CBCS Syllabus for T.Y.B.Sc. Mathematics
(2022 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** T.Y.B.Sc.
Semester	**:** VI
Course Type	**:** Theory
Course Name	**:** Complex Analysis
Course Code	**:** USMT361
No. of Teaching Hours	**:** 45
No. of Credits	**:** 3

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

Teaching Hours

Unit 1: Complex Numbers **06**

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 **11**

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 **06**

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 **11**

4.1 Derivatives of functions, Definite integrals of functions, Contours
4.2 Contour integral, Upper bounds for Moduli of contour integrals, Anti-derivatives, Cauchy-Groursat'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 **05**

5.1 Convergence of sequences and series
5.2 Taylor's series, Laurent series, examples

Unit 6: Residues and Poles **06**

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 Books:

J.W. Brown and R.V. Churchill, *Complex Variables and Applications*, International Student Edition, 2009. (Eighth 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 (2nd Edition).
2. S. Lang, *Complex Analysis*, Springer Verlag.
3. A.R. Shastri, *An Introduction to Complex Analysis*, MacMillan.

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
PO1	3	3	3	3	3	3	3
PO2	2	3	3	3	3	3	3
PO3	1	1	1	1	1	1	2
PO4	2	3	3	3	3	3	3
PO5	1	2	2	2	2	2	3
PO6	2	2	2	2	2	2	2
PO7	1	1	1	1	1	1	1
PO8	1	1	1	1	1	1	2
PO9	2	3	3	3	3	3	3

Justification for the mapping

PO1: ***Disciplinary Knowledge*** - All COs directly relate to disciplinary knowledge as they involve understanding and applying advanced calculus concepts, integral to the mathematical analysis discipline (Rating: 3).
PO2: ***Critical Thinking and Problem Solving*** - High relevance in applying complex analysis techniques for solving mathematical and real-world problems.
PO3: ***Social Competence*** - Minimal direct social interaction, but CO7 involves applications in fields affecting society.
PO4: ***Research-related Skills and Scientific Temper*** - Involves analytical thinking and exploring advanced concepts relevant for research in complex analysis.
PO5: ***Trans-disciplinary Knowledge*** - Cross-disciplinary applications become more apparent in CO7 for physics and engineering.
PO6: ***Personal and Professional Competence*** - Competence in complex analysis enhances both personal mathematical understanding and professional application.
PO7: ***Effective Citizenship and Ethics*** - Little direct connection to citizenship and ethics within this specific mathematical framework.
PO8: ***Environment and Sustainability*** - Indirect relevance, with potential applications in modeling systems affecting the environment.
PO9: ***Self-directed and Life-long Learning*** - High correlation with independent learning in advanced topics and continual mathematical skill improvement.

CBCS Syllabus for T.Y.B.Sc. Mathematics
(2022 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** T.Y.B.Sc.
Semester	**:** VI
Course Type	**:** Theory
Course Name	**:** Real Analysis II
Course Code	**:** USMT362
No. of Teaching Hours	**:** 45
No. of Credits	**:** 3

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

	Teaching Hours
Unit 1: Riemann Integral	**12**
1.1 Sets of measure zero	
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	**15**
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	**10**
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	**08**
4.1 Convergence and uniform convergence of series of functions	
4.2 Integration and differentiation of series of functions	

Text Books:

1. 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
2. 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*, Third edition, John Wiley and Sons.
3. Shantinarayan and Mittal, *A course of Mathematical Analysis*, Revised edition, S. Chand and Co. (2002).
4. 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
PO1	3	3	3	3	3	3	3
PO2	2	3	3	3	3	3	3
PO3							
PO4	1	2	2	2	2	2	2
PO5	1	1	1	2	2	2	2
PO6					1	1	1
PO7							
PO8							
PO9	1	2	2	2	3	3	3

Justification for the mapping

PO1: ***Disciplinary Knowledge*** - All COs directly relate to disciplinary knowledge as they involve understanding and applying advanced calculus concepts, integral to the mathematical analysis discipline (Rating: 3).
PO2: ***Critical Thinking and Problem Solving*** - CO1 involves determining integrals, which requires critical thinking (Rating: 2) and CO2 to CO7 have strong application of theorems, convergence analysis, and problem-solving in series and sequences, directly tied to problem-solving skills (Rating: 3).
PO4: ***Research-related Skills and Scientific Temper*** - CO1 involves defining integrals, which introduces students to foundational research skills (Rating: 1), In CO2 to CO6 analysis of convergence and series involves research skills, scientific temper, and preparing for research (Rating: 2) and CO7 involve strong preparation for further study or research, directly connected to research-related skills (Rating: 3).
PO5: ***Trans-disciplinary Knowledge*** - CO1 to CO3 have minimal direct connection, but some interdisciplinary application (e.g., physics, engineering) (Rating: 1) and CO4 to CO7 have greater relevance in fields like economics, computer science, and engineering, making these applicable across disciplines (Rating: 2).
PO6: ***Personal and Professional Competence*** - CO5 to CO7 are indirectly improves competence in mathematical analysis, useful in various professions (Rating: 1).
PO9: ***Self-directed and Life-long Learning*** - CO1 to CO4 have moderate impact by fostering independent learning and problem-solving skills (Rating: 2) and CO5 to CO7 have strongly encourages continuous learning, especially in advanced calculus and mathematical analysis (Rating: 3).

CBCS Syllabus for T.Y.B.Sc. Mathematics
(2022 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** T.Y.B.Sc.
Semester	**:** VI
Course Type	**:** Theory
Course Name	**:** Ring Theory
Course Code	**:** USMT363
No. of Teaching Hours	**:** 45
No. of Credits	**:** 3

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 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 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

	Teaching Hours
Unit 1: Introduction to Ring	**5**
1.1 Definition and examples	
1.2 Properties of Ring	
1.3 Subring	
Unit 2: Integral Domains	**6**
2.1 Definition and examples	
2.2 Field	
2.3 Characteristics of Ring	
Unit 3: Ideals and Factor Rings	**6**
3.1 Ideals	
3.2 Factor Ring	
3.3 Prime Ideals and Maximal Ideals	
Unit 4: Homomorphism of Rings	**6**
4.1 Definition and examples	
4.2 Properties of Ring Homomorphism	
4.3 The field of Quotients	
Unit 5: Polynomial Ring	**6**
5.1 Definition and Examples	
5.2 The Division Algorithm	
5.3 Consequences	
Unit 6: Factorization of Polynomial	**8**
6.1 Reducibility Tests	
6.2 Irreducibility Tests	
6.3 Unique Factorization in Z[x]	
Unit 7: Divisibility in Integral Domain	**8**
7.1 Irreducible	
7.2 Primes	
7.3 Unique Factorization Domains	
7.4 Euclidean Domains	

Text Books:

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

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

Reference Books:

1. J. B. Fraleigh, *First course in Abstract Algebra* (4rd Edition). Narosa Publishing House.
2. I. N. Herstein, *Abstract Algebra*, (3rd Edition), Prentitice Hall of India, 1996.
3. N.S. Gopalkrishnan, *University of Algebra*, Wiley Eastern 1986. 4. C. Musili, Rings and Modules, Narosa Publishing House, 1992.
4. Khanna V. K., Bhamri S. K.. *A course in abstract algebra*, Vikas Publishing House; 2016.

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
PO1	3	3	3	3	3	3	3
PO2	2	2	3	3	3	3	3
PO3	1	1	1	1	1	1	1
PO4	2	2	3	3	2	3	3
PO5	1	1	2	2	2	2	2
PO6	1	1	2	2	2	2	2
PO7	1	1	1	1	1	1	1
PO8	1	1	1	1	1	1	1
PO9	2	2	3	3	3	3	3

Justification for the mapping

PO1: *Disciplinary Knowledge* - Strong understanding of algebraic structures, including rings and polynomials, is foundational to the discipline.
PO2: *Critical Thinking and Problem Solving* - Problem-solving skills are critical for analyzing ideals, ring homomorphisms, and factorization.
PO3: *Social Competence* - Limited direct interaction with social competence, though mathematical logic and collaboration may play a role.
PO4: *Research-related Skills and Scientific Temper* - Research skills are required for deeper exploration of homomorphisms, ideals, and factorization techniques.
PO5: *Trans-disciplinary Knowledge* - Moderate application of algebraic concepts across other fields like computer science, physics, or engineering.
PO6: *Personal and Professional Competence* - Building proficiency in abstract thinking and logical reasoning contributes to professional growth.
PO7: *Effective Citizenship and Ethics* - Ethical considerations are not a major focus in algebraic theory but can be linked to the integrity of solutions.
PO8: *Environment and Sustainability* - No direct link to environmental and sustainability concerns.
PO9: *Self-directed and Life-long Learning* - The abstract nature of ring theory encourages continuous learning and self-directed exploration.

CBCS Syllabus for T.Y.B.Sc. Mathematics
(2022 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** T.Y.B.Sc.
Semester	**:** VI
Course Type	**:** Theory
Course Name	**:** Partial Differential Equations
Course Code	**:** USMT364
No. of Teaching Hours	**:** 45
No. of Credits	**:** 3

Course Objectives:

1. To develop a solid understanding of surfaces and curves in three-dimensional space, which are foundational in solving differential equations in multiple variables.
2. To learn to solve simultaneous differential equations of the first order and first degree in three variables, a crucial skill for dealing with complex systems.
3. To gain proficiency in the theory and solution techniques for Pfaffian differential equations, a critical component in advanced mathematical modeling.
4. To develop the ability to derive and solve first-order partial differential equations, with an emphasis on understanding their origins and applications.
5. To learn to apply Cauchy's method of characteristics for solving nonlinear first-order partial differential equations.
6. To investigate the concept of orthogonal trajectories and their application in various types of differential equations.
7. To develop skills in advanced solution methods such as Charpit's method and other techniques for solving nonlinear partial differential equations.

Course Outcomes:

CO1: Students will be able to apply concepts of surfaces and curves in three dimensions to solve complex differential equations.
CO2: Students will demonstrate the ability to solve simultaneous differential equations involving multiple variables with accuracy.
CO3: Students will be able to identify, formulate, and solve Pfaffian differential equations in both two and three variables.
CO4: Students will develop the ability to analyze first-order partial differential equations and apply appropriate solution methods to real-world problems.
CO5: Students will demonstrate proficiency in applying Cauchy's method of characteristics to solve nonlinear partial differential equations.
CO6: Students will be able to construct integral surfaces passing through a given curve and understand their significance in physical and engineering contexts.
CO7: Students will be equipped to solve nonlinear first-order partial differential equations using Charpit's method and other advanced techniques.

Topics and Learning Points

Teaching Hours

Unit 1: Ordinary Differential Equations in more than two variables **10**

1.1 Surface and curves in three dimensions

1.2 Simultaneous Differential Equations of the first order and first degree in 3 variables

1.3 Methods of solution of $dx/P = dy/Q = dz/R$

1.4 Orthogonal trajectories of a system of curves on a surface

Unit 2: Pfaffian Differential Equations **10**

2.1 Pfaffian Differential forms

2.2 Pfaffian Differential Equations

2.3 Solution of Pfaffian Differential Equations in two variables

2.4 Solution of Pfaffian Differential Equations in three variables

Unit 3: Partial Differential Equations of the first order **12**

3.1 Partial Differential Equations

3.2 Origins of first-order Partial Differential Equations

3.3 Cauchy's problem for first -order equations

3.4 Linear equations of the first order

3.5 Integral surfaces passing through a given curve

3.6 Surfaces orthogonal to a given system of surfaces

Unit 4: Nonlinear Partial Differential Equations of the first order **13**

4.1 Definition of nonlinear Partial Differential Equations of the first order

4.2 Cauchy's method of characteristics

4.3 Compatible systems of first-order equations

4.4 Charpit's method

4.5 Special types of first-order equations

Text Books:

Ian Sneddon, *Element of Partial Differential Equations*, McGraw-Hill Book Company, McGraw-Hill Book Company.

Unit 1: Ch. 1, Section 1 to 4, **Unit 2:** Ch. 1, Section 5 and 6,

Unit 3: Ch. 2, Section 1 to 6, **Unit 4:** Ch. 2, Section 7 to 11.

Reference Books:

1. W.E. Williams, *Partial Differential Equations*, Clarendon Press, Oxford.
2. K. Sankara Rao, *Introduction to Partial Differential Equations*, Third Edition, PHI.
3. T. Amaranath, *An Elementary Course in Partial Differential Equations*, Narosa Publishing, House 2nd Edition, 2003 (Reprint, 2006).

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
PO1	3	3	3	3	3	3	3
PO2	2	3	3	3	3	2	3
PO3	1	1	1	1	1	1	1
PO4	2	2	2	2	2	3	3
PO5	3	2	3	3	3	3	3
PO6	1	2	2	2	2	2	2
PO7	1	1	1	1	1	1	1
PO8	1	1	1	1	1	1	1
PO9	3	3	3	3	3	3	3

Justification for the mapping

PO1: ***Disciplinary Knowledge*** - Mastery of complex differential equations directly requires disciplinary knowledge.

PO2: ***Critical Thinking and Problem Solving*** - All COs develop critical thinking, especially CO2, CO3, and CO7, through problem-solving in differential equations.

PO3: ***Social Competence*** - Minimal direct connection to social competence in this context.

PO4: ***Research-related Skills and Scientific Temper*** - Research skills are developed in analyzing complex surfaces and solving advanced equations.

PO5: ***Trans-disciplinary Knowledge*** - Understanding and applying differential equations is crucial in multiple disciplines like physics and engineering.

PO6: ***Personal and Professional Competence*** - Problem-solving enhances personal competence; the professional aspect is indirectly developed.

PO7: ***Effective Citizenship and Ethics*** - The focus of the COs is not directly linked to citizenship or ethics.

PO8: ***Environment and Sustainability*** - No direct connection to sustainability or environmental awareness.

PO9: ***Self-directed and Life-long Learning*** - The complexity of topics demands continuous learning and independent study across all COs.

CBCS Syllabus for T.Y.B.Sc. Mathematics
(2022 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** T.Y.B.Sc.
Semester	**:** VI
Course Type	**:** Theory
Course Name	**:** Lebesgue Integration
Course Code	**:** USMT365
No. of Teaching Hours	**:** 45
No. of Credits	**:** 3

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

	Teaching Hours
Unit 1: Measurable Sets	**12**
1.1 Length of open sets and closed sets	
1.2 Inner and outer measure	
1.3 Measurable sets	
1.4 Properties of measurable sets	
Unit 2: Measurable Functions	**12**
2.1 Definition and examples	
2.2 Properties of measurable functions	
2.3 Sequence of measurable functions	
Unit 3: The Lebesgue Integrals	**12**
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	**09**
4.1 Lebesgue dominated convergence theorem	
4.2 Fatou's lemma	

Text Books:

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. Tom Apostol, *Advanced Calculus*, 2nd Edition, Prentice Hall of India, (1994).
2. D. Somasundaram and B. Choudhari, *A first course in Mathematical Analysis*, Narosa Publishing House, (1997).
3. R.G. Bartle and D.R. Scherbert, *Introduction to real analysis*, 2nd Edition, John Wiley, (1992).
4. Inder K. Rana, *Measure and Integration*

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
PO1	3	3	3	3	3	3	3
PO2	2	2	3	3	3	3	3
PO3	1	1	1	1	1	1	1
PO4	2	2	3	3	3	3	3
PO5	1	1	2	2	2	2	3
PO6	2	2	2	2	3	3	3
PO7	1	1	1	1	1	1	1
PO8	1	1	1	1	1	1	1
PO9	2	2	3	3	3	3	3

Justification for the mapping

PO1: *Disciplinary Knowledge* - Comprehensive understanding of measurable sets, functions, and Lebesgue integrals is foundational in measure theory.
PO2: *Critical Thinking and Problem Solving* - The course develops critical problem-solving skills, especially in integration and advanced analysis techniques.
PO3: *Social Competence* - Social competence has minimal relevance in this technical mathematical context.
PO4: *Research-related Skills and Scientific Temper* - In-depth engagement with complex theorems fosters research skills and analytical thinking.
PO5: *Trans-disciplinary Knowledge* - Trans-disciplinary knowledge is moderately engaged in applications of measure theory in other fields of analysis.
PO6: *Personal and Professional Competence* - Mastery of measure theory enhances professional competence, especially for advanced mathematical research.
PO7: *Effective Citizenship and Ethics* - Ethical considerations are not directly involved in this mathematical course.
PO8: *Environment and Sustainability* - Environment and sustainability are not relevant in this context.
PO9: *Self-directed and Life-long Learning* - Measure theory equips students with the self-learning capacity needed for advanced topics in analysis and research.

CBCS Syllabus for T.Y.B.Sc. Mathematics
(2022 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** T.Y.B.Sc.
Semester	**:** VI
Course Type	**:** Theory
Course Name	**:** Optimization Techniques
Course Code	**:** USMT366(A)
No. of Teaching Hours	**:** 45
No. of Credits	**:** 3

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

	Teaching Hours
Unit 1: Network Models	**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**
1.1 Decision under uncertainty	
1.2 Game theory: Some basic terminologies	
1.3 Optimal solution of two-person zero sum game	
1.4 Solution of mixed strategy games	
1.5 Graphical solution of games	
1.6 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**
3.1 Introduction	
3.2 Notation, terminology and assumptions	
3.3 Processing n jobs through two machines	
3.4 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:

1. 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
2. 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, Gerald J. Lieberman, *Introduction to Operation Research* (8th Edition) Tata McGraw Hill.
2. Hira and Gupta, *Operation Research*.

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
PO1	3	2	3	3	3	3	2
PO2	3	3	3	2	2	3	3
PO3			2	2			3
PO4	2	2	2	3	2	3	2
PO5	2	2	3	2	2	2	3
PO6	2	3	2	3	3	3	3
PO7							2
PO8							
PO9	2	3	2	2	2	3	3

Justification for the mapping

PO1: ***Disciplinary Knowledge*** - CO1, CO3, CO4, CO5, CO6 are strongly align (3) as they involve the application of specific techniques and theories within the discipline, CO2 and CO7 have a moderate relation (2) as they involve decision-making and practical applications.

PO2: ***Critical Thinking and Problem Solving*** - CO1, CO2, CO3, CO6, CO7 are strongly align (3) as they require critical thinking to optimize schedules, make decisions under uncertainty, apply game theory, and solve optimization problems, CO4 and CO5 have a moderate relation (2) as they involve problem-solving but to a lesser extent.

PO3: ***Social Competence*** - CO7 has a strong relation (3) as it involves applying theoretical concepts in real-world scenarios, which enhances social competence, CO3 and CO4 have a moderate relation (2) due to their focus on strategic decision-making and optimization, which may involve team collaboration.

PO4: ***Research-related Skills and Scientific Temper*** - CO4 and CO6 are strongly align (3) as they involve research-related skills, such as determining optimal strategies and solving constrained problems, CO1, CO2, CO3, CO5 and CO7 have a moderate relation (2) due to their involvement in analytical and research-based approaches.

PO5: ***Trans-disciplinary Knowledge*** - CO3 and CO7 are strongly align (3) as they involve the application of concepts like game theory and real-world scenarios, bridging multiple disciplines, CO1, CO2, CO4, CO5 and CO6 have a moderate relation (2) as they require knowledge across various operational research techniques.

PO6: ***Personal and Professional Competence*** - CO2, CO4, CO5, CO6 and CO7 are strongly align (3) as they contribute directly to decision-making, optimization, and operational efficiency, which are crucial for professional competence, CO1 and CO3 have a moderate relation (2) as they contribute to project management and strategy but less directly to personal competence.

PO7: ***Effective Citizenship and Ethics*** - CO7 have a moderate relation (2) as applying theoretical concepts in real-world scenarios often requires ethical considerations and contributes to effective citizenship.

PO9: ***Self-directed and Life-long Learning*** - CO2, CO6 and CO7 are strongly align (3) as they require ongoing learning, adaptation, and application of concepts in various contexts, CO1, CO3, CO4 and CO5 have a moderate relation (2) as they contribute to building a strong foundation for continuous learning.

CBCS Syllabus for T.Y.B.Sc. Mathematics
(2022 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** T.Y.B.Sc.
Semester	**:** VI
Course Type	**:** Theory
Course Name	**:** Introduction to Python Programming
Course Code	**:** USMT366(B)
No. of Teaching Hours	**:** 45
No. of Credits	**:** 3

Course Objectives:

1. To familiarize students with the basic concepts of programming and the Python language's syntax and structure.
2. To equip students with the ability to use Python's control structures, functions, and recursion to solve computational problems.
3. To provide students with a thorough understanding of Python's built-in data structures like lists, tuples, dictionaries, and sets, and their applications.
4. To instruct students on how to perform file operations and implement error handling in Python, ensuring robust and reliable programs.
5. To introduce the basic principles of object-oriented programming (OOP) and how to apply them in Python.
6. To develop students' ability to think computationally and apply Python programming to practical, real-world problems.
7. To encourage the adoption of best practices in Python programming, including code readability, modularity, and proper documentation.

Course Outcomes:

CO1: Students will demonstrate a solid understanding of Python's basic syntax, structure, and core programming concepts.
CO2: Students will be able to apply control structures, functions, and recursion in Python to solve a variety of computational problems.
CO3: Students will effectively use Python's data structures, such as lists, tuples, dictionaries, and sets, in programming tasks.
CO4: Students will competently perform file operations and implement exception handling to create robust Python programs.
CO5: Students will grasp the foundational concepts of object-oriented programming and apply them by creating classes, objects, and utilizing inheritance in Python.
CO6: Students will write modular and well-structured Python programs, demonstrating good coding practices and code organization.
CO7: Students will be well-prepared for more advanced studies in Python programming and other programming languages, building on the foundational skills acquired.

Topics and Learning Points

Teaching Hours

Unit 1: Introduction to Python **12**

1.1 Overview of Programming Languages: History and evolution of Python, Applications of Python in various fields.

1.2 Setting Up Python Environment: Installation of Python and IDEs (e.g., Anaconda, PyCharm), Introduction to Jupyter Notebooks.

1.3 Basic Syntax and Structure: Python script structure, comments, and indentation, Variables, data types, and type conversion, Input and output operations.

1.4 Basic Operators and Expressions: Arithmetic, comparison, and logical operators, Operator precedence and associativity.

Unit 2: Control Structures and Functions **13**

2.1 Conditional Statements: if, else, and elif statements, Nested conditions and multi-branch decisions.

2.2 Loops: for and while loops, Nested loops and loop control statements (break, continue, pass).

2.3 Functions: Defining and calling functions, Function parameters and return values, Scope of variables (local and global), Lambda functions.

2.4 Recursion: Understanding recursive functions, Simple recursive algorithms (e.g., factorial, Fibonacci).

Unit 3: Data Structures in Python **06**

3.1 Lists: Creating and modifying lists, List operations (indexing, slicing, concatenation, iteration), List comprehensions.

3.2 Tuples: Creating and using tuples, Tuple operations and immutability.

3.3 Dictionaries: Creating and accessing dictionaries, Dictionary methods and operations.

3.4 Sets: Creating and using sets, Set operations (union, intersection, difference).

3.5 Strings: String operations and methods, String formatting and manipulation.

Unit 4: File Handling and Exception Handling **08**

4.1 File Handling: Reading from and writing to files, File modes (r, w, a, rb, wb), Working with CSV files.

4.2 Exception Handling: Understanding exceptions and errors, try, except, finally blocks, Raising and handling exceptions, Custom exceptions.

Unit 5: Introduction to Object-Oriented Programming (OOP) **06**

5.1 Basic Concepts of OOP: Classes and objects, Attributes and methods.

5.2 Encapsulation and Information Hiding: Public and private attributes, Getter and setter methods.

5.3 Inheritance: Single and multiple inheritance, Overriding methods.

5.4 Polymorphism: Method overloading and overriding.

5.5 Introduction to Modules and Packages: Importing modules and using built-in functions, Creating and using custom modules.

Text Books:

Eric Matthes, *Python Crash Course: A Hands On, Project Based Introduction to Programming*, (2nd Edition), No Starch Press, San Francisco

Unit 1: Ch. 1 & 2 **Unit 2:** Ch. 5, 6, 7 & 8 **Unit 3:** Ch. 3 & 4
Unit 4: Ch. 10 **Unit 5:** Ch. 9

Reference Books:

1. T. R. Padmanabhan, *Programming with Python*, Springer.
2. John Zelle, *Python Programming: An Introduction to Computer Science*, Franklin, Beedle & Associates Inc.
3. Robert Sedgewick, Kevin Wayne, and Robert Dondero, *Python Programming: An Interdisciplinary Approach*, Pearson.
4. Cay S. Horstmann and Rance D. Necaise, *Python for Everyone*, Wiley.
5. Martin C. Brown, *Python: The Complete Reference*, McGraw-Hill.

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
PO1	3	3	3	3	3	3	3
PO2	2	3	3	3	3	3	3
PO3	1	2	1	1	1	2	2
PO4	2	2	2	3	3	2	2
PO5	1	2	2	2	2	2	3
PO6	2	2	2	3	3	3	3
PO7	1	1	1	2	2	2	2
PO8	1	1	1	2	2	2	2
PO9	2	3	3	3	3	3	3

Justification for the mapping

PO1: ***Disciplinary Knowledge*** - All COs contribute strongly (3) as they are directly related to the foundational and advanced knowledge of Python programming.
PO2: ***Critical Thinking and Problem Solving*** - CO2 to CO7 are strongly related (3) because they involve applying control structures, functions, recursion, and OOP principles to solve computational problems. CO1 is moderately related (2) as it provides the necessary background knowledge.
PO3: ***Social Competence*** - CO2 and CO6 have a moderate relationship (2) as they involve collaborative problem-solving and coding practices that may require working in teams or understanding user requirements. The other COs have a weaker relationship (1).
PO4: ***Research-related Skills and Scientific Temper*** - CO4 and CO5 are strongly related (3) as they involve implementing robust programs and understanding advanced concepts like OOP, which require a methodical and scientific approach. CO1, CO2, CO3, CO6, and CO7 are moderately related (2) as they provide the foundation and context for developing research-related skills.
PO5: ***Trans-disciplinary Knowledge*** - CO7 is strongly related (3) as it prepares students for advanced studies that may cross disciplinary boundaries. CO2 to CO6 have a moderate relationship (2) due to their application in various interdisciplinary areas. CO1 has a weak relationship (1).
PO6: ***Personal and Professional Competence*** - CO4 to CO7 are strongly related (3) as they contribute to writing modular and professional-quality Python code. CO1 to CO3 have a moderate relationship (2) as they build the foundational skills necessary for professional competence.
PO7: ***Effective Citizenship and Ethics*** - CO4 to CO7 are moderately related (2) as they involve ethical considerations in programming. The other COs have a weaker relationship (1).
PO8: ***Environment and Sustainability*** - CO4 to CO7 are moderately related (2) as they involve writing efficient and sustainable code, which can contribute to environmental sustainability. The other COs have a weaker relationship (1).
PO9: ***Self-directed and Life-long Learning*** - All COs are strongly related (3) as they equip students with the foundational and advanced skills necessary for continuous learning and adaptation in the evolving field of programming.

CBCS Syllabus for T.Y.B.Sc. Mathematics
(2022 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** T.Y.B.Sc.
Semester	**:** VI
Course Type	**:** Practical
Course Name	**:** Mathematics Practical 1
Course Code	**:** USMT367
No. of Teaching Hours	**:** 60
No. of Credits	**:** 2

Course Objectives:

1. To explore and verify the fundamental properties of analytic functions, including the application of the Cauchy-Riemann equations.
2. To apply contour integration techniques, particularly the Cauchy integral formula, for evaluating complex integrals in various scenarios.
3. To understand and apply the Taylor and Laurent series in expanding complex functions for deeper insights.
4. To practice calculating residues and use the residue theorem to evaluate complex integrals, emphasizing real-world applications.
5. To perform calculations and interpret the geometric implications of Riemann integrals in various contexts.
6. To investigate improper integrals and the behavior of sequences and series of functions, with a focus on convergence and divergence.
7. To explore the properties and structures of ideals, quotient rings, polynomial rings, and commutative rings, along with the implications of ring homomorphisms and isomorphisms.

Course Outcomes:

CO1: Students will be able to verify the Cauchy-Riemann equations for complex functions and apply these concepts to solve analytic problems.
CO2: Students will demonstrate the ability to evaluate complex integrals using the Cauchy integral formula and other contour integration techniques.
CO3: Students will be proficient in expanding complex functions using Taylor and Laurent series, understanding the implications of each series.
CO4: Students will be able to calculate residues and apply the residue theorem to evaluate complex integrals, solving practical problems.
CO5: Students will effectively compute Riemann integrals and provide geometric interpretations, enhancing their understanding of real analysis.
CO6: Students will analyze improper integrals, convergence, and divergence of sequences and series of functions, applying these concepts to practical examples.
CO7: Students will gain a thorough understanding of ring theory concepts, including the properties of ideals, quotient rings, polynomial rings, and commutative rings, and will apply this knowledge to solve algebraic problems.

Topics and Learning Points

Teaching Hours

Practical based on Complex Analysis: **20**

1. Exploring analytic functions: Verification and application of Cauchy-Riemann equations
2. Contour integration: Evaluating integrals using the Cauchy integral formula
3. Series expansion of complex functions: Taylor and Laurent series
4. Residue theorem in practice: Calculating resides and evaluating complex integrals

Practical based on Real Analysis 2: **20**

1. Exploring Riemann integrals: Calculations and geometric interpretations
2. Analyzing improper integrals: Techniques and applications
3. Investigating convergence and divergence in sequence of functions
4. Series of functions: Uniform convergence and its implications

Practical based on Ring theory: **20**

1. Exploring ideals and quotient rings: Properties and examples
2. Understanding ring homomorphisms and isomorphisms through concrete examples
3. Analyzing the structure of polynomial rings and factorization
4. Investigating the properties of commutative rings and integral domains

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
PO1	3	3	3	3	3	3	3
PO2	2	3	2	3	2	3	3
PO3							1
PO4	2	3	2	3	2	3	2
PO5	2	2	2	2	2	2	2
PO6	1	2	2	2	2	2	3
PO7							
PO8							
PO9	2	2	2	3	2	3	3

Justification for the mapping

PO1: ***Disciplinary Knowledge*** – It is strongly mapped (3) across all COs because each CO directly involves the application of complex analysis, real analysis, and algebraic concepts, all of which are fundamental to the discipline of mathematics.
PO2: ***Critical Thinking and Problem Solving*** - Shows moderate to strong mapping, especially with CO2, CO4, CO6, and CO7, as these outcomes involve problem-solving through advanced techniques like contour integration, residue theorem, and ring theory.
PO3: ***Social Competence*** - CO7 has a weak relation (1) due to its relevance in collaborative problem-solving in algebra.
PO4: ***Research-related Skills and Scientific Temper*** - It is moderately to strongly mapped (2 or 3) with most COs, as they involve the application of mathematical reasoning and analysis, essential for scientific inquiry and research.
PO5: ***Trans-disciplinary Knowledge*** - It is moderately mapped (2) since the application of mathematical principles can intersect with other disciplines, although the focus remains primarily on mathematics.
PO6: ***Personal and Professional Competence*** - It is moderately to strongly mapped (2 or 3), particularly with CO7, as mastery of these mathematical concepts enhances professional skills that can be applied in various contexts, including teaching, research, and technical professions.
PO9: ***Self-directed and Life-long Learning*** - Shows moderate to strong mapping (2 or 3) in COs like CO4, CO6, and CO7, where students must independently apply advanced concepts and continue learning complex mathematical ideas, promoting life-long learning skills.

CBCS Syllabus for T.Y.B.Sc. Mathematics
(2022 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** T.Y.B.Sc.
Semester	**:** VI
Course Type	**:** Practical
Course Name	**:** Mathematics Practical 2
Course Code	**:** USMT368
No. of Teaching Hours	**:** 60
No. of Credits	**:** 2

Course Objectives:

1. To equip students with the skills to analyze and solve simultaneous differential equations in three variables, including orthogonal trajectories and Pfaffian differential equations.
2. To enable students to apply first-order partial differential equations and Charpit's method to real-world problems in various fields.
3. To provide students with practical knowledge of optimization techniques, including CPM, PERT, game theory, and classical optimization methods.
4. To understand and apply project management techniques like CPM and PERT for efficient project planning and execution.
5. To cultivate the ability to make informed strategic decisions through practical applications of game theory.
6. To introduce students to Lebesgue integration, focusing on measurable sets, functions, and the computation of Lebesgue integrals.
7. To develop the ability to compare and contrast Riemann and Lebesgue integration through practical examples, understanding their respective advantages and applications.

Course Outcomes:

CO1: Students will be able to analyze and solve problems involving surfaces and curves in three dimensions using advanced calculus techniques.
CO2: Students will demonstrate proficiency in solving simultaneous differential equations in three variables and applying orthogonal trajectories and Pfaffian differential equations.
CO3: Students will be able to apply optimization techniques such as CPM, PERT, and game theory in real-world scenarios to optimize processes and decision-making.
CO4: Students will gain the ability to apply project management models like CPM and PERT to plan, manage, and execute projects efficiently.
CO5: Students will be able to apply game theory concepts to analyze and make strategic decisions in competitive and cooperative environments.
CO6: Students will understand measurable sets and functions and will be able to compute Lebesgue integrals for various types of functions.
CO7: Students will be able to compare Riemann and Lebesgue integration methods, understanding when and why one method may be preferred over the other.

Topics and Learning Points

Teaching Hours

Practical based on Partial Differential Equations: **20**

1. Surface and curves in three dimensions
2. Solving simultaneous differential equations in three variables
3. Orthogonal trajectories and Pfaffian differential equations
4. First order partial differential equations and Charpit's method

Practical based on Lebesgue Integration: **20**

1. Introduction to measurable sets: Definitions, properties and examples
2. Exploring measurable functions: Definitions, properties and examples
3. Calculating Lebesgue integrals: Techniques and applications
4. Comparing Riemann and Lebesgue integration: Analyzing differences through practical examples

Practical based on Optimization Techniques: **20**

1. Analyzing project management techniques: A practical approach to CPM and PERT network models
2. Strategic decision-making: Practical applications of game theory
3. Integrating efficiency: A practical study of replacement and sequencing models in operation management
4. Exploring classical optimization techniques: A practical application of unconstrained and constrained programming

OR

Practical based on Python Programming: **20**

1. Basic Python Syntax and Operations e.g. write a Python script to calculate the area of a rectangle. The user should input the length and width.
2. Control Structures e.g. write a Python program to determine if a given year is a leap year or not.
3. Working with Lists, Tuples, and Dictionaries e.g. Write a Python program that takes a list of numbers as input and returns the largest and smallest numbers in the list.
4. File Handling and Exception Handling e.g. Write a Python program to read a text file and count the number of words, lines, and characters in the file.

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
PO1	3	3	3	3	3	3	3
PO2	3	3	3	2	3	3	3
PO3	1	1	2	2	3	1	1
PO4	2	3	3	2	3	3	3
PO5	2	2	3	3	3	2	2
PO6	1	2	3	3	3	2	2
PO7	1	1	2	2	2	1	1
PO8	1	1	2	2	2	1	1
PO9	2	3	3	3	3	3	3

Justification for the mapping

PO1: ***Disciplinary Knowledge*** - All COs are mapped strongly to PO1 as they all involve the application of advanced calculus, differential equations, optimization techniques, project management, and integration methods, which are fundamental to the discipline.

PO2: ***Critical Thinking and Problem Solving*** - CO1, CO2, CO3, CO5, CO6 and CO7 are strongly related to critical thinking and problem-solving as these outcomes involve complex mathematical techniques, optimization, and integration that require analytical thinking and CO4 is moderately related as project management involves problem-solving but also focuses on planning and execution.

PO3: ***Social Competence*** - CO3, CO4 and CO5 are moderately related because applying optimization and project management techniques often involves teamwork, communication, and strategic decision-making, impacting social interactions whereas CO1, CO2, CO6 and CO7 are weakly related as these outcomes are more focused on technical skills rather than social competence.

PO4: ***Research-related Skills and Scientific Temper*** - CO2, CO3, CO5, CO6 and CO7 are strongly related as these outcomes involve research-oriented skills, such as the application of differential equations, optimization, and integration methods, which require a scientific approach, CO1 and CO4 are moderately related as they also contribute to research skills but to a lesser extent.

PO5: ***Trans-disciplinary Knowledge*** - CO3, CO4 and CO5 are strongly related as these outcomes involve applying mathematical concepts in project management and game theory, which are trans-disciplinary in nature and CO1, CO2, CO6 and CO7 are moderately related, as these involve knowledge that can be applied across disciplines but are more specialized in mathematical theory.

PO6: ***Personal and Professional Competence*** - CO3, CO4 are CO5 are strongly related as these involve skills like project management and strategic decision-making, which are crucial for professional competence, CO2, CO6 and CO7 are moderately related, as they contribute to personal competence through the development of advanced problem-solving skills.

PO7: ***Effective Citizenship and Ethics*** - CO3, CO4 and CO5 are moderately related as applying these concepts in real-world scenarios may involve ethical decision-making and responsible citizenship and CO1, CO2, CO6 and CO7 are weakly related as these focus more on technical skills and less on citizenship and ethics.

PO8: ***Environment and Sustainability*** - CO3, CO4 and CO5 are moderately related as optimization and project management can be applied to sustainable practices and environmental management and CO1, CO2, CO6 and CO7 are weakly related as they are more focused on technical aspects with limited direct application to environmental concerns.
PO9: ***Self-directed and Life-long Learning*** - All COs are strongly related to life-long learning as mastering these concepts requires continuous learning and adaptation, which are essential in a professional career.

CBCS Syllabus for T.Y.B.Sc. Mathematics
(2022 Pattern)

Name of the Programme : B.Sc. Mathematics
Program Code : USMT
Class : T.Y.B.Sc.
Semester : VI
Course Type : Practical
Course Name : Project
Course Code : USMT369
No. of Teaching Hours : 60
No. of Credits : 2

Course Objectives:

1. To enable students to conduct independent research, including problem formulation, literature review, and methodology selection in various mathematical domains.
2. To improve students' ability to analyze complex mathematical problems and derive solutions using appropriate techniques and theories.
3. To facilitate the application of advanced mathematical concepts, such as algebra, analysis, and differential equations, to solve real-world problems.
4. To promote teamwork and collaboration among students in tackling complex mathematical challenges.
5. To inspire students to explore innovative approaches and techniques in solving mathematical problems.
6. To help students develop the ability to effectively communicate mathematical ideas and findings, both in written and oral forms.
7. To prepare students for future research endeavors, including postgraduate studies or careers in academia and industry.

Course Outcomes:

CO1: Students will be able to independently conduct mathematical research, from problem identification to solution development and presentation.
CO2: Students will demonstrate the ability to solve complex mathematical problems using a variety of advanced techniques and tools.
CO3: Students will be able to apply theoretical knowledge from areas like analysis, algebra, and differential equations to real-world scenarios.
CO4: Students will work effectively in teams to solve mathematical problems, demonstrating the ability to collaborate and contribute meaningfully.
CO5: Students will develop innovative solutions to mathematical problems, showing creativity in their approach to challenges.
CO6: Students will effectively communicate their research findings and mathematical ideas through written reports and oral presentations.
CO7: Students will be well-prepared for further studies or professional work in mathematics, with a solid foundation in research and practical problem-solving.

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
PO1	3	3	3	2	2	2	3
PO2	2	3	3	2	3	2	3
PO3	1	1	2	3	2	3	2
PO4	3	2	3	2	2	3	3
PO5	2	2	3	2	3	2	3
PO6	3	2	2	3	3	3	2
PO7	1	1	1	2	2	1	2
PO8	1	1	2	2	2	1	2
PO9	3	2	3	2	3	3	3

Justification for the mapping

PO1: ***Disciplinary Knowledge*** - Understanding advanced mathematical concepts is key to solving complex problems and conducting research.
PO2: ***Critical Thinking and Problem Solving*** - Complex problem-solving and applying various techniques are essential in mathematical research and innovation.
PO3: ***Social Competence*** - Teamwork and effective communication foster collaboration in research and solving problems together.
PO4: ***Research-related Skills and Scientific Temper*** - COs emphasize research, innovation, and applying methods to mathematical problems.
PO5: ***Trans-disciplinary Knowledge*** - Using knowledge across fields helps apply math concepts in interdisciplinary research.
PO6: ***Personal and Professional Competence*** - Competence grows through innovation, teamwork, and presentation skills in research.
PO7: ***Effective Citizenship and Ethics*** - Applying ethical considerations and responsibility in research and problem-solving is part of professional growth.
PO8: ***Environment and Sustainability*** - Applying math in sustainable development requires innovative problem-solving with social impact.
PO9: ***Self-directed and Life-long Learning*** - Research and learning skills foster continuous development and adaptation in the field.