Anekant Education Society's
Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

Autonomous

Course Structure for B.Sc. Mathematics

F. Y. B. Sc. Mathematics

Semester	Paper Code	Title of Paper	No. of Credits
I	MAT1101	Algebra	2
	MAT1102	Calculus-I	2
	MAT1103	Practical Based on MAT1101 & MAT1102	2
II	MAT1201	Geometry	2
	MAT1202	Calculus-II	2
	MAT1203	Practical Based on MAT1201 & MAT1202	2

S. Y. B. Sc. Mathematics

Semester	Paper Code	Title of Paper	No. of Credits
III	MAT2301	Multivariable Calculus-I	3
	MAT2302	Laplace Transform & Fourier Series	3
	MAT2303	Practical Based on MAT2301 & MAT2302	2
IV	MAT2401	Linear Algebra	3
	MAT2402	Multivariable Calculus-II	3
	MAT2403	Practical Based on MAT2401 & MAT2402	2

T.Y.B.Sc Mathematics

Subject	Semester	Paper Code	Paper Title
Mathematics T.Y.B.Sc	V	MAT3501	Metric Spaces
		MAT3502	Real Analysis I
		MAT3503	Group Theory
		MAT3504	Ordinary Differential Equation
		MAT3505	Operation Research
		MAT3506	Number Theory
		MAT3507	Practical Based on MAT3501 & MAT3502
		MAT3508	Practical Based on MAT3503 & MAT3504
		MAT3509	Practical Based on MAT3505 & MAT3506
	VI	MAT3601	Complex Analysis
		MAT3602	Real Analysis II
		MAT3603	Ring Theory
		MAT3604	Partial Differential Equation
		MAT3605	Optimization Techniques
		MAT3606	Lebesgue Integration
		MAT3607	Practical Based on MAT3601, MAT3602 & MAT3603
		MAT3608	Practical Based on MAT3604, MAT3605 & MAT3606
		MAT3609	Project

SYLLABUS (CBCS) FOR T. Y. B. Sc. MATHEMATICS
(w.e.f. June, 2021)

Academic Year 2021-2022

Class : T.Y. B. Sc. (Semester- V)
Paper Code: MAT3501
Paper : I **Title of Paper :**Metric Spaces
Credit : 3 **No. of lectures:** 48

A) Learning Objectives:

- Understand basic definitions with various examples.
- Cauchy sequence and understand which metric spaces are complete.
- Understand metric properties such as connectedness and compactness
- To develop analytical thinking of students toward higher mathematics.

B) Learning Outcome: It will create a skill of understanding which spaces are homeomorphic. This subject will develop a platform for subjects like Topology and Manifolds in postgraduate mathematics.

TOPICS/CONTENTS:
Unit 01: Basic Concepts [*8 Lectures*]

- Inequalities
- Metric Spaces
- Sequences in Metric Spaces
- Cauchy Sequences
- Completion of a Metric Space

Unit 02: Topology of a Metric Space [*8Lectures*]

- Open and Closed Sets
- Relativisation and Subspaces
- Countability Axioms and Separability
- Baire's Category Theorem

Unit 03: Continuity [*10 Lectures*]

- Continuous Mappings
- Extension Theorems
- Real and Complex-valued Continuous Functions
- Uniform Continuity
- Homeomorphism, Equivalent Metrics and Isometry

Unit 04: Connected Spaces [*8 Lectures*]

- Connectedness
- Local Connectedness
- Arcwise Connectedness

Unit 05: Compact Spaces [*10 Lectures*]

- Bounded sets and Compactness
- Other Characterisations of Compactness
- Continuous Functions on Compact Spaces
- Locally Compact Spaces
- Compact Sets in Special Metric Spaces

Unit 05: Product Spaces [*4 Lectures*]

- Finite and Infinite Products of Sets
- Finite Metric Products
- Infinite Metric Products
- Cantor Set .

Textbook:
Satish Shirali and Harkrishan L. Vasudeva, Metric Spaces, Springer

Reference Books:
1) O'Searcoid, Metric Spaces, Springer
2) James R. Munkres, Topology, Pearson
3) Richard R. Goldberg, Methods of Real Analysis**,** Oxford & IBH Publishing Co Pvt.Ltd

Class **:** T.Y. B. Sc. (Semester- V)
Paper Code: MAT3502
Paper **:** II **Title of Paper:** Real Analysis – I
Credit **:** 3 **No. of lectures:** 48

TOPICS/CONTENTS:

Unit 01: Sets and functions [*12 Lectures*]

- Sets and elements
- Operations on sets
- Functions
- Real-valued functions
- Equivalence. Countability
- Real numbers
- Least upper bounds

Unit 02: Sequences of Real Numbers [*18 Lectures*]

- Definition of sequence and subsequence
- Limit of a sequence
- Convergent sequences
- Divergent sequences
- Bounded sequences
- Monotone sequences
- Operations on convergent sequences
- Operations on divergent sequences
- Limit superior and limit inferior
- Cauchy sequences

Unit 03: Series of Real Numbers [*18 Lectures*]

- Convergence and divergence
- Series with nonnegative terms
- Alternating series
- Conditional convergence and absolute convergence
- Tests for absolute convergence
- Series whose terms form a nonincreasing sequence
- The class l^2

Text book:

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

Ch. 1, Art 1.1 to 1.7; Ch. 2, Art 2.1 to 2.10; Ch. 3, Art 3.1 to3.7 and 3.10.

Reference Books:

1. Ajit Kumar and S.Kumaresan, *A Basic Course in Real Analysis*, CRC Press, Second Indian Reprint 2015.
2. D. Somasundaram and B. Choudhary, *A first course in Mathematical Analysis*, Narosa Publishing House, 1997.
3. Robert, G. Bartle, Donald Sherbert, *Introduction to Real Analysis*, Third edition, John Wiley and Sons.
4. Shantinarayan and Mittal, *A course of Mathematical Analysis*, Revised edition, S. Chand and Co. (2002).
5. S.C. Malik and Savita Arora, *Mathematical Analysis*, New Age International Publications, third Edition,(2008).

Class **:** T.Y. B. Sc. (Semester- V)
Paper Code: MAT3503
Paper **:** III **Title of Paper:** Group Theory
Credit **:** 3 **No. of lectures:** 48

TOPICS/CONTENTS:

Unit 01: Introduction to Groups [*8Lectures*]

- Symmetries of square
- The Dihedral groups
- Definition and examples of groups
- Elementary properties of groups

Unit 02:Finite Groups and Subgroups [*8Lectures*]

- Order of group, order of elements.
- Subgroup Tests and examples.
- Center of a group
- Centralizer of element.
- Cosets: definition and properties
- Lagrange's theorem and corollary

Unit 03: Cyclic Groups [*10Lectures*]

- Properties of cyclic groups and examples
- Order of finite cyclic groups
- Generators of finite cyclic groups
- Generators of Zn
- Fundamental theorem of Cyclic Groups

Unit 04: Permutation Groups [*8Lectures*]

- Definition and examples
- Permutation on S_n, detail discussion of S_3
- Cycle notation
- Properties and theorems on permutation.
- Even odd permutation

Unit 05:Normal Subgroup [*4Lectures*]

- Definition
- If G is abelian then every subgroup of G is normal subgroup

- Theorems on Normal subgroup.

Unit 06: Homomorphism and Isomorphism's [*10Lectures*]

- Homomorphism and fundamental theorem of homomorphism
- Group isomorphism's
- Cayley's Theorem
- Properties of isomorphism
- Automorphisms

Textbook:

1. Contemporary Abstract Algebra, Joseph Gallian. (Ch. 1 to 6 and ch .9)
2. I.N. Herstein, Topics in Algebra,Wiley.(Normal subgroup chapter).

Reference Books:

1. P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, Basic abstract Algebra, Second Ed.
2. J. B. Fraleigh, A. First Course in Abstract Algebra, Third Edition, Narosa publication.
3. M. Artin, Algebra, Prentice Hall of India, New Delhi.

Class **:** T.Y. B. Sc. (Semester- V)
Paper Code: MAT3504
Paper **:** IV **Title of Paper:** Ordinary Differential Equations
Credit **:** 3 **No. of lectures:** 48

TOPICS/CONTENTS:

Unit 01: Linear Differential Equations with constant coefficients[*12Lectures*]

- The auxiliary equations.
- Distinct roots, repeated roots, Complex roots.
- Particular solution.
- The operator $1/f\ (D)$ and its evaluation for the functions $x^m, e^{mx}, e^{axv}v$.
- The operator $1/(D^2 + a^2)$ acting on $sinax$ and $cosax$ with proofs.

Unit 02: Non-Homogeneous Differential Equations [*14Lectures*]

- Method of undetermined coefficients.
- Method of variation of parameters.
- Method of reduction of order.
- The use of a known solution to find another.

Unit 03: Power series solutions [*12Lectures*]

- Introduction and review of power series.
- Linear equations and power series.
- Convergence of power series.
- Ordinary points and regular singular points.

Unit 04: **System of First-Order Equations** [*10Lectures*]

- Introductory remarks
- Linear systems
- Homogeneous linear systems with constant Coefficients
- Distinct roots, repeated roots, Complex roots

Textbook:
Elementary Differential Equations, Rainville and Bedient, Macmillan Publication.

Reference Books:
- Differential Equations by George F. Simmons, Steven G. Krantz, Tata McGraw Hill.
- Ordinary and Partial Differential Equation, by M.D. Raisinghania, S. Chand and Company LTD, 2009.
- Daniel Murray, Introductory Course in Differential Equations, Orient Longman.

Class **:** T.Y. B. Sc. (Semester- V)
Paper Code: MAT3505
Paper **:** V **Title of Paper:** Operations Research
Credit **:** 3 **No. of lectures:** 48

TOPICS/CONTENTS:

Unit 01: Modeling with Linear Programming [*08 Lectures*]

- Two variable LP Model
- Graphical LP solution
- Selected LP Applications
- Graphical Sensitivity analysis

Unit 02: The Simplex Method [*16 Lectures*]

- LP Model in equation form
- Transition from graphical to algebraic solutions
- The simplex method
- Artificial starting solutions.

Unit 03: Duality [*06 Lectures*]

- Definition of the dual problem
- Primal dual relationship

Unit 04: Transportation Model [*12 Lectures*]

- Definition of the Transportation model
- The Transportation algorithm

Unit 05: Assignment Model [*06 Lectures*]

- The Hungarian method
- Simplex explanation of the Hungarian method.

Text Book:

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

Ch.2: 2.1,2.2,2.3(2.3.4, 2.3.5, 2.3.6). Ch.3: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 (3.6.1).

Ch.4: 4.1, 4.2. Ch.5: 5.1,5.3 (5.3.1, 5.3.2, 5.3.3), 5.4(5.4.1, 5.4.2).

Reference Books:

1. Frederick S. Hillier, Gerald J. Lieberman, *Introduction to Operation Research* (8th Edition) Tata McGraw Hill.
2. J. K. Sharma, *Operations Research: Theory and Applications*, (2nd Edition, 2006), Macmilan India Ltd.
3. Hira and Gupta, *Operation Research*.

Class **:** T.Y. B. Sc. (Semester- V)
Paper Code: MAT3506
Paper **:** VI **Title of Paper :** Number Theory
Credit **:** 3 **No. of lectures:** 48

A) Learning Objectives:

- Definition of divisibility in integers and understand their properties
- Definition of congruences and use their properties to solve problems on divisibility
- Definition of Legendre and Jacobi symbol and use them to solve quadratic equations

B) Learning Outcome:
Demonstrate knowledge and understanding of topics including, but not limited to divisibility, prime numbers, congruence, quadratic reciprocity, Diophantine equations. Learn methods and techniques used in number theory.

TOPICS/CONTENTS:

Unit 01: Divisibility [*8 Lectures*]

- Divisibility in integers, Division Algorithm
- GCD, LCM,
- Fundamental theorem of Arithmetic
- Infinitude of primes

Unit 02: Congruences [*12 Lectures*]

- Properties of Congruences
- Residue classes, complete and reduced residue system, their properties
- Fermat's theorem. Euler's theorem, Wilson's theorem
- Linear Congruences of degree 1
- Chinese remainder theorem

Unit 03: Greatest integer function [*10 Lectures*]

- Arithmetic functions Euler's function
- the number of divisors d(n)
- $\sigma(n)$, $\omega(n)$ *and* $\Omega(n)$
- Multiplicative functions, Mobius function, Mobius inversion formula.

Unit 04: Quadratic Reciprocity [*10 Lectures*]

- Quadratic residues
- Legendre's symbol and its properties
- Law of quadratic reciprocity
- Jacobi symbol

Unit 05: Diophantine Equations [*8 Lectures*]

- Diophantine Equations ax + by = c
- Pythagorean triplets

Text Book:

I. Niven, H. Zuckerman and H.L. Montgomery, An Introduction to Theory of Numbers, 5th Edition, John Wiley and Sons.
(§1.1- §1.3, §2.1- §2.3, §3.1- §3.3, §4.1 -§4.3, §5.1 and §5.3.)

Reference Book:

David M. Burton, Elementary Number Theory (Second Ed.), Universal Book Stall, New Delhi, 1991.

Class **:** T.Y. B. Sc. (Semester- III)
Paper Code **:** MAT3507
Paper **:** VII **Title of Paper:** Practical Based on MAT3501 & MAT3502
Credit **:** 2 **No. of lectures:** 48

TOPICS/ CONTENT:

Title of experiments:
Metric Spaces:

- Metric Spaces
- Sequences in Metric Spaces
- Cauchy Sequences
- Completion of a Metric Space
- Open and Closed Sets
- Relativisation and Subspaces
- Countability Axioms and Separability
- Baire's Category Theorem

Real Analysis 1:

- Sets and functions
- Equivalence and countability
- Sequence of real numbers
- Limit superior, limit inferior and Cauchy sequence
- Series of real numbers
- Conditional and absolute convergence of series

Class **:** T.Y. B. Sc. (Semester- III)
Paper Code **:** MAT3508
Paper **:** VIII **Title of Paper:** Practical Based on MAT3503 & MAT3504
Credit **:** 2 **No. of lectures:** 48

TOPICS/ CONTENT:

Title of experiments:
Group Theory:

- Elementary properties of groups
- Finite Groups and Subgroups
- Cyclic Groups
- Permutation Groups
- Normal Subgroup
- Homomorphism and Isomorphism's

Ordinary Differential Equations:

- Linear Differential Equations with constant coefficients
- Non-Homogeneous Differential Equations
- Power series solutions
- System of First-Order Equations

Class **:** T.Y. B. Sc. (Semester- III)
Paper Code **:** MAT3509
Paper **:** IX **Title of Paper:** Practical Based on MAT3505 & MAT3506
Credit **:** 2 **No. of lectures:** 48

TOPICS/ CONTENT:

Title of experiments:
Operations Research:
- Formulation of LPP
- Graphical solution to LPP
- Simplex method
- Big-M method
- Duality in LPP
- Graphical sensitivity in LPP
- Transportation problems
- Assignment Problems

Number Theory:
- Divisibility
- Congruences
- Greatest integer function
- Quadratic Reciprocity
- Diophantine Equations

Choice Based Credit System Syllabus (2019 Pattern)

Class: T.Y.B.Sc. (Semester – V)
Course Code: MAT 3502
Course: 2 **Title of the Course:** Real Analysis I
Credit: 2 **No. of Lectures:** 48

A) Course Objectives:

1. Define sets and comprehend foundational concepts such as subsets, intersections, unions, complements, and power sets.
2. Analyze and manipulate functions, including composition, inverses, domains, ranges, and graphing techniques for real-valued functions.
3. Investigate advanced concepts like equivalence relations, countability, and the Cantor set.
4. Describe and comprehend the fundamental properties of sequences of real numbers, including terms such as boundedness, monotonicity, and convergence criteria.
5. Analyze and differentiate between convergent and divergent sequences, employing various convergence tests and techniques such as limit definitions, Cauchy sequences, and the comparison test.
6. Apply the knowledge of convergence and divergence of sequences to solve real-world problems in different fields such as calculus, mathematical analysis, and engineering.
7. To enable students to comprehend the concepts of convergence and divergence in series of real numbers.
8. To familiarize students with fundamental convergence tests such as the Comparison Test, Ratio Test, and Root Test.

B) Course Outcomes:

1. Students will be able to demonstrate proficiency in performing set operations, including unions, intersections, and complements, and apply these operations to solve problems in various contexts.
2. Students will be able to apply the concepts of equivalence relations, countability, and the Cantor set to solve complex problems in diverse areas, showcasing an understanding of their practical applications.
3. Students will be able to identify convergence or divergence in a given sequence of real numbers, analyze the behavior of sequences toward specific limits or infinity, and apply relevant tests to determine convergence or divergence.
4. Students will be proficient in using the Cauchy criteria to establish convergence, demonstrate the properties of Cauchy sequences, and apply related theorems to analyze and solve problems involving real sequences.
5. Students will be able to apply their knowledge of convergence, divergence, and Cauchy sequences to model and analyze real-world scenarios, interpret their mathematical significance, and communicate findings effectively using mathematical reasoning.
6. Students will be able to distinguish between convergent and divergent series within the context of real numbers.

7. Students will apply convergence tests rigorously to ascertain convergence or divergence of different series encountered in real-world applications.

Mapping of Program Outcomes with Course Outcomes

Class: TYBSc (Sem V) **Subject:** Mathematics
Course: Real Analysis I **Course Code:** MAT 3502
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	2	2							
CO 2	3	2			1				1
CO 3	3	3			1				
CO 4	2	3		1	1				
CO 5	2	2							
CO 6	2	2							
CO 7	3	3						1	1

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Mastering set operations enables students to solve diverse problems across disciplines by efficiently manipulating relationships between sets through unions, intersections, and complements.

CO2: Understanding equivalence relations, countability, and the Cantor set enables students to discern patterns, classify diverse data, and model complex systems across disciplines, fostering problem-solving prowess through practical application.

CO3: Understanding convergence and divergence in sequences of real numbers is foundational in various disciplines, enabling precise analysis of limits and applications of convergence tests for robust mathematical problem-solving.

CO4: Mastering the Cauchy criteria empowers students to rigorously assess convergence, unveil properties of sequences, and effectively employ theorems to tackle real-world problems in sequence analysis.

CO5: Understanding convergence, divergence, and Cauchy sequences equips students with the tools to mathematically model real-world phenomena, interpret their implications, and communicate findings coherently, enhancing their disciplinary knowledge and analytical abilities.

CO6: Understanding the distinction between convergent and divergent series is crucial in real numbers to grasp the behavior and limits of mathematical sequences.

CO7: Students rigorously apply convergence tests to ensure accuracy when determining the convergence or divergence of series in real-world applications within Disciplinary Knowledge.

PO2: Critical Thinking and Problem Solving

CO1: Understanding set operations fosters logical thinking and problem-solving by enabling students to manipulate and combine elements, crucial for solving diverse real-world problems across various contexts.

CO2: Understanding equivalence relations, countability, and the Cantor set cultivates analytical skills essential for tackling multifaceted problems across disciplines, demonstrating the practicality of abstract mathematical concepts in fostering critical thinking and problem-solving prowess.

CO3: Understanding convergence or divergence in sequences of real numbers enhances critical thinking by sharpening analytical skills and applying test strategies to ascertain the behavior of sequences towards specific limits or infinity.

CO4: Students will enhance critical thinking by mastering the Cauchy criteria, empowering them to analyze convergence, properties, and problem-solving involving real sequences.

CO5: Understanding convergence, divergence, and Cauchy sequences equips students with the essential tools to analyze real-world scenarios through mathematical models, fostering effective communication and interpretation of findings to solve complex problems.

CO6: Understanding convergent and divergent series in the context of real numbers cultivates analytical thinking by discerning the limits and behaviors of mathematical sequences, fostering critical problem-solving skills.

CO7: Applying convergence tests rigorously ensures accurate determination of convergence or divergence, crucial for real-world applications' validity and reliability in Critical Thinking and Problem Solving.

PO4: Research-related skills and Scientific temper

CO3: Mastering Cauchy criteria empowers students to rigorously assess convergence, analyze sequence properties, and apply theorems effectively, fostering essential research skills and a scientific mindset for problem-solving in real sequences.

PO5: Trans-disciplinary Knowledge

CO2: Understanding equivalence relations, countability, and the Cantor set enables students to unravel intricate problems across disciplines, fostering a versatile problem-solving approach essential in trans-disciplinary fields.

CO3: Understanding convergence and divergence in sequences of real numbers is essential across various disciplines as it facilitates analysis of patterns, predictions of outcomes, and modeling behaviors in diverse systems.

CO4: Mastering the Cauchy criteria equips students to rigorously analyze convergence, explore the characteristics of Cauchy sequences, and effectively solve real-world problems across diverse fields reliant on sequences' properties.

PO8: Environment and Sustainability

CO7: Applying convergence tests rigorously ensures accurate determination of series convergence or divergence, critical in modeling and analyzing real-world environmental and sustainability phenomena.

PO9: Self-directed and Life-long Learning

CO2: Understanding equivalence relations, countability, and the Cantor set fosters problem-solving skills across diverse fields, facilitating self-directed learning by applying these concepts practically, thereby nurturing life-long learning capabilities.

CO7: Rigorous application of convergence tests ensures accurate determination of convergence or divergence in series, vital for real-world applications, fostering self-directed and lifelong learning in mathematical analysis.

Class: T.Y.B.Sc.

Paper Code: MAT3503

Title of Paper: Group Theory

Course Outcomes:

C01 Students will able to recognize the mathematical objects called groups.
C02 Students will able to link the fundamental concepts of groups and symmetries of geometrical objects.
C03 Students will able to explain the significance of the notions of cosets, normal subgroups and factor groups.
C04 Students will able to analyse consequences of Lagrange's theorem.
C05 Students will able to describe about structure preserving maps between groups and their consequences.
C06 Students will able to learn Automorphisms for constructing new groups from the given group.
C07 Students can apply group theory to solve some special problems in elementary number theory like Fermat's Theorem, Wilson's Theorem etc.

(2019Pattern)

Mapping of Program Outcomes with Course Outcomes

Class: T.Y.B.Sc. (Sem V) **Subject:** Mathematics

Course: Group Theory **Course Code: MAT3503**

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

	Programme Outcomes(POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	3				2			2
CO 2	3	3		2	3	2			2
CO 3	3	3				2			2
CO 4	3	3				2			2
CO 5	3	3		2	2	2			2
CO 6	3	3				2			2
CO 7	3	3		2	2	2			2

Justification for the mapping

PO 1: Disciplinary Knowledge:

All of these course outcomes (COs) contribute to the students development of abstract reasoning skills by working with the abstract algebraic structures inherent in group theory.For example, CO1,CO2,CO3,CO5,CO6 requires student to develop deep learning of groups,symmetry,subgroups,factor group, isomorphism of groups.CO4 and CO7 requires students to apply the concepts of Group Theory in many fields like engineering,Chemistry and computer science.

PO2:Critical Thinking and Problem Solving:

All of these course outcomes (COs) contribute to the development of students critical thinking and problem solving. For example, CO1, CO2 CO3, CO5 requires students to think critically and apply these to solve complex problems in various filed like engineering and physics. CO4,CO6 and CO7 requires to apply and construct logical proofs to solve real world problems.

PO4: Research-related skills and Scientific temper:

CO2,CO5,CO7 contribute to the development of students research related skills and scientific temper. For example, CO2 and CO7 requires students to develop their ability to think critically and apply knowledge to various field. CO5 requires students to apply knowledge of homomorphism to solvee real life problems

PO5:Trans-disciplinary Knowledge:

CO2, CO5, CO7 requires students to apply group theory concepts in various fields like Chemistry, Engineering and Computer science.

PO6:Personal and professional competence:

All COs contribute to development of personal and professional competences. For example , all COs requires students to approach and solve complex problem systematically.

PO9:Self-directed and Life-long learning:

All these course outcomes contribute to development of students ability to engage in self directed and life-long learning. For example, all COs requires students to develop their ability to learn new concepts , form a simple proof and apply them to new problem.

Class: T.Y.B.Sc.

Paper Code: MAT3504

Title of Paper: Ordinary Differential Equations

Course Outcomes:

C01 Students will able to understand basic concept of differential equations.
C02 Students will able to solve first order differential equations.
C03 Student will able to grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.
C04 Students will able to solve differential equations using variation of parameter method, undetermined coefficient and by numerical methods.
C05 Student will able to solve constant-coefficient linear second-order differential equations.
C06 Students will able to demonstrate ability to think critically by determining and using appropriate techniques for solving a variety of differential equations.
C07 Students will able to demonstrate the ability to integrate knowledge and ideas of differential equations in a coherent and meaningful manner for solving real world problems.

Mapping of Program Outcomes with Course Outcomes

Class: T.Y.B.Sc. (Sem V) **Subject:** Mathematics

Course: Ordinary Differential Equations **Course Code: MAT3504**

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

	Programme Outcomes(POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	3							
CO 2	3	3		2	3				
CO 3	3	3							
CO 4	3	3							
CO 5	3	3		2	2				
CO 6	3	3							
CO 7	3	3		2	2				

Justification for the mapping

PO 1: Disciplinary Knowledge:

All of these course outcomes (COs) contribute to the development of students ability to formation of solution of differential equations.For example, CO1,CO2,CO3,CO5 requires student to develop deep learning of solution of homogeneous and non-homogeneous ordinary differential equation.CO4,CO6 and CO7 requires students to apply the concepts of ordinary differential equations in many fields like engineering,Chemistry and Biology.

PO2:Critical Thinking and Problem Solving:

All of these course outcomes (COs) contribute to the development of students critical thinking and problem solving. For example, CO1, CO2 CO3, CO5 requires students to think critically and apply these to solve complex problems in various filed like engineering and physics. CO4,CO6 and CO7 requires to solve real world problems.

PO4: Research-related skills and Scientific temper:

CO2,CO5,CO7 contribute to the development of students research related skills and scientific temper. For example, CO2 and CO7 requires students to develop their ability to think critically and apply knowledge to various field. CO5 requires students to apply knowledge of homomorphism to solve real life problems

PO5:Trans-disciplinary Knowledge:

CO2, CO5, CO7 requires students to apply differential equations concepts in various fields like Chemistry, Engineering and Physics.

Class: T.Y.B.Sc. (Semester – V)
Course Code: MAT 3505
Course: 5 **Title of the Course:** Operations Research
Credit: 2 **No. of Lectures:** 48

A) Course Objectives:

1. To familiarize students with the basic concepts, terminologies, and constraints involved in linear programming problems, enabling them to articulate problem formulations effectively.
2. Develop students' proficiency in graphically representing and solving linear programming problems using the graphical method, including identifying feasible regions, optimal solutions, and sensitivity analysis.
3. Enable students to apply the simplex method algorithmically to solve complex linear programming problems, emphasizing the understanding of pivot operations and iterations.
4. Equip students with the skills to handle linear programming problems with constraints that require artificial variables using the Big-M method, focusing on conversion and manipulation techniques.
5. Introduce students to graphical sensitivity analysis methods to assess the impact of changes in objective function coefficients, resource availability, and constraint boundaries on optimal solutions.
6. To enable students to understand and apply the concept of duality in Linear Programming (LP) problems, exploring its significance, properties, and practical implications.
7. To familiarize students with the core concepts, algorithms, and mathematical techniques used in transportation modeling, enabling them to comprehend the underlying principles of optimization in transportation systems.
8. To equip students with the ability to identify, formulate, and solve transportation problems using appropriate mathematical models and optimization techniques. This includes practical applications in logistics, supply chain management, and urban transportation planning.
9. To familiarize students with the fundamental principles and concepts underlying assignment models in Operations Research, including the Hungarian method, transportation problems, and linear programming techniques used in solving assignment problems.

B) Course Outcomes:

1. Students will demonstrate the ability to formulate real-world problems into mathematical linear programming models, identifying decision variables, constraints, and the objective function accurately.
2. Students will be able to graphically solve and interpret linear programming problems, accurately identifying feasible regions, optimal solutions, and performing sensitivity analysis on graphical representations.

3. Students will apply the simplex method proficiently to solve multi-variable linear programming problems, showcasing competence in formulating initial tables, conducting iterations, and identifying optimal solutions.
4. Students will exhibit proficiency in applying the Big-M method to solve problems with artificial variables, manipulating constraints effectively, and transitioning between phases while solving LP problems.
5. Students will be able to explain the concept of duality in Linear Programming, outlining its mathematical basis and relevance in optimization problems.
6. Students will be able to develop and implement transportation models to optimize logistical operations, effectively analyze transportation networks, and propose strategic solutions for minimizing transportation costs, maximizing efficiency, and addressing complex real-world transportation challenges.
7. Students will be proficient in formulating assignment problems in different contexts (such as workforce allocation, resource assignment, task optimization) as mathematical models. They will demonstrate the capability to apply appropriate algorithms and techniques, like the Hungarian algorithm or linear programming, to solve these assignment problems efficiently and effectively.

Mapping of Program Outcomes with Course Outcomes

Class: TYBSc (Sem V) **Subject:** Mathematics
Course: Operations Research **Course Code:** MAT 3505
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	2	2				1			
CO 2	3	2			1				
CO 3	2	2							
CO 4	3	3		1	1			1	1
CO 5	2	1							
CO 6	3	2		1	1	1		1	1
CO 7	2	2			1				1

Justification for the mapping

PO1: Disciplinary Knowledge
CO1: Students will apply linear programming to convert real-world problems into mathematical models, showcasing adeptness in defining decision variables, constraints, and objective functions, vital in problem-solving within the discipline.
CO2: Students will acquire vital analytical skills by graphically solving linear programming problems, enabling them to identify feasible regions, optimal solutions, and conduct sensitivity analysis, fostering a deeper understanding of quantitative decision-making.

CO3: Students will master the simplex method to efficiently tackle multi-variable linear programming problems, demonstrating expertise in constructing tables, performing iterations, and recognizing optimal solutions within Disciplinary Knowledge.
CO4: Students demonstrate mastery in utilizing the Big-M method by efficiently employing artificial variables, effectively manipulating constraints, and smoothly transitioning between phases when solving Linear Programming (LP) problems.
CO5: Duality in Linear Programming provides a complementary perspective by establishing relationships between primal and dual problems, enabling students to comprehend optimization trade-offs and derive optimal solutions efficiently in various disciplinary applications.
CO6: Students will gain expertise in transportation modeling to optimize logistics, analyze networks, and propose cost-effective strategic solutions, addressing real-world transportation challenges comprehensively.
CO7: Equips students with the expertise to translate real-world scenarios into mathematical models and adeptly utilize algorithms such as the Hungarian algorithm or linear programming for optimal problem-solving in diverse contexts.

PO2: Critical Thinking and Problem Solving
CO1: Developing linear programming models sharpens analytical skills by translating real-world problems into mathematical formulations, clarifying decision variables, constraints, and the objective function with precision.
CO2: Graphical linear programming enables students to visually analyze constraints, pinpoint feasible regions, optimize solutions, and conduct sensitivity analysis, fostering critical thinking in problem-solving.
CO3: Students will demonstrate critical thinking and problem-solving skills by efficiently utilizing the simplex method to navigate complex multi-variable linear programming problems, displaying adeptness in constructing initial tables, performing iterative calculations, and discerning optimal solutions.
CO4: Students will develop problem-solving skills by mastering the Big-M method, efficiently handling artificial variables, constraints, and seamlessly transitioning between phases in Linear Programming problem-solving.
CO5: Understanding duality in Linear Programming offers a dual perspective to optimization, presenting a mathematical basis for exploring alternative solutions and providing valuable insights into the primal problem, fostering critical thinking and problem-solving skills in tackling complex optimization challenges.
CO6: Empowering students with transportation modeling skills fosters the ability to strategically tackle real-world logistical challenges by optimizing networks, minimizing costs, and maximizing operational efficiency.
CO7: Students will enhance critical thinking by mastering diverse mathematical modeling techniques, like the Hungarian algorithm or linear programming, to proficiently solve assignment problems across various real-world scenarios, fostering effective problem-solving skills.

PO4: Research-related skills and Scientific temper
CO4: Mastering the Big-M method fosters adeptness in handling artificial variables, efficiently manipulating constraints, and seamlessly transitioning between phases, essential for resolving LP problems in research settings.

CO6: Students will acquire the expertise to devise and apply transportation models, enabling them to optimize logistics, analyze networks effectively, and propose strategic solutions, fostering a robust approach towards minimizing costs, maximizing efficiency, and addressing multifaceted real-world transportation challenges.

PO5: Trans-disciplinary Knowledge

CO2: Graphical solutions in linear programming facilitate comprehension of feasible regions, optimal solutions, and sensitivity analysis, aiding students' trans-disciplinary understanding of complex problem-solving and decision-making processes.

CO4: Mastering the Big-M method allows students to adeptly navigate artificial variables, manipulate constraints, and seamlessly transition phases, enabling effective problem-solving in Trans-disciplinary Knowledge.

CO6: Students will acquire essential skills to enhance logistical efficiency and tackle real-world transportation complexities by mastering transportation modeling and strategic optimization techniques within a trans-disciplinary framework.

CO7: Equipping students with diverse mathematical modeling skills and algorithmic techniques ensures adeptness in solving assignment problems across varied contexts, fostering trans-disciplinary problem-solving expertise.

PO6: Personal and Professional Competence

CO1: Enables strategic problem-solving by converting real-world scenarios into precise mathematical representations, optimizing decision-making through linear programming techniques.

CO6: Enables students to apply transportation models for cost-effective logistics, network analysis, and strategic problem-solving in real-world transportation scenarios, enhancing their personal and professional competence.

PO8: Environment and Sustainability

CO4: Mastering the Big-M method empowers students to navigate and solve complex environmental and sustainability problems by adeptly manipulating constraints and seamlessly transitioning between phases in linear programming.

CO6: Students will acquire expertise in transportation modeling to optimize logistics, analyze networks, and propose cost-effective, efficient solutions for real-world sustainability challenges in transportation.

PO9: Self-directed and Life-long Learning

CO4: Mastering the Big-M method enables seamless problem-solving by adeptly handling artificial variables, constraints manipulation, and phase transitions in Linear Programming, fostering self-directed and lifelong learning.

CO6: Empowering students with transportation modeling skills fosters lifelong learning by enabling them to strategically optimize logistics, analyze networks, and innovate solutions for cost reduction and efficiency enhancement in real-world transportation complexities.

CO7: Equipping students to translate real-world scenarios into mathematical models and apply relevant algorithms fosters adaptable problem-solving skills crucial for continual learning and self-directed problem resolution.

Class: T.Y.B.Sc. (Semester – V)
Course Code: MAT 3507
Course: 7
Title of the Course: Practical based on MAT 3501 and MAT 3502
Credit: 2
No. of Lectures: 48

A) Course Objectives:

1. Apply the principles of metric space topology to model and resolve practical problems in various fields such as computer science, engineering, physics, and data analysis.
2. Understand the concept of continuity in metric spaces, exploring its theoretical underpinnings and its practical applications.
3. Develop proficiency in applying the principles of continuity within metric spaces to solve real-world problems in various mathematical contexts.
4. Analyze and demonstrate an understanding of connectedness, compactness, and completeness in metric spaces through theoretical study and practical applications.
5. Apply the concepts of connectedness, compactness, and completeness in metric spaces to solve real-world mathematical problems in diverse fields, emphasizing practical relevance.
6. Analyze and manipulate functions, including composition, inverses, domains, ranges, and graphing techniques for real-valued functions.
7. Investigate advanced concepts like equivalence relations, countability, and the Cantor set.
8. Analyze and differentiate between convergent and divergent sequences, employing various convergence tests and techniques such as limit definitions, Cauchy sequences, and the comparison test.
9. To enable students to comprehend the concepts of convergence and divergence in series of real numbers.
10. To familiarize students with fundamental convergence tests such as the Comparison Test, Ratio Test, and Root Test.

B) Course Outcomes:

1. Students will be proficient in utilizing the topology of metric spaces to formulate and address real-life problems, demonstrating the practical applicability of mathematical concepts in diverse practical contexts.
2. Students will be capable of analyzing and solving practical problems involving continuity within metric spaces, demonstrating a clear understanding of its relevance and applications in diverse mathematical scenarios.
3. Students will proficiently utilize the principles of connectedness, compactness, and completeness in metric spaces to address practical mathematical challenges in various applied domains, showcasing the practical applicability of these concepts in problem-solving.
4. Students will be able to apply the concepts of equivalence relations, countability, and the Cantor set to solve complex problems in diverse areas, showcasing an understanding of their practical applications.

5. Students will be able to identify convergence or divergence in a given sequence of real numbers, analyze the behavior of sequences toward specific limits or infinity, and apply relevant tests to determine convergence or divergence.
6. Students will be able to apply their knowledge of convergence, divergence, and Cauchy sequences to model and analyze real-world scenarios, interpret their mathematical significance, and communicate findings effectively using mathematical reasoning.
7. Students will apply convergence tests rigorously to ascertain convergence or divergence of different series encountered in real-world applications.

Mapping of Program Outcomes with Course Outcomes

Class: TYBSc (Sem V) **Subject:** Mathematics
Course: Practical based on MAT 3501 and MAT 3502 **Course Code:** MAT 3507
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	2	2							
CO 2	3	2							
CO 3	3	3			1				
CO 4	3	2			1				1
CO 5	3	3			1				
CO 6	2	2							
CO 7	3	3						1	1

Justification for the mapping

PO1: Disciplinary Knowledge
CO1: Students proficient in metric space topology can apply abstract mathematical concepts to solve real-world problems across various disciplines, showcasing the practical relevance of mathematics in diverse contexts.
CO2: Students will develop problem-solving skills in metric spaces, crucial for diverse mathematical applications requiring continuity comprehension.
CO3: Students proficient in connectedness, compactness, and completeness in metric spaces navigate real-world problem-solving across disciplines by employing fundamental mathematical principles.
CO4: Understanding equivalence relations, countability, and the Cantor set enables students to discern patterns, classify diverse data, and model complex systems across disciplines, fostering problem-solving prowess through practical application.
CO5: Understanding convergence and divergence in sequences of real numbers is foundational in various disciplines, enabling precise analysis of limits and applications of convergence tests for robust mathematical problem-solving.
CO6: Understanding convergence, divergence, and Cauchy sequences equips students with the tools to mathematically model real-world phenomena, interpret their implications, and

communicate findings coherently, enhancing their disciplinary knowledge and analytical abilities.
CO7: Students rigorously apply convergence tests to ensure accuracy when determining the convergence or divergence of series in real-world applications within Disciplinary Knowledge.

PO2: Critical Thinking and Problem Solving
CO1: Students proficient in metric space topology can apply abstract mathematical concepts to solve real-world problems, showcasing critical thinking across various practical scenarios.
CO2: Students will develop critical thinking skills by mastering the analysis and resolution of real-world problems using continuity in metric spaces, showcasing its broad relevance across various mathematical contexts.
CO3: Students proficient in metric space principles enhance critical thinking by leveraging connectedness, compactness, and completeness to solve real-world problems across diverse applied fields, showcasing practicality in problem-solving.
CO4: Understanding equivalence relations, countability, and the Cantor set cultivates analytical skills essential for tackling multifaceted problems across disciplines, demonstrating the practicality of abstract mathematical concepts in fostering critical thinking and problem-solving prowess.
CO5: Understanding convergence or divergence in sequences of real numbers enhances critical thinking by sharpening analytical skills and applying test strategies to ascertain the behavior of sequences towards specific limits or infinity.
CO6: Understanding convergence, divergence, and Cauchy sequences equips students with the essential tools to analyze real-world scenarios through mathematical models, fostering effective communication and interpretation of findings to solve complex problems.
CO7: Applying convergence tests rigorously ensures accurate determination of convergence or divergence, crucial for real-world applications' validity and reliability in Critical Thinking and Problem Solving.

PO4: Research-related skills and Scientific temper
CO5: Mastering Cauchy criteria empowers students to rigorously assess convergence, analyze sequence properties, and apply theorems effectively, fostering essential research skills and a scientific mindset for problem-solving in real sequences.

PO5: Trans-disciplinary Knowledge
CO3: Utilizing connectedness, compactness, and completeness in metric spaces enhances problem-solving across diverse fields by enabling rigorous analysis and solution development in trans-disciplinary contexts.
CO4: Understanding equivalence relations, countability, and the Cantor set enables students to unravel intricate problems across disciplines, fostering a versatile problem-solving approach essential in trans-disciplinary fields.
CO5: Understanding convergence and divergence in sequences of real numbers is essential across various disciplines as it facilitates analysis of patterns, predictions of outcomes, and modeling behaviors in diverse systems.

PO8: Environment and Sustainability

CO7: Applying convergence tests rigorously ensures accurate determination of series convergence or divergence, critical in modeling and analyzing real-world environmental and sustainability phenomena.

PO9: Self-directed and Life-long Learning

CO4: Understanding equivalence relations, countability, and the Cantor set fosters problem-solving skills across diverse fields, facilitating self-directed learning by applying these concepts practically, thereby nurturing life-long learning capabilities.

CO7: Rigorous application of convergence tests ensures accurate determination of convergence or divergence in series, vital for real-world applications, fostering self-directed and lifelong learning in mathematical analysis.

Class: T.Y.B.Sc.

Paper Code: MAT3506

Title of Paper: Practical Based on MAT3504 & MAT3505.

Course Outcomes:

C01 Students will able to demonstrate when a binary algebraic structure is a group.
C02 Students will able to determine possible subgroup of a group.
C03 Students will understand the isomorphism between two groups.
C04 Students will able to understand the symmetry of regular n-gon.
C05 Student will able to understand the genesis of ordinary differential equations.
C06 Student will able to learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
C07 Students will able to understand the formation of modelling problems in ordinary differential equations and apply some standard methods to obtain its solutions.

Mapping of Program Outcomes with Course Outcomes

Class: T.Y.B.Sc. (Sem V) **Subject:** Mathematics

Course: Practical based on MAT3504 & MAT3505 **Course Code: MAT3506**

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

	Programme Outcomes(POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	3							
CO 2	3	3							
CO 3	3	3		3	2				
CO 4	3	2							
CO 5	3	2							
CO 6	3	2		2	2				
CO 7	3	2		2	2				

Justification for the mapping

PO 1: Disciplinary Knowledge:

All of these course outcomes (COs) contribute to the development of students Develop abstract reasoning skills by working with the abstract algebraic structures inherent in group theory and solution of ordinary differential equations.For example, CO1,CO2,CO3 requires student to develop deep learning of solution of homogeneous and non-homogeneous ordinary differential equation.CO4,CO5,CO6 and CO7 requires students to apply the concepts of ordinary differential equations in many fields like engineering,Chemistry and Biology.

PO2:Critical Thinking and Problem Solving:

All of these course outcomes (COs) contribute to the development of students critical thinking and problem solving. For example, CO1, CO2 CO3 requires students to think critically and apply these to solve complex problems in various filed like engineering and physics. CO4,CO5,CO6 and CO7 requires to solve real world problems.

PO4: Research-related skills and Scientific temper:

CO3,CO6,CO7 contribute to the development of students research related skills and scientific temper. For example, CO3 requires students to develop their ability to think critically and apply knowledge to various field. CO6 and CO7 requires students to apply knowledge of homomorphism to solve real life problems

PO5:Trans-disciplinary Knowledge:

CO3, CO6, CO7 requires students to apply isomorphism and differential equations concepts in various fields like Chemistry, Engineering and Physics.

Class: T.Y.B.Sc. (Semester – V)
Course Code: MAT 3509
Course: 9
Title of the Course: Practical based on MAT 3505 and MAT 3506
Credit: 2
No. of Lectures: 48

A) Course Objectives:

1. To familiarize students with the basic concepts, terminologies, and constraints involved in linear programming problems, enabling them to articulate problem formulations effectively.
2. Equip students with the skills to handle linear programming problems with constraints that require artificial variables using the Big-M method, focusing on conversion and manipulation techniques.
3. To familiarize students with the core concepts, algorithms, and mathematical techniques used in transportation modeling, enabling them to comprehend the underlying principles of optimization in transportation systems.
4. To equip students with the ability to identify, formulate, and solve transportation problems using appropriate mathematical models and optimization techniques. This includes practical applications in logistics, supply chain management, and urban transportation planning.
5. To familiarize students with the fundamental principles and concepts underlying assignment models in Operations Research, including the Hungarian method, transportation problems, and linear programming techniques used in solving assignment problems.
6. To enable students to apply congruence concepts practically in cryptography, coding theory, and other real-world applications.
7. To enable undergraduate students to comprehend and apply the greatest integer function in various real-world scenarios, such as modeling discrete quantities and analyzing step functions in practical contexts.
8. To equip students with a deep understanding of quadratic reciprocity and its practical applications in cryptography, number theory, and other fields.

B) Course Outcomes:

1. Students will demonstrate the ability to formulate real-world problems into mathematical linear programming models, identifying decision variables, constraints, and the objective function accurately.
2. Students will apply the simplex method proficiently to solve multi-variable linear programming problems, showcasing competence in formulating initial tables, conducting iterations, and identifying optimal solutions.
3. Students will be able to develop and implement transportation models to optimize logistical operations, effectively analyze transportation networks, and propose strategic solutions for minimizing transportation costs, maximizing efficiency, and addressing complex real-world transportation challenges.

4. Students will be proficient in formulating assignment problems in different contexts (such as workforce allocation, resource assignment, task optimization) as mathematical models. They will demonstrate the capability to apply appropriate algorithms and techniques, like the Hungarian algorithm or linear programming, to solve these assignment problems efficiently and effectively.
5. Students will be able to analyze and implement congruence-based algorithms in practical scenarios, such as encryption techniques or error-detection mechanisms in digital communication systems.
6. Students will proficiently utilize the greatest integer function to model and solve practical problems encountered in fields like computer science, economics, and engineering, demonstrating its applicability in discrete data representation and algorithmic design.
7. Students will proficiently apply the principles of quadratic reciprocity to solve complex mathematical problems in cryptography, number theory, and related practical domains, demonstrating their ability to employ this concept in real-world applications.

Mapping of Program Outcomes with Course Outcomes

Class: TYBSc (Sem V) **Subject:** Mathematics
Course: Practical based on MAT 3505 and MAT 3506 **Course Code:** MAT 3509
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	2	2				1			
CO 2	2	2		1	1			1	1
CO 3	3	2		1	1	1		1	1
CO 4	2	2			1				1
CO 5	3	2							
CO 6	2	2							
CO 7	2	2							

Justification for the mapping

PO1: Disciplinary Knowledge
CO1: Students will apply linear programming to convert real-world problems into mathematical models, showcasing adeptness in defining decision variables, constraints, and objective functions, vital in problem-solving within the discipline.
CO2: Students will master the simplex method to efficiently tackle multi-variable linear programming problems, demonstrating expertise in constructing tables, performing iterations, and recognizing optimal solutions within Disciplinary Knowledge.
CO3: Students will gain expertise in transportation modeling to optimize logistics, analyze networks, and propose cost-effective strategic solutions, addressing real-world transportation challenges comprehensively.

CO4: Equips students with the expertise to translate real-world scenarios into mathematical models and adeptly utilize algorithms such as the Hungarian algorithm or linear programming for optimal problem-solving in diverse contexts.
CO5: Students will gain proficiency in applying congruence-based algorithms for encryption and error detection in digital communication systems, enhancing their disciplinary knowledge.
CO6: Utilizing the greatest integer function facilitates precise discrete data representation and algorithmic design, crucial across computer science, economics, and engineering for solving practical problems effectively.
CO7: Application of quadratic reciprocity enables students to solve intricate cryptographic and number theory problems, fostering their adeptness in real-world contexts and practical domains.

PO2: Critical Thinking and Problem Solving
CO1: Developing linear programming models sharpens analytical skills by translating real-world problems into mathematical formulations, clarifying decision variables, constraints, and the objective function with precision.
CO2: Students will demonstrate critical thinking and problem-solving skills by efficiently utilizing the simplex method to navigate complex multi-variable linear programming problems, displaying adeptness in constructing initial tables, performing iterative calculations, and discerning optimal solutions.
CO3: Empowering students with transportation modeling skills fosters the ability to strategically tackle real-world logistical challenges by optimizing networks, minimizing costs, and maximizing operational efficiency.
CO4: Students will enhance critical thinking by mastering diverse mathematical modeling techniques, like the Hungarian algorithm or linear programming, to proficiently solve assignment problems across various real-world scenarios, fostering effective problem-solving skills.
CO5: Students develop critical thinking by applying congruence-based algorithms to real-world scenarios like encryption or error-detection, fostering problem-solving skills in digital communication systems.
CO6: The greatest integer function serves as a fundamental tool for modeling real-world scenarios in discrete data analysis, algorithmic design, and problem-solving across computer science, economics, and engineering disciplines.
CO7: Mastering quadratic reciprocity fosters critical thinking and problem-solving skills vital for tackling intricate cryptographic challenges and practical applications in number theory.

PO4: Research-related skills and Scientific temper
CO2: Mastering the Big-M method fosters adeptness in handling artificial variables, efficiently manipulating constraints, and seamlessly transitioning between phases, essential for resolving LP problems in research settings.
CO3: Students will acquire the expertise to devise and apply transportation models, enabling them to optimize logistics, analyze networks effectively, and propose strategic solutions, fostering a robust approach towards minimizing costs, maximizing efficiency, and addressing multifaceted real-world transportation challenges.

PO5: Trans-disciplinary Knowledge
CO2: Mastering the Big-M method allows students to adeptly navigate artificial variables, manipulate constraints, and seamlessly transition phases, enabling effective problem-solving in Trans-disciplinary Knowledge.
CO3: Students will acquire essential skills to enhance logistical efficiency and tackle real-world transportation complexities by mastering transportation modeling and strategic optimization techniques within a trans-disciplinary framework.
CO4: Equipping students with diverse mathematical modeling skills and algorithmic techniques ensures adeptness in solving assignment problems across varied contexts, fostering trans-disciplinary problem-solving expertise.

PO6: Personal and Professional Competence
CO1: Enables strategic problem-solving by converting real-world scenarios into precise mathematical representations, optimizing decision-making through linear programming techniques.
CO3: Enables students to apply transportation models for cost-effective logistics, network analysis, and strategic problem-solving in real-world transportation scenarios, enhancing their personal and professional competence.

PO8: Environment and Sustainability
CO2: Mastering the Big-M method empowers students to navigate and solve complex environmental and sustainability problems by adeptly manipulating constraints and seamlessly transitioning between phases in linear programming.
CO3: Students will acquire expertise in transportation modeling to optimize logistics, analyze networks, and propose cost-effective, efficient solutions for real-world sustainability challenges in transportation.

PO9: Self-directed and Life-long Learning
CO2: Mastering the Big-M method enables seamless problem-solving by adeptly handling artificial variables, constraints manipulation, and phase transitions in Linear Programming, fostering self-directed and lifelong learning.
CO3: Empowering students with transportation modeling skills fosters lifelong learning by enabling them to strategically optimize logistics, analyze networks, and innovate solutions for cost reduction and efficiency enhancement in real-world transportation complexities.
CO4: Equipping students to translate real-world scenarios into mathematical models and apply relevant algorithms fosters adaptable problem-solving skills crucial for continual learning and self-directed problem resolution.