploring limits along different paths, verifying theorems (like Clairaut's), and connecting concepts (like differentiability and continuity) cultivates a research-oriented, investigative mindset.

PO8: Learning how to learn skills - Mastering multivariable calculus requires students to build upon single-variable concepts, developing self-study strategies and abstract thinking skills essential for lifelong learning in technical fields.

PO9: Digital and technological skills - Students often use mathematical software (like MATLAB, Python) to visualize surfaces, level curves, and verify their solutions, which requires and develops digital technological skills.

PO10: *Multicultural competence, inclusive spirit, and empathy* - The content is universal and abstract, with no direct connection to multicultural or empathetic perspectives.

PO11: *Value inculcation and environmental awareness* - The syllabus does not directly address values or environmental issues.

PO12: *Autonomy, responsibility, and accountability* - Success in this course requires a high degree of personal responsibility for mastering complex material and autonomously working through problem sets.

PO13: *Community engagement and service* - The theoretical nature of the course does not directly involve community engagement or service.

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	: B.Sc. Mathematics
Program Code	: USMT
Class	: T.Y.B.Sc.
Semester	: VI
Course Type	: Major Mandatory
Course Name	: Riemann Integration and Series of Functions
Course Code	: MAT-353-MJM
No. of Teaching Hours	: 30
No. of Credits	: 2

Course Objectives:

1. To provide a thorough understanding of the Riemann integral, including its definition, properties, and the conditions under which it exists.
2. To introduce the fundamental theorem of integral calculus and the mean value theorems, emphasizing their importance in mathematical analysis.
3. To explore the concept of improper integrals, including definitions, convergence tests, and the differences between absolute and conditional convergence.
4. To teach students various tests for the convergence of series, such as the comparison test and integral test, particularly in the context of improper integrals.
5. To investigate the pointwise and uniform convergence of sequences of functions, and to understand their implications in analysis.
6. To examine the convergence and uniform convergence of series of functions, and to explore how integration and differentiation can be applied to such series.
7. To cultivate analytical thinking and problem-solving skills through rigorous exploration of integral calculus and sequences/series of functions.

Course Outcomes:

- CO1:** Students will be able to define and determine the Riemann integral for a wide range of functions, demonstrating an understanding of its properties and existence criteria.
- CO2:** Students will apply the fundamental theorem of integral calculus and mean value theorems to solve problems in integral calculus.
- CO3:** Students will identify and evaluate improper integrals of the first and second kinds, using appropriate convergence tests to determine their behavior.
- CO4:** Students will apply comparison and integral tests to analyze the convergence of series, and distinguish between absolute and conditional convergence.
- CO5:** Students will evaluate the pointwise and uniform convergence of sequences of functions, understanding the implications of uniform convergence on continuity, integration, and differentiation.
- CO6:** Students will analyze the convergence of series of functions and apply integration and differentiation to series, understanding when these operations are valid.
- CO7:** Students will develop strong problem-solving skills in advanced calculus, preparing them for further study or research in mathematical analysis.

Topics and Learning Points	
Unit 1: Riemann Integral	Teaching Hours
1.1 Sets of measure zero	08
1.2 Definition of the Riemann integral	
1.3 Existence of the Riemann integral	
1.4 Properties of the Riemann integral	
1.5 Fundamental theorem of integral calculus	
1.6 Mean value theorems of integral calculus	
Unit 2: Improper Integrals	08
2.1 Definition of improper integral of first kind	
2.2 Comparison test	
2.3 Absolute and conditional convergence	
2.4 Integral test for convergence of series	
2.5 Definition of improper integral of second kind	
2.6 Cauchy principal value	
Unit 3: Sequences of functions	07
3.1 Point wise convergence of sequences of functions	
3.2 Uniform convergence of sequences of functions	
3.3 Consequences of uniform convergence	
Unit 4: Series of functions	07
4.1 Convergence and uniform convergence of series of functions	
4.2 Integration and differentiation of series of functions	

Text Books:

R. R. Goldberg, *Methods of Real Analysis*, Oxford & I. B. H. Publications, 1970.

Unit 1: Ch. 7, Art. 7.1 to 7.4 and 7.8, **Unit 3:** Ch. 9, Art. 9.1 to 9.3,

Unit 4: Ch. 9, Art. 9.4 and 9.5.

D. Somasundaram and B. Choudhary, *A first course in Mathematical Analysis*, Narosa Publishing House, 1997.

Unit 2: Ch. 8, Art 8.5.

Reference Books:

1. Ajit Kumar and S. Kumaresan, *A Basic Course in Real Analysis*, CRC Press, Second Indian Reprint 2015.
2. Robert, G. Bartle, Donald Sherbert, *Introduction to Real Analysis*, 3rd Edition, John Wiley and Sons.
3. Tom M. Apostol, *Mathematical Analysis*, Addison-Wesley.
4. S. C. Malik and Savita Arora, *Mathematical Analysis*, New Age International Publications, third Edition, (2008).
5. Walter Rudin, *Principles of Mathematical Analysis*, McGraw-Hill International Edition.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	2	2	2	2	2	2	3
PO03	1	1	1	1	1	1	2
PO04	3	3	3	3	3	3	3
PO05	2	3	2	3	3	3	3
PO06	1	1	1	1	1	1	2
PO07	2	2	2	2	3	3	3
PO08	2	2	2	2	2	2	3
PO09	1	1	1	1	1	1	1
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	2	2	2	2	2	2	3
PO13	1	1	1	1	1	1	1

Justification for the mapping

PO1: Comprehensive knowledge and understanding - The course builds comprehensive understanding of multivariable calculus concepts, limits, continuity, partial derivatives, and their applications.

PO2: Practical, professional, and procedural knowledge -

- Strong emphasis on applying theorems and developing problem-solving skills (CO7)
- Moderate practical application in computing derivatives and analyzing convergence (all other COs)

PO3: Entrepreneurial mindset and knowledge -

- Some development of analytical thinking applicable to entrepreneurial contexts (CO7)
- Limited direct entrepreneurial application (all other COs)

PO4: Specialized skills and competencies - Course develops specialized mathematical skills in advanced calculus and analysis

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning -

- Strong focus on problem-solving and analytical reasoning (CO2, CO4, CO5, CO6 and CO7)
- Moderate application and reasoning components (CO1 and CO3)

PO6: Communication skills and collaboration -

- Some development through problem-solving approaches (CO7)
- Limited emphasis on communication and collaboration (all other COs)

PO7: Research-related skills -

- Strong development of analytical thinking and convergence analysis skills relevant to research (CO5, CO6 and CO7)
- Moderate research skill development (all other COs)

PO8: Learning how to learn skills -

- Strong emphasis on developing independent problem-solving abilities (CO7)
- Moderate development of self-learning through concept understanding (all other COs)

PO9: *Digital and technological skills* - Limited integration of digital technologies in the course content

PO10: *Multicultural competence, inclusive spirit, and empathy* - Not directly addressed in technical mathematical content

PO11: *Value inculcation and environmental awareness* - Not a primary focus of the mathematical content

PO12: *Autonomy, responsibility, and accountability* -

- Strong development through independent problem-solving (CO7)
- Moderate development through individual learning (all other COs)

PO13: *Community engagement and service* - Limited direct community engagement component

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	: B.Sc. Mathematics
Program Code	: USMT
Class	: T.Y.B.Sc.
Semester	: VI
Course Type	: Major Mandatory
Course Name	: Lebesgue Integration
Course Code	: MAT-354-MJM
No. of Teaching Hours	: 30
No. of Credits	: 2

Course Objectives:

1. To provide a foundational understanding of measure theory, focusing on measurable sets and functions, which are crucial for advanced mathematical analysis.
2. To study the length, inner and outer measure, and properties of open and closed sets, developing a clear understanding of measurable sets.
3. To define measurable functions, analyze their properties, and explore sequences of measurable functions, laying the groundwork for advanced integration theory.
4. To introduce the concept of the Lebesgue integral, including its definition for both bounded and unbounded functions, and examine its fundamental properties.
5. To explore and apply key theorems in measure theory, such as the Lebesgue Dominated Convergence Theorem and Fatou's Lemma, in various contexts.
6. To enhance students' ability to work with abstract mathematical concepts and apply them to solve complex problems in analysis.
7. To prepare students for further studies in real analysis, functional analysis, and other areas of mathematics that require a deep understanding of measure and integration.

Course Outcomes:

CO1: Students will be able to describe and characterize measurable sets, understanding their significance in measure theory.

CO2: Students will demonstrate proficiency in defining and working with measurable functions, including analyzing their sequences.

CO3: Students will be able to compute and apply Lebesgue integrals for both bounded and unbounded functions, understanding their properties and applications.

CO4: Students will effectively apply the Lebesgue Dominated Convergence Theorem and Fatou's Lemma to solve problems in integration theory.

CO5: Students will develop strong analytical and problem-solving skills, particularly in the context of measure and integration.

CO6: Students will be well-prepared for advanced courses in real and functional analysis, having gained a solid foundation in measure theory and integration.

CO7: Students will be equipped with the knowledge and skills necessary to engage in research or further study in mathematical analysis and related fields.

Topics and Learning Points	
Unit 1: Measurable Sets	Teaching Hours
1.1 Length of open sets and closed sets	10
1.2 Inner and outer measure	
1.3 Measurable sets	
1.4 Properties of measurable sets	
Unit 2: Measurable Functions	09
2.1 Definition and examples	
2.2 Properties of measurable functions	
2.3 Sequence of measurable functions	
Unit 3: The Lebesgue Integrals	06
3.1 Definition and example of the Lebesgue integrals for bounded functions	
3.2 Properties of Lebesgue integrals for bounded measurable functions	
3.3 The Lebesgue integral for unbounded functions	
Unit 4: Some Fundamental Theorems	05
4.1 Lebesgue dominated convergence theorem	
4.2 Fatou's lemma	

Text Book:

R. R. Goldberg, *Methods of Real Analysis*, Oxford & I. B. H. Publications, 1970.

Unit 1: Ch. 11, Art. 11.1 to 11.3,

Unit 2: Ch. 11, Art. 11.4,

Unit 3: Ch. 11, Art. 11.5 to 11.7,

Unit 4: Ch. 11, Art. 11.8

Reference Books:

1. G. de Barra, *Measure and Integration*, Elsevier, 2003.
2. H. L. Royden and Patrick Fitzpatrick, *Real Analysis*, Prentice Hall, 2010.
3. Walter Rudin, *Real and Complex Analysis*, McGraw-Hill Education, 1987.
4. Frank Jones, *Lebesgue Integration on Euclidean Space*, Jones and Bartlett Publishers.
5. Inder K. Rana, *Introduction to Measure and Integration*, Narosa Publishing House.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	2	2	3	3	3	2	2
PO03	1	1	1	1	2	1	2
PO04	3	3	3	3	3	3	3
PO05	2	2	3	3	3	2	2
PO06	1	1	1	1	2	1	2
PO07	2	2	2	3	3	3	3
PO08	2	2	2	2	3	3	3
PO09	1	1	1	1	1	1	1
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	2	2	2	2	3	2	3
PO13	1	1	1	1	1	1	1

Justification for the mapping

PO1: Comprehensive knowledge and understanding - The course provides deep theoretical understanding of measure theory, measurable sets/functions, and Lebesgue integration.

PO2: Practical, professional, and procedural knowledge -

- Strong practical application in computing Lebesgue integrals and applying convergence theorems (CO3, CO4 and CO5)
- Moderate procedural knowledge in theoretical concepts (all other COs)

PO3: Entrepreneurial mindset and knowledge -

- Analytical skills applicable to complex problem-solving in various domains (CO5 and CO7)
- Limited direct entrepreneurial application (all other COs)

PO4: Specialized skills and competencies - Course develops highly specialized mathematical skills in measure theory and advanced integration

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning -

- Strong emphasis on applying integration theory and developing analytical reasoning (CO3, CO4 and CO5)
- Moderate problem-solving components (all other COs)

PO6: Communication skills and collaboration -

- Some development through rigorous mathematical reasoning and presentation (CO5 and CO7)
- Limited emphasis on collaborative work (all other COs)

PO7: Research-related skills -

- Strong development of advanced analytical skills crucial for mathematical research (CO4, CO5, CO6 and CO7)
- Foundation for research in analysis (all other COs)

PO8: Learning how to learn skills -

- Strong emphasis on developing independent learning and preparation for advanced study (CO5, CO6 and CO7)

- Moderate development through abstract concept mastery (all other COs)

PO9: *Digital and technological skills* - Theoretical course with limited technological integration

PO10: *Multicultural competence, inclusive spirit, and empathy* - Not directly addressed in advanced mathematical theory

PO11: *Value inculcation and environmental awareness* - Not a focus of the technical mathematical content

PO12: *Autonomy, responsibility, and accountability* -

- Strong development through independent problem-solving and research preparation (CO5 and CO7)
- Moderate autonomy in theoretical understanding (all other COs)

PO13: *Community engagement and service* - Limited direct community engagement in advanced theoretical mathematics

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	: B.Sc. Mathematics
Program Code	: USMT
Class	: T.Y.B.Sc.
Semester	: VI
Course Type	: Major Mandatory
Course Name	: Practical on Analysis and Algebra – II
Course Code	: MAT-355-MJM
No. of Teaching Hours	: 60
No. of Credits	: 2

Course Objectives:

1. To develop an understanding of complex number operations and their geometric interpretations.
2. To explore fundamental concepts of analytic functions, contour integration, and applications of residue theorem.
3. To introduce fundamental algebraic structures such as rings, subrings, and polynomial rings.
4. To understand the role of homomorphisms, factor rings, and integral domains in abstract algebra.
5. To enhance the comprehension of Riemann integration, improper integrals, and their convergence properties.
6. To introduce the concepts of measurable sets, measurable functions, and their significance in measure theory.
7. To apply Lebesgue integration techniques for bounded and unbounded functions and analyze their properties.

Course Outcomes:

CO1: Student will be able to visualize and perform operations on complex numbers, applying them in function analysis.

CO2: Student will be able to verify Cauchy-Riemann equations and analyze analytic functions.

CO3: Student will be able to compute contour integrals and apply the residue theorem to evaluate complex integrals.

CO4: Student will be able to define and explore algebraic structures such as rings, subrings, and factor rings.

CO5: Student will be able to analyze sequences and series of functions, distinguishing between pointwise and uniform convergence.

CO6: Student will be able to compute outer and inner measures and verify properties of measurable functions.

CO7: Student will be able to evaluate Lebesgue integrals for bounded and unbounded functions and apply key convergence theorems.

Topics and Learning Points**Teaching Hours**
60**List of practical:**

- 1) Visualization and Operations on Complex Numbers
- 2) Analytic Functions and Cauchy-Riemann Equations
- 3) Contour Integration and Residue Theorem Applications
- 4) Exploring Rings and Subrings
- 5) Homomorphisms and Factor Rings
- 6) Factorization in Polynomial Rings and Integral Domains
- 7) Evaluation of Riemann Integrals and Verification of Fundamental Theorems
- 8) Analysis of Improper Integrals and Convergence Tests
- 9) Pointwise and Uniform Convergence of Sequences and Series of Functions
- 10) Computation of Outer and Inner Measure for Given Sets
- 11) Verification of Properties of Measurable Functions and Sequences
- 12) Evaluation of Lebesgue Integral for Bounded and Unbounded Functions

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	2	2	3	2	2	2	3
PO03	1	1	1	1	1	1	1
PO04	3	3	3	3	3	3	3
PO05	2	3	3	2	3	3	3
PO06	1	1	1	1	1	1	1
PO07	2	2	3	2	2	2	3
PO08	2	2	2	2	2	2	2
PO09	1	1	1	1	1	1	1
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	2	2	2	2	2	2	2
PO13	1	1	1	1	1	1	1

Justification for the mapping

PO1: Comprehensive knowledge and understanding - The course provides comprehensive understanding across complex analysis, abstract algebra, and measure theory domains.

PO2: Practical, professional, and procedural knowledge -

- Strong practical application in computing contour integrals and Lebesgue integrals (CO3 and CO7)
- Moderate procedural knowledge in theoretical concepts and verification processes (all other COs)

PO3: Entrepreneurial mindset and knowledge - Limited direct entrepreneurial application in advanced mathematical theory

PO4: Specialized skills and competencies - Course develops highly specialized mathematical skills across multiple advanced mathematical domains

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning -

- Strong emphasis on analytical reasoning in function analysis, integration, and convergence (CO2, CO3, CO5, CO6 and CO7)
- Moderate problem-solving in complex number operations and algebraic structures (CO1 and CO4)

PO6: Communication skills and collaboration - Theoretical mathematics course with limited emphasis on communication and collaboration

PO7: Research-related skills -

- Strong development of advanced integration techniques crucial for mathematical research (CO3 and CO7)
- Foundation for research in complex analysis and abstract algebra (all other COs)

PO8: Learning how to learn skills - Moderate development of independent learning through abstract mathematical concept mastery

PO9: Digital and technological skills - Theoretical course with limited technological integration

PO10: Multicultural competence, inclusive spirit, and empathy - Not directly addressed in advanced mathematical theory

PO11: *Value inculcation and environmental awareness* - Not a focus of the technical mathematical content

PO12: *Autonomy, responsibility, and accountability* - Moderate development through independent problem-solving in theoretical mathematics

PO13: *Community engagement and service* - Limited direct community engagement in advanced theoretical mathematics

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	: B.Sc. Mathematics
Program Code	: USMT
Class	: T.Y.B.Sc.
Semester	: VI
Course Type	: Major Elective
Course Name	: Optimization Techniques
Course Code	: MAT-356-MJE (A)
No. of Teaching Hours	: 30
No. of Credits	: 2

Course Objectives:

1. To comprehend the principles of network models, including CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique), and their application in project management.
2. To learn the techniques for identifying and analyzing critical paths within a network, enabling efficient time management and resource allocation.
3. To develop decision-making skills under conditions of uncertainty, using probabilistic models and game theory.
4. To grasp the fundamental concepts of game theory, including terminologies, optimal solutions for two-person zero-sum games, and mixed strategy games.
5. To understand the concepts of replacement and maintenance models, focusing on the replacement of items whose efficiency deteriorates over time.
6. To learn how to formulate and solve sequencing problems involving multiple jobs and machines, optimizing job order and resource utilization.
7. To explore classical optimization theory, including both unconstrained and constrained problems, with a focus on the Lagrangian method for constrained optimization.

Course Outcomes:

CO1: Students will be able to construct and analyze CPM and PERT networks, identifying critical paths and optimizing project schedules.

CO2: Students will develop the ability to make informed decisions under uncertainty, utilizing decision analysis techniques.

CO3: Students will be proficient in applying game theory to determine optimal strategies in competitive situations, including the use of linear programming for game representation.

CO4: Students will understand various types of failures and will be able to determine optimal replacement strategies for items whose efficiency deteriorates over time.

CO5: Students will be capable of solving sequencing problems, optimizing the processing of multiple jobs through different machines.

CO6: Students will be able to apply classical optimization techniques to solve both unconstrained and constrained problems, with a strong grasp of the Lagrangian method.

CO7: Students will be able to apply the theoretical concepts learned in real-world scenarios, improving project management, decision-making, and operational efficiency in various contexts.

Topics and Learning Points	
Unit 1: Network Models	Teaching Hours 12
1.1 CPM and PERT	
1.2 Network representation	
1.3 Critical Path Computations	
1.4 Construction of the time schedule	
Unit 2: Decision Analysis and Games	13
2.1 Decision under uncertainty	
2.2 Game theory: Some basic terminologies	
2.3 Optimal solution of two-person zero sum game	
2.4 Solution of mixed strategy games	
2.5 Graphical solution of games	
2.6 Representing game as a linear programme	
Unit 3: Replacement and Maintenance Models	06
3.1 Introduction	
3.2 Types of failure	
3.3 Replacement of items whose efficiency deteriorates with time	
Unit 4: Sequencing Problems	08
4.1 Introduction, notation, terminology and assumptions	
4.2 Processing n jobs through two machines	
4.3 Processing n jobs through three machines	
Unit 5: Classical Optimization Theory	06
5.1 Unconstrained problems	
5.2 Constrained problems (Lagrangian Method Only)	

Text Books:

J. K. Sharma, *Operations Research: Theory and Applications*, (2nd Edition, 2006), Macmilan India Ltd.

Unit 1: Ch. 13

Unit 2: Ch. 12

Unit 3: Ch. 17

Unit 4: Ch. 20

Hamdy A. Taha, *Operation Research* (8th Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi.

Unit 5: Ch. 18

Reference Books:

1. Frederick S. Hillier and Gerald J. Lieberman, *Introduction to Operation Research*, McGraw Hill, 2011.
2. A. Ravindran, Don T. Phillip and James J. Solberg, *Operations Research: Principles and Practice*, Wiley.
3. Richard Bronson and Govindasami Naadimuthu, *Schaum's Outline Operations Research*, McGraw-Hill, 1982.
4. Paul A. Jensen and Jonathan F. Bard, *Operations Research: Models and Methods*, Wiley.
5. Maurice Sasieni, Arthur Yaspan and Lawrence Friedman, *Operations Research: Methods and Problems*, Wiley.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	3	3	3	3	3	3	3
PO03	3	3	3	3	3	3	3
PO04	3	3	3	3	3	3	3
PO05	3	3	3	3	3	3	3
PO06	2	2	2	2	2	2	3
PO07	2	2	2	2	2	2	3
PO08	2	2	2	2	2	2	3
PO09	1	1	1	1	1	1	2
PO10	1	1	1	1	1	1	2
PO11	1	1	1	1	1	1	2
PO12	2	2	2	2	2	2	3
PO13	1	1	1	1	1	1	2

Justification for the mapping

PO1: Comprehensive knowledge and understanding - Course provides comprehensive understanding of operations research methodologies and optimization techniques.

PO2: Practical, professional, and procedural knowledge - Strong emphasis on practical application of project management, decision analysis, and optimization techniques.

PO3: Entrepreneurial mindset and knowledge - Direct application to business optimization, resource allocation, and strategic decision-making essential for entrepreneurship.

PO4: Specialized skills and competencies - Develops specialized skills in operations research, optimization, and quantitative decision-making.

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning - Core focus on analytical problem-solving, optimization, and decision-making under uncertainty.

PO6: Communication skills and collaboration -

- Strong development through real-world scenario applications and project management (CO7)
- Moderate emphasis on communicating analytical results (all other COs)

PO7: Research-related skills -

- Strong research application in real-world optimization problems (CO7)
- Moderate research skill development through analytical techniques (all other COs)

PO8: Learning how to learn skills -

- Strong emphasis on adapting theoretical concepts to practical scenarios (CO7)
- Moderate development through complex problem-solving approaches (all other COs)

PO9: Digital and technological skills -

- Some application of technology in real-world implementations (CO7)
- Limited direct technological integration in theoretical concepts (all other COs)

PO10: Multicultural competence, inclusive spirit, and empathy -

- Some consideration in real-world applications (CO7)
- Limited direct emphasis in technical content (all other COs)

PO11: *Value inculcation and environmental awareness* -

- Some consideration in real-world operational efficiency (CO7)
- Limited direct emphasis in optimization techniques (all other COs)

PO12: *Autonomy, responsibility, and accountability* -

- Strong development through real-world decision-making responsibility (CO7)
- Moderate autonomy in analytical problem-solving (all other COs)

PO13: *Community engagement and service* -

- Potential application in community project management (CO7)
- Limited direct community engagement focus (all other COs)

**CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Mathematics
(2023 Pattern)**

Name of the Programme	: B.Sc. Mathematics
Program Code	: USMT
Class	: T.Y.B.Sc.
Semester	: VI
Course Type	: Major Elective
Course Name	: Computational Geometry
Course Code	: MAT-356-MJE (B)
No. of Teaching Hours	: 30
No. of Credits	: 2

Course Objectives:

1. To introduce fundamental concepts of two-dimensional transformations and their applications in geometry.
2. To develop an understanding of three-dimensional transformations and their role in graphics and modeling.
3. To familiarize students with the mathematical representation of plane curves and their transformations.
4. To explore different types of projections used in affine and perspective geometry.
5. To introduce Bezier curves and their properties, including curve fitting techniques.
6. To enable students to apply matrices and coordinate transformations to geometric problems.
7. To enhance problem-solving skills by applying computational techniques to transformation geometry.

Course Outcomes:

CO1: Student will be able to apply 2D transformations (rotation, scaling, reflection, translation) using matrices.

CO2: Student will be able to perform 3D transformations, including rotation about an arbitrary axis and reflection through an arbitrary plane.

CO3: Student will be able to represent and analyze parametric and non-parametric curves, including circles, ellipses, parabolas, and hyperbolas.

CO4: Student will be able to understand and implement different projection techniques, such as orthographic and perspective projections.

CO5: Student will be able to construct Bezier curves and apply curve-fitting techniques for polynomial approximation.

CO6: Student will be able to solve real-world geometric problems using matrix-based transformation techniques.

CO7: Student will be able to apply geometric transformations in areas such as computer graphics, engineering design, and robotics.

Topics and Learning Points	
Unit 1: Two Dimensional Transformations	Teaching Hours 09
1.1 Introduction, Representation of points	
1.2 Transformations and Matrices	
1.3 Transformation of point and straight lines	
1.4 Midpoint transformation, Parallel lines and Intersecting lines	
1.5 Rotation, Reflection and Scaling	
1.6 Combined operations, Transformation of a unit square	
1.7 Arbitrary 2×2 rotation matrix	
1.8 Two-dimensional translation and Homogeneous coordinates	
Unit 2: Three Dimensional Transformations	08
2.1 Three-dimensional scaling, shearing and rotation	
2.2 Reflection and translation in three dimensions	
2.3 Rotation about an arbitrary axis in space	
2.4 Reflection through an arbitrary plane	
2.5 Affine and perspective geometry	
2.6 Orthographic, Axonometric and Oblique projections	
2.7 Techniques for generating perspective views	
Unit 3: Plane Curves	07
3.1 Representation of curve	
3.2 Non-parametric and Parametric curves	
3.3 Parametric representations of circle, ellipse, parabola and hyperbola	
Unit 4: Bezier Curves	06
4.1 Definition	
4.2 Properties (without proof)	
4.3 Curve fitting (up to $n = 3$)	
4.4 Equation of curve in matrix form (up to $n = 3$)	

Text Book:

David F. Rogers and J. Alan Adams, *Mathematical Elements for Computer Graphics*, McGraw-Hill, 2nd Edition.

Unit 1: Sections 2.1 to 2.15,

Unit 2: Sections 3.1 to 3.12,

Unit 3: Sections 4.1 to 4.10,

Unit 4: Section 5.7.

Reference Books:

1. James D. Foley, Andries van Dam, Steven K. Feiner, John F. Hughes, *Computer Graphics: Principles and Practice*, Addison-Wesley
2. Donald Hearn and M. Pauline Baker, *Computer Graphics*, Pearson.
3. Kenwright, *Introduction to Computer Graphics and the Vulkan API*, Create Space Independent Publishing Platform, 2017.
4. Michael E. Mortenson, *Geometric Modeling*, Wiley.
5. M. de Berg, M. van Kreveld, M. Overmars, O. Schwarzkopf, *Computational Geometry: Algorithms and Applications*, Springer.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	3	3	3	3	3	3	3
PO03	2	2	2	2	2	3	3
PO04	3	3	3	3	3	3	3
PO05	3	3	3	3	3	3	3
PO06	2	2	2	2	2	2	2
PO07	2	2	2	2	2	2	3
PO08	2	2	2	2	2	2	3
PO09	3	3	3	3	3	3	3
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	2	2	2	2	2	2	3
PO13	1	1	1	1	1	1	2

Justification for the mapping

PO1: Comprehensive knowledge and understanding - Course provides comprehensive understanding of geometric transformations, curves, and projection techniques.

PO2: Practical, professional, and procedural knowledge - Strong emphasis on practical implementation of transformation matrices and geometric algorithms.

PO3: Entrepreneurial mindset and knowledge -

- Direct application to real-world problems in graphics, engineering, and robotics with entrepreneurial potential (CO6 and CO7)
- Moderate entrepreneurial application in geometric techniques (all other COs)

PO4: Specialized skills and competencies - Develops specialized skills in computer graphics, geometric modeling, and transformation mathematics.

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning - Core focus on analytical problem-solving using geometric transformations and curve fitting.

PO6: Communication skills and collaboration - Moderate development through visualization and technical implementation discussions

PO7: Research-related skills -

- Strong research application in advanced graphics and robotics (CO7)
- Moderate research skill development through geometric algorithms (all other COs)

PO8: Learning how to learn skills -

- Strong emphasis on adapting geometric concepts to emerging technologies (CO7)
- Moderate development through complex transformation techniques (all other COs)

PO9: Digital and technological skills - Strong digital skills development in computer graphics, transformation algorithms, and geometric modeling.

PO10: Multicultural competence, inclusive spirit, and empathy - Limited direct emphasis in technical geometric content

PO11: Value inculcation and environmental awareness - Not a primary focus of geometric transformation content

PO12: *Autonomy, responsibility, and accountability* -

- Strong development through real-world applications in critical domains (CO7)
- Moderate autonomy in geometric problem-solving (all other COs)

PO13: *Community engagement and service* -

- Potential application in community graphics projects (CO7)
- Limited direct community engagement focus (all other COs)

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	: B.Sc. Mathematics
Program Code	: USMT
Class	: T.Y.B.Sc.
Semester	: VI
Course Type	: Major Elective
Course Name	: Introduction to Lattice Theory
Course Code	: MAT-356-MJE (C)
No. of Teaching Hours	: 30
No. of Credits	: 2

Course Objectives:

1. To introduce the fundamental concepts of ordered sets and their representation using diagrams.
2. To develop an understanding of lattices as both ordered sets and algebraic structures.
3. To explore maps between ordered sets, sublattices, and lattice homomorphisms.
4. To analyze ideals, filters, and their role in complete lattices.
5. To examine key properties such as chain conditions, completeness, and join-irreducible elements.
6. To study modular, distributive, and Boolean lattices with a focus on their algebraic identities.
7. To apply Boolean algebra principles, including Boolean terms and disjunctive normal form.

Course Outcomes:

CO1: Students will be able to understand the structure of ordered sets and construct their corresponding diagrams.

CO2: Students will be able to analyze lattices as both ordered sets and algebraic structures, identifying sublattices and their properties.

CO3: Students will be able to demonstrate an ability to work with homomorphisms in lattices and recognize important substructures.

CO4: Students will be able to apply the concepts of ideals and filters in the study of complete lattices.

CO5: Students will be able to evaluate chain conditions, completeness, and join-irreducible elements in lattice structures.

CO6: Students will be able to differentiate between modular, distributive, and Boolean lattices based on their algebraic identities.

CO7: Students will be able to utilize Boolean algebra techniques to express logical statements in disjunctive normal form.

Topics and Learning Points	
Unit 1: Ordered Sets	Teaching Hours 08
1.1 Ordered sets and examples	
1.2 Diagrams: the art of drawing ordered sets	
1.3 Constructing and de-constructing ordered sets	
1.4 Down-sets and up-sets	
1.5 Maps between ordered sets	
Unit 2: Lattices	07
2.1 Lattices as ordered sets	
2.2 Lattices as algebraic structures	
2.3 Sublattices and products	
2.4 Homomorphisms	
Unit 3: Ideals and Complete Lattices	06
3.1 Ideals and filters	
3.2 Complete lattices and $\cap$ –structures	
3.3 Chain conditions and completeness	
3.4 Join-irreducible elements	
Unit 4: Modular, Distributive and Boolean Lattices	09
4.1 Lattices satisfying additional identities	
4.2 The $M_3 - N_5$ theorem	
4.3 Boolean lattices and Boolean algebras	
4.4 Boolean terms and disjunctive normal form	

Text Book:

B. A. Davey and H. A. Priestley, *Introduction to Lattice and Order*, Cambridge University Press, 2nd Edition, 2002.

Unit 1: Chapter 1,

Unit 2: Chapter 2,

Unit 3: Chapter 2,

Unit 4: Chapter 4.

Reference Books:

1. George Grätzer, *Lattice Theory: Foundation*, Birkhauser.
2. Bernd S. W. Schroder, *Ordered Sets: An Introduction*, Springer.
3. Ian Anderson, *Combinatorics of Finite Sets*, Dover Publications.
4. Garrett Birkhoff, *Lattice Theory*, American Mathematical Society.
5. Vijay K. Garg, *Introduction to Lattice Theory with Computer Science Applications*, Wiley.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	2	2	2	2	2	2	2
PO03	1	1	1	1	1	1	1
PO04	3	3	3	3	3	3	3
PO05	3	3	3	3	3	3	3
PO06	1	1	1	1	1	1	1
PO07	2	2	2	2	3	3	3
PO08	2	2	2	2	2	2	2
PO09	1	1	1	1	1	1	1
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	2	2	2	2	2	2	2
PO13	1	1	1	1	1	1	1

Justification for the mapping

PO1: Comprehensive knowledge and understanding - Course provides deep theoretical understanding of ordered sets, lattice structures, and Boolean algebra foundations.

PO2: Practical, professional, and procedural knowledge - Moderate practical application in abstract algebraic structures with some procedural knowledge in lattice operations

PO3: Entrepreneurial mindset and knowledge - Limited direct entrepreneurial application in pure mathematical lattice theory

PO4: Specialized skills and competencies - Develops highly specialized mathematical skills in abstract algebra, lattice theory, and Boolean algebras.

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning - Strong emphasis on analytical reasoning in structural analysis, algebraic properties, and logical formulation.

PO6: Communication skills and collaboration - Theoretical mathematics course with limited emphasis on communication and collaboration

PO7: Research-related skills -

- Strong research foundation in advanced lattice properties and Boolean algebra applications (CO5, CO6 and CO7)
- Basic research skills in algebraic structures (all other COs)

PO8: Learning how to learn skills - Moderate development through abstract mathematical concept mastery and structural analysis

PO9: Digital and technological skills - Theoretical course with limited technological integration

PO10: Multicultural competence, inclusive spirit, and empathy - Not directly addressed in abstract algebraic content

PO11: Value inculcation and environmental awareness - Not a focus of pure mathematical theory

PO12: Autonomy, responsibility, and accountability - Moderate development through independent work on abstract mathematical proofs and structures

PO13: Community engagement and service - Limited direct community engagement in advanced abstract algebra

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	: B.Sc. Mathematics
Program Code	: USMT
Class	: T.Y.B.Sc.
Semester	: VI
Course Type	: Minor
Course Name	: Mathematical Analysis
Course Code	: MAT-361-MN
No. of Teaching Hours	: 30
No. of Credits	: 2

Course Objectives:

1. To introduce the fundamental concepts of sequences and series, including their convergence and divergence.
2. To develop an understanding of limits, continuity, and bounded functions in real analysis.
3. To explore the properties and structure of metric spaces, including open and closed sets.
4. To provide a foundation for the study of differentiability and its applications, including the Mean Value Theorem.
5. To introduce the concept of the Riemann integral and its fundamental properties.
6. To establish a connection between differentiation and integration through the Fundamental Theorems of Calculus.
7. To develop logical reasoning and analytical skills required for solving mathematical problems in real analysis.

Course Outcomes:

- CO1:** Student will understand the definitions and properties of sequences, subsequences, and their convergence criteria.
- CO2:** Student will analyze and determine the continuity and limits of functions, applying relevant theorems.
- CO3:** Student will be able to explain the concept of metric spaces and work with limits, open, and closed sets.
- CO4:** Student will be able to apply the Mean Value Theorem and understand the conditions for differentiability.
- CO5:** Student will be able to define and compute the Riemann integral for given functions.
- CO6:** Student will recognize the fundamental theorems of calculus and their significance in analysis.
- CO7:** Student will be able to develop problem-solving skills in real analysis and apply theoretical concepts to practical problems.

Topics and Learning Points	
Unit 1: Sequences and Series	Teaching Hours 08
1.1 Sequences and subsequences	
1.2 Convergence and divergence of sequences	
1.3 Bounded and monotone sequences	
1.4 Operations on sequences (theorems without proof)	
1.5 Cauchy sequences	
1.6 Convergence and divergence of an infinite series	
Unit 2: Limits and Continuity	06
2.1 Introduction	
2.2 Bounded functions	
2.3 Limits of functions	
2.4 Monotone functions	
2.5 Continuous functions	
Unit 3: Metric Spaces	08
3.1 Definitions and examples	
3.2 Limits of sequences in (X, d)	
3.3 Equivalence of metrics and bounded sets	
3.4 Limit and continuity in metric spaces	
3.5 Open and closed sets in metric spaces	
Unit 4: Differentiability and the Riemann Integration	08
4.1 Differentiability	
4.2 Mean value theorem for derivatives	
4.3 Definition of the Riemann integral	
4.4 Existence of Riemann integral (without proof)	
4.5 Properties of the Riemann integral (theorems without proof)	
4.6 Fundamental theorems of calculus (theorems without proof)	

Text Book:

D. Somasundaram and B. Choudhary, *A first course in Mathematical Analysis*, Narosa Publication, Corrected Edition, 1999.

Unit 1: Sections 2.1 to 2.9, 2.11 & 3.1, **Unit 2:** Sections 4.1 to 4.5,
Unit 3: Sections 5.1 to 5.8, **Unit 4:** Sections 7.1, 7.3, 8.1 to 8.4.

Reference Books:

1. R. R. Goldberg, *Methods of Real Analysis*, Oxford & I. B. H. Publications, 1970.
2. Robert, G. Bartle, Donald Sherbert, *Introduction to Real Analysis*, 3rd Edition, John Wiley and Sons.
3. Walter Rudin, *Principles of Mathematical Analysis*, McGraw-Hill International Edition.
4. Ajit Kumar and S. Kumaresan, *A Basic Course in Real Analysis*, CRC Press, Second Indian Reprint 2015.
5. S. C. Malik and Savita Arora, *Mathematical Analysis*, New Age International Publications, third Edition, (2008).

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	2	2	2	2	2	2	2
PO03	1	1	1	1	1	1	1
PO04	3	3	3	3	3	3	3
PO05	3	3	3	3	3	3	3
PO06	1	1	1	1	1	1	1
PO07	2	2	2	2	3	3	3
PO08	2	2	2	2	2	2	2
PO09	1	1	1	1	1	1	1
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	2	2	2	2	2	2	2
PO13	1	1	1	1	1	1	1

Justification for the mapping

PO1: Comprehensive knowledge and understanding - Course provides deep theoretical understanding of ordered sets, lattice structures, and Boolean algebra foundations.

PO2: Practical, professional, and procedural knowledge - Moderate practical application in abstract algebraic structures with some procedural knowledge in lattice operations

PO3: Entrepreneurial mindset and knowledge - Limited direct entrepreneurial application in pure mathematical lattice theory

PO4: Specialized skills and competencies - Develops highly specialized mathematical skills in abstract algebra, lattice theory, and Boolean algebras.

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning - Strong emphasis on analytical reasoning in structural analysis, algebraic properties, and logical formulation.

PO6: Communication skills and collaboration - Theoretical mathematics course with limited emphasis on communication and collaboration

PO7: Research-related skills -

- Strong research foundation in advanced lattice properties and Boolean algebra applications (CO5, CO6 and CO7)
- Basic research skills in algebraic structures (all other COs)

PO8: Learning how to learn skills - Moderate development through abstract mathematical concept mastery and structural analysis

PO9: Digital and technological skills - Theoretical course with limited technological integration

PO10: Multicultural competence, inclusive spirit, and empathy - Not directly addressed in abstract algebraic content

PO11: Value inculcation and environmental awareness - Not a focus of pure mathematical theory

PO12: Autonomy, responsibility, and accountability - Moderate development through independent work on abstract mathematical proofs and structures

PO13: Community engagement and service - Limited direct community engagement in advanced abstract algebra

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	: B.Sc. Mathematics
Program Code	: USMT
Class	: T.Y.B.Sc.
Semester	: VI
Course Type	: Minor
Course Name	: Practical based on Laplace Transform and Fourier Series
Course Code	: MAT-362-MN
No. of Teaching Hours	: 60
No. of Credits	: 2

Course Objectives:

1. To introduce students to the fundamental concepts of Laplace and Fourier transforms.
2. To develop computational skills for evaluating Laplace and Inverse Laplace transforms of elementary functions.
3. To explore the properties of Laplace transforms, including linearity, shifting, and scaling.
4. To apply Laplace transform techniques to solve ordinary differential equations.
5. To demonstrate the use of Fourier series in representing periodic functions.
6. To analyze the Dirichlet conditions and Fourier integral representation of functions.
7. To apply Laplace and Fourier transforms in real-world applications such as electrical circuits and signal processing.

Course Outcomes:

- CO1:** Students will be able to compute Laplace transforms of various elementary and special functions.
- CO2:** Students will be able to use properties of Laplace transforms to simplify computations and solve integrals.
- CO3:** Students will be able to evaluate inverse Laplace transforms and apply shifting and convolution properties.
- CO4:** Students will be able to solve first-order and second-order differential equations using Laplace transforms.
- CO5:** Students will be able to expand periodic functions using Fourier series and analyze their convergence.
- CO6:** Students will be able to verify Dirichlet conditions and derive Fourier integral representations for given functions.
- CO7:** Students will be able to apply Laplace and Fourier transform techniques to practical problems in engineering, physics, and applied mathematics.

Topics and Learning Points

Teaching Hours
12

Theory:

1. The Laplace Transform
2. The Inverse Laplace Transform
3. Applications of Laplace Transform
4. Fourier Series

List of practical:

48

1. Computation of Laplace Transforms of elementary functions: exponential, trigonometric, polynomial functions
2. Properties of Laplace Transform: Linearity, shifting theorems, and scaling properties
3. Laplace Transform of Derivatives and Integrals: Verification using examples
4. Laplace Transform of Special Functions: Gamma function, unit step function, and Dirac delta function.
5. Computation of Inverse Laplace Transforms of elementary functions
6. Properties of Inverse Laplace Transform: Shifting, convolution theorem, and applications
7. Solving Definite Integrals using Inverse Laplace Transform: Evaluation of improper integrals
8. Solving First-Order and Second-Order Differential Equations using Laplace Transform
9. Application of Laplace Transform to Electrical Circuits
10. Fourier Series Expansion of Periodic Functions: Sine and cosine series representation
11. Half-Range Fourier Series: Finding Fourier sine and cosine series for given functions
12. Verification of Dirichlet Conditions and Fourier Integral Representation for given functions.

Text Book:

Murray R. Spiegel, *Schaum's Outlines Laplace Transforms*, McGraw-Hill Education.

Reference Books:

1. Phil Dyke, *An Introduction to Laplace Transforms and Fourier Series*, Springer.
2. Rajendra Thete, *A Textbook of Laplace Transform and Fourier Series*, Advent Publishing.
3. Joel L. Schiff, *The Laplace Transforms - Theory and Applications*, Springer- Verlag, New York 1999.
4. N. W. McLachlan, *Laplace Transform and their Applications to Differential Equations*, Dover.
5. Georgi P. Tolstov, *Fourier Series*, Lushena Books.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	3	3	3	3	3	3	3
PO03	2	2	2	2	2	2	3
PO04	3	3	3	3	3	3	3
PO05	3	3	3	3	3	3	3
PO06	1	1	1	1	1	1	2
PO07	2	2	2	2	3	3	3
PO08	2	2	2	2	2	2	3
PO09	1	1	1	1	1	1	2
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	2	2	2	2	2	2	3
PO13	1	1	1	1	1	1	2

Justification for the mapping

PO1: Comprehensive knowledge and understanding - Course provides comprehensive understanding of integral transforms, their properties, and applications in differential equations.

PO2: Practical, professional, and procedural knowledge - Strong emphasis on practical computational techniques for transforms and their applications in solving differential equations.

PO3: Entrepreneurial mindset and knowledge -

- Direct application to engineering and physics problems with entrepreneurial potential (CO7)
- Moderate application in analytical techniques (all other COs)

PO4: Specialized skills and competencies - Develops specialized mathematical skills in transform methods, differential equations, and Fourier analysis.

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning - Core focus on analytical problem-solving using transform techniques for differential equations and integral evaluations.

PO6: Communication skills and collaboration -

- Moderate development through practical problem applications (CO7)
- Limited emphasis in technical computational content (all other COs)

PO7: Research-related skills -

- Strong research foundation in Fourier analysis, convergence theory, and applied transform methods (CO5, CO6 and CO7)
- Basic research skills in transform computations (all other COs)

PO8: Learning how to learn skills -

- Strong emphasis on adapting transform methods to diverse application domains (CO7)
- Moderate development through complex mathematical techniques (all other COs)

PO9: Digital and technological skills -

- Some application of computational tools in practical problems (CO7)
- Limited technological integration in theoretical computations (all other COs)

PO10: *Multicultural competence, inclusive spirit, and empathy* - Not directly addressed in technical mathematical content

PO11: *Value inculcation and environmental awareness* - Not a primary focus of transform theory

PO12: *Autonomy, responsibility, and accountability* -

- Strong development through real-world engineering applications (CO7)
- Moderate autonomy in mathematical problem-solving (all other COs)

PO13: *Community engagement and service* -

- Potential application in community technical projects (CO7)
- Limited direct community engagement focus (all other COs)

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	: B.Sc. Mathematics
Program Code	: USMT
Class	: T.Y.B.Sc.
Semester	: VI
Course Type	: On Job Training
Course Name	: On Job Training
Course Code	: MAT-385-OJT
No. of Teaching Hours	: 120
No. of Credits	: 4

Course Objectives:

1. To provide hands-on experience in applying mathematical concepts to real-world problems.
2. To develop analytical and problem-solving skills through industry exposure.
3. To enhance students' ability to work in a professional environment and collaborate with teams.
4. To familiarize students with the use of mathematical tools, software, and computational techniques in practical applications.
5. To improve students' communication and presentation skills in a workplace setting.
6. To cultivate a sense of professional ethics, responsibility, and work discipline.
7. To prepare students for future careers by bridging the gap between academic knowledge and industrial applications.

Course Outcomes:

CO1: Student will gain practical exposure to the applications of mathematics in various industries.

CO2: Student will be able to apply mathematical techniques to analyze and solve real-world problems.

CO3: Student will develop computational skills by using relevant software and programming tools.

CO4: Student will be able to work effectively in a professional team and contribute to project-based tasks.

CO5: Student will improve their ability to document and present technical work effectively.

CO6: Student will develop an understanding of professional ethics and workplace responsibilities.

CO7: Student will be able to explore career opportunities and enhance employability through hands-on training.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	2	1	1	1	2
PO02	3	3	3	2	2	3	3
PO03	2	2	1	1	1	1	3
PO04	3	3	3	2	2	1	2
PO05	2	3	2	2	1	1	2
PO06	1	1	1	3	3	1	2
PO07	2	2	2	1	2	1	1
PO08	2	2	3	2	2	1	3
PO09	2	2	3	1	2	1	1
PO10	1	1	1	3	1	2	1
PO11	1	1	1	2	1	3	2
PO12	2	2	2	3	2	3	2
PO13	1	1	1	1	1	2	1

Justification for the mapping

PO1: Comprehensive knowledge and understanding –

- CO1 – Directly builds comprehensive knowledge of mathematical applications in real-world contexts.
- CO2 – Strongly requires a deep understanding to apply techniques to complex problems.
- CO3 – Requires understanding of computational principles, but focus is on skill application.

PO2: Practical, professional, and procedural knowledge –

- CO1, CO2, CO3, CO7 – The core of these outcomes is gaining and applying practical, industry-relevant knowledge and procedures.
- CO4, CO5, CO6 – Involve professional conduct, but are more focused on soft skills and ethics.

PO3: Entrepreneurial mindset and knowledge –

- CO7 – Directly related to exploring opportunities and enhancing employability, key entrepreneurial aspects.
- CO1, CO2 – Solving real-world problems can foster an innovative, solution-oriented mindset.

PO4: Specialized skills and competencies –

- CO1, CO2, CO3 – Directly aims to develop specialized mathematical, analytical, and computational competencies.
- CO4, CO5 – Teamwork and presentation are important professional competencies.

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning –

- CO2 – The primary focus is on applying knowledge to solve problems.
- CO1, CO3, CO4, CO7 – All involve elements of application and reasoning in a practical setting.

PO6: Communication skills and collaboration –

- CO4, CO5 – Directly targets effective teamwork and presentation of technical work.
- CO7 – Enhancing employability involves communicating one's skills.

PO7: Research-related skills –

- CO1, CO2, CO3, CO5 – Involves analyzing problems, using tools, and documenting work, which are foundational research skills.

PO8: Learning how to learn skills –

- CO3 – Using new software/tools inherently requires self-learning and adaptation.
- CO7 – Career exploration and skill enhancement are continuous learning processes.
- CO1, CO2, CO4, CO5 (2) – Exposure to new applications and professional environments fosters adaptive learning.

PO9: Digital and technological skills –

- CO3 – Directly focused on developing computational and digital tool skills.
- CO2, CO5 – Solving problems and presenting work often involve digital technologies.

PO10: Multicultural competence, inclusive spirit, and empathy –

- CO4 – Working effectively in a team directly requires inclusivity and collaboration with diverse individuals.

PO11: Value inculcation and environmental awareness –

- CO6 – Directly addresses the understanding of professional ethics and responsibilities (value inculcation).
- CO4, CO7 – Teamwork and professional conduct are underpinned by strong values.

PO12: Autonomy, responsibility, and accountability –

- CO4, CO6 – Teamwork and understanding workplace responsibilities directly require accountability and responsible conduct.
- CO1, CO2, CO3, CO5, CO7 – All project-based and professional tasks require a degree of autonomy and responsibility.

PO13: Community engagement and service

- CO6 – Understanding professional ethics includes a dimension of social responsibility, linking weakly to community service.