Programme	B.Sc. Mathematics Honours			
Course Code	MAT3CJ201			
Course Title	**MULTIVARIABLE CALCULUS**			
Type of Course	**Major**			
Semester	III			
Academic Level	200-299			
Course Details	Credit	Lecture/ Tutorial per week	Practical per week	Total Hours
	4	3	2	75
Pre-requisites	Basic knowledge of vectors, dot product, cross product, triple products, lines and planes in 3-dimensional space			
Course Summary	Multivariable Calculus takes the concepts learned in the single variable calculus course and extends them to multiple dimensions. Topics discussed include: Parameterizations of Plane Curves, Polar Coordinates, Lines and Planes in Space, Cylinders and Quadric Surfaces, Cylindrical and Spherical Coordinates, functions of many variables, limit, continuity, differentiation, and integration of vector-valued functions; application of vector-valued functions limits, and derivatives of multivariable functions, tangent planes and normal lines of surfaces, applying double and triple integrals to multivariable functions to find area, volume, surface area, vector fields, finding curl and divergence of vector fields; line integrals; Green's Theorem; parametric surfaces, including normal vectors, tangent planes, and areas; orientation of a surface; Divergence Theorem; and Stokes's Theorem.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe various coordinate systems— Cartesian, polar, cylindrical, and spherical—to represent, analyze, and interpret geometric figures and spatial relationships.	Ap	C	Internal Examination/ Assignment/End Sem exam
CO2	Compute and apply limits and partial derivatives for functions of several variables to solve various mathematical problems.	Ap	C	Internal Examination/ Seminar/ Assignment/ Report/ End Sem examination

CO3	Apply partial derivatives to solve real world problems.	Ap	C	Internal Examination/Sem inar/ Assignment/ Report/ End Sem examination
CO4	Compute line and double integrals, apply it to solve problems and understand the relations between integrals.	Ap	C	Internal Examination/Seminar/ Assignment/ Report/ End Sem examination
CO5	Compute triple integrals in different coordinate systems, apply it to solve various real world problems and understand the relations between the integrals.	Ap	C	Internal Examination/Seminar/ Assignment/ Report/ End Sem examination
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	**Calculus and Analytic Geometry, 9th Edition, George B. Thomas, Jr. Ross L. Finney, Pearson Publications, 2010, ISBN: 978-8174906168.**		
Module	**Unit**	**Content**	**Hrs (45+30)**
I	**Module I**		
	1	Section 9.4: Parameterizations of Plane Curves Topics up to and including Example 7	**10**
	2	Section 9.6: Polar Coordinates Definition of Polar Coordinates, Negative Values of r, Elementary Coordinate Equations and Inequalities, Cartesian Versus Polar Coordinates.	
	3	Section 10.5: Lines and Planes in Space Lines and Line Segments in Space, The Distance from a Point to a Line in Space, Equations for Planes in Space, Angles between Planes; Lines of Intersection.	
	4	Section 10.6: Cylinders and Quadric Surfaces Cylinders, Drawing Lesson, Quadric Surfaces, Drawing Lesson.	
	5	Section 10.7: Cylindrical and Spherical Coordinates Cylindrical Coordinates, Spherical Coordinates	

II		**Module II**	
	6	Section 12.1: Functions of Several Variables Functions and Variables, Graphs and Level Curves of Functions of Two Variables, Contour Lines, Level Surfaces of Functions of Three Variables.	**12**
	7	Section 12.2: Limits and Continuity Limits, Continuity, Functions of More Than Two Variables.	
	8	Section 12.3: Partial Derivatives Definitions and Notation, Calculations, Functions of More Than Two Variables, The Relationship Between Continuity and the Existence of Partial Derivatives, Second Order Partial Derivatives, Euler's Theorem, Partial Derivatives of Still Higher Order.	
	9	Section 12.4: Differentiability, Linearization, and Differentials Differentiability, How to Linearize a Function of Two Variables, How Accurate is the Standard Linear Approximation? Predicting Change with Differentials (Topics up to and including Example 7)	
	10	Section 12.5: The Chain Rule The Chain Rule for Functions of Two Variables (Proof of Theorem 5 is optional), The Chain Rule for Functions of Three Variables, The Chain Rule for Functions Defined on Surfaces, Implicit Differentiation, Remembering the Different Forms of the Chain Rule, The Chain Rule for Functions of Many Variables.	
III		**Module III**	
	11	Section 12.7: Directional Derivatives, Gradient Vectors, and Tangent Planes Directional Derivatives in the Plane, Geometric Interpretation of the Directional Derivative, Calculation, Properties of Directional Derivatives, Gradients and Tangent to Level Curves, Functions of Three Variables.	**11**
	12	Section 12.7: Directional Derivatives, Gradient Vectors, and Tangent Planes Equations for Tangent Planes and Normal Lines, Planes Tangent to a Surface z=f(x,y), Algebra Rules for Gradients.	
	13	Section 12.8: Extreme Values and Saddle points The Derivative Tests.	
	14	Section 12.8: Extreme Values and Saddle points Absolute Maxima and Minima on Closed Bounded Regions, Conclusion.	

	15	Section 12.9: Lagrange Multipliers Constrained Maxima and Minima, The Method of Lagrange Multipliers (Theorem 9 and Corollary of Theorem 9 are optional).	
	16	Section 12.9: Lagrange Multipliers Lagrange Multipliers with Two Constraints.	
IV	**Module IV**		
	17	Section 13.1: Double Integrals, Double Integrals over Rectangles, Properties of Double Integrals, Double Integrals as Volumes, Fubini’s Theorem for Calculating Double Integrals.	**12**
	18	Section 13.1: Double Integrals	

		Double Integrals over Bounded Nonrectangular Regions, Finding the Limits of Integration.	
	19	Section 13.2: Areas, Moments and Centers of Mass Areas of Bounded Regions in the Plane, Average Value.	
	20	Section 13.3: Double Integrals in Polar Form Integrals in Polar Coordinates, Limits of Integration, Changing Cartesian Integrals into Polar Integrals.	
	21	Section 13.4: Triple Integrals in Rectangular Coordinates Triple Integrals, Properties of Triple Integrals, Volume of a Region in Space, Evaluation.	
	22	Section 13.4: Triple Integrals in Rectangular Coordinates Average Value of a Function in Space.	
V	**Practicum**		**30**

	Triple Integrals in Cylindrical Coordinates, Spherical coordinates Substitution in Multiple Integrals Vector Valued Functions and Space Curves Line Integrals Vector Fields, Work, Circulation and Flux Path Independence, Potential Functions and Conservative Fields. Green's Theorem in the Plane (Proof is Optional) Surface area and surface integrals Parametrized surfaces Stoke's theorem (Proof is optional) The Divergence theorem (Proof is Optional)	

References:

1. Anton, Bivens & Davis : Calculus Early Transcendentals (10/e) John Wiley & Sons, Inc.(2012) ISBN: 9780470647691
2. Arnold Ostebee & Paul Zorn: Multivariable Calculus (2/e) W. H. Freeman Custom Publishing, N.Y.(2008)ISBN: 9781429230339
3. James Stewart : Calculus (8/e) Brooks/Cole Cengage Learning(2016) ISBN:9781285740621
4. Jerrold E. Marsden & Anthony Tromba :Vector Calculus (6/e) W. H. Freeman and Company ,New York(2012) ISBN: 9781429215084
5. Joel Hass, Christopher Heil & Maurice D. Weir : Thomas' Calculus (14/e) Pearson(2018) ISBN 0134438981
6. Jon Rogawski: Multivariable Calculus Early Transcendentals (2/e) W. H. Freeman and Company (2012) ISBN: 1429231874
7. Robert A Adams & Christopher Essex : Calculus: A complete Course (8/e) Pearson Education Canada (2013) ISBN: 032187742X
8. William Wade: An Introduction to Analysis, (4/e) Pearson Education

***Optional topics are exempted for end semester examination **70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	3	2	1	2	1	3	0	2	2	3	0	3
CO 2	3	3	2	1	3	1	3	0	2	2	3	0	3
CO 3	3	3	2	1	3	1	3	0	2	2	3	0	3
CO4	3	3	2	1	3	1	3	0	2	2	3	0	3
CO5	3	3	2	1	3	1	3	0	2	2	3	0	3

Programme	BSc Mathematics Honours			
Course Code	MAT3CJ202			
Course Title	**MATRIX ALGEBRA**			
Type of Course	**Major**			
Semester	III			
Academic Level	200 – 299			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	-	60
Pre-requisites	1. System of linear equations and their solution sets. 2. Euclidean Spaces and their algebraic and geometric properties.			
Course Summary	This course covers matrix theory and linear algebra, emphasizing topics useful in many other disciplines. It begins with the study of systems of linear equations and the properties of matrices. Emphasis is given to topics including systems of equations, vector spaces, linear dependence and independence, dimension, linear transformations, eigenvalues and diagonalization.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the structure and solutions of linear systems using matrix notation, row operations, and echelon forms.	U	C	Internal Exam/Assignment/Seminar/Viva/ End Sem Exam
CO2	Apply vector equations and matrix transformations to represent and solve geometric and real-world problems	Ap	P	Internal Exam/Assignment/Seminar/Viva/ End Sem Exam
CO3	Apply the properties of matrices, including inverse and determinants, to solve linear equations and model transformations	Ap	P	Internal Exam/Assignment/Seminar/Viva/ End Sem Exam
CO4	Understand the concepts of linear independence, subspaces, dimension, and rank to analyze vector spaces.	U	P	Internal Exam/Assignment/Seminar/Viva/ End Sem Exam
CO5	Apply the concepts of eigenvalues, eigenvectors, and diagonalization to simplify matrix computations and interpret linear transformations.	Ap	C	Internal Exam/Assignment/Seminar/Viva/ End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Text Book	**Linear Algebra and its Applications, Third Edition, David. C. Lay, Pearson Publications 2006**.			
Module	**Unit**	**Content**	**Hrs (60)**	**External Marks (70)**
I		**Module I**		**Min. 15**
	1	Section 1.1: Systems of Linear Equations Systems of Linear Equations, Matrix Notation, Solving a Linear System.	14	
	2	Section 1.1: Systems of Linear Equations Elementary Row Operations, Existence and Uniqueness Questions.		
	3	Section 1.2: Row Reduction and Echelon Forms Row Reduction and Echelon Forms, Pivot Positions, The Row Reduction Algorithm.		
	4	Section 1.2: Row Reduction and Echelon Forms Solutions of Linear Systems, Parametric Descriptions of Solution Sets, Back Substitution, Existence and Uniqueness Questions.		
	5	Section 1.3: Vector Equations Vector Equations, Vectors in $\mathbb{R}^2$, Geometric Descriptions of $\mathbb{R}^2$, Vectors in $\mathbb{R}^3$, Vectors in $\mathbb{R}^n$.		
	6	Section 1.3: Vector Equations Linear Combinations, A Geometric Description of Span$\{v\}$ and Span $\{u, v\}$, Linear Combinations in Applications.		
	7	Section 1.4: The Matrix Equation Ax = b The Matrix Equation Ax = b, Existence of Solutions, Computation of Ax, Properties of the Matrix-Vector Product Ax.		
II		**Module II**		
	8	Section 1.5: Solution Sets of Linear Systems Homogeneous Linear Systems, Parametric Vector Form, Solutions of Non-Homogenous Systems.	13	
	9	Section 1.7: Linear Independence		

		Linear Independence, Linear Independence of Matrix Columns, Sets of One or Two Vectors, Sets of Two or More Vectors.		Min. 15
	10	Section 1.8: Introduction to Linear Transformations Introduction to Linear transformations, Matrix Transformations.		
	11	Section 1.8: Introduction to Linear Transformations Linear Transformations		
	12	Section 1.9: The Matrix of a Linear Transformation The Matrix of a Linear Transformation, Geometric Linear Transformation of $\mathbb{R}^2$.		
	13	Section 1.9: The Matrix of a Linear Transformation Existence and Uniqueness Questions. (Topics up to and including Theorem 11).		
III	**Module III**			Min. 15
	14	Section 2.1: Matrix Operations Matrix Operations, Sums and Scalar Multiples, Matrix Multiplication, Properties of Matrix Multiplication, Powers of a Matrix, The Transpose of a Matrix.	11	
	15	Section 2.2: The Inverse of a Matrix The Inverse of a Matrix (Example 3 is optional), Elementary Matrices (Proof of Theorem 7 is optional).		
	16	Section 2.2: The Inverse of a Matrix An Algorithm for Finding A^{-1}, Another View of Matrix Inversion.		
	17	Section 2.8 : Subspaces of $\mathbb{R}^n$ Subspaces of $\mathbb{R}^n$, Column Space and Null Space of a Matrix, Basis for a Subspace.		
	18	Section 2.9: Dimension and Rank Coordinate Systems, The Dimension of a Subspace (Topics up to and including Theorem 15).		
IV	**Module IV**			
	19	Section 5.1: Eigen Vectors and Eigen Values Eigen Vectors and Eigen Values (Topics up to and including Theorem 2).	10	

	20	Section 5.2: The Characteristic Equation The Characteristic Equation, Determinants (Topics up to and including Theorem 3).		Min. 15
	21	Section 5.2: The Characteristic Equation The Characteristic Equation, Similarity (Topics up to and including Theorem 4).		
	22	Section 5.3: Diagonalization Diagonalization (Proof of Theorem 5 is optional), Diagonalizing Matrices, Matrices Whose Eigen Values Are Not Distinct.		
V	**Module V (Open Ended)**		**12**	
	Determinants, Properties of Determinants, Applications of Linear Systems, Characterizations of Invertible Matrices, Partitioned Matrices, Application to Computer Graphics, Eigen Vectors and Linear Transformations.			

References

1. Elementary Linear Algebra, Howard Anton, Chris Rorres, Wiley Publications
2. Linear Algebra Done Right, 3/e, Sheldon Axler, Springer Nature,2015.
3. Introduction to Linear Algebra, 6/e, Gilbert Strang, Wellesley-Cambridge Press.
4. Basic Linear Algebra, 2/e, T. S. Blyth and E.F. Robertson, Springer, 2002.
5. Linear Algebra And its Applications, 4/e, Gilbert Strang, Cengage India Private Limited
6. Linear Algebra – A Geometric Approach, S.Kumaresan, Prentice Hall of India.
7. Bretscher, Otto. *Linear algebra with applications*. Vol. 52. Eaglewood Cliffs, NJ: Prentice Hall, 1997.
8. Holt, Jeffrey. *Linear Algebra with Applications*. wh freeman, 2017.

***Optional topics are exempted for end semester examination**

****70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO 1	3	1	2	2	3	1	3	3	3	2	1	1	1
CO 2	3	1	2	2	3	0	3	3	3	3	1	1	1
CO 3	3	0	2	2	3	0	3	3	3	1	1	1	1
CO 4	3	1	2	2	3	1	3	3	3	1	0	1	1
CO 5	3	0	2	2	3	0	3	3	3	3	0	1	1

Programme	B. Sc. Mathematics Honours			
Course Code	MAT3MN202			
Course Title	**DIFFERENTIAL EQUATIONS AND FOURIER SERIES**			
Type of Course	**Minor**			
Semester	III			
Academic Level	200-299			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	-	60
Pre-requisites	Basic Calculus and familiarity with Real Numbers			
Course Summary	In Module I students are introduced to various types of differential equations, including linear, separable, exact equations, and Bernoulli's equation. Module II delves deeper into linear equations, both homogeneous and nonhomogeneous. Module III introduces Fourier series, including trigonometric series, Fourier cosine and sine series, and half-range expansions. Module IV transitions into algebra of complex numbers, , and functions of complex variables, including analytic functions and the Cauchy-Riemann equations, which are fundamental in complex analysis.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply various methods, such as separation of variables, linear, and exact equations, integrating factors, and substitution, to solve differential equations, including those with constant coefficients and Cauchy-Euler equations.	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Analyse and solve partial differential equations, including separable ones, and comprehend Fourier series and their applications in solving differential equations and understanding periodic function	An	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Apply complex number theory, including arithmetic operations, polar forms, powers, roots, sets in the complex plane, functions of a complex variable, and Cauchy-Riemann equations, to analyze and solve real-world problems in various fields.	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Book	Advanced Engineering Mathematics(6/e) : Dennis G Zill, Jones & Bartlett, Learning, LLC(2018)ISBN: 978-1-284-10590-2

Module	Unit	Content	Hrs 60	External Marks (70)
I		**Foundations of Differential Equations**		
	1	Introduction to Differential Equations Section 1.1: Definitions and Terminology Introduction, A Definition, Classification by Type, Notation, Classification by Order, Classification by Linearity, Solution.	10	Min 15
	2	Section 2.2: Separable Equations Introduction, A Definition, Method of Solution.		
	3	Section 2.3: Linear Equations Introduction, A Definition, Standard Form, Method of Solution, An Initial Value Problem		
	4	Section 2.4: Exact Equations Introduction, Differential of a Function of Two Variables (Definition 2.4.1 and Theorem 2.4.1 only), Method of Solution.		
	5	Section 2.4: Exact Equations Integrating Factors		
	6	Section 2.5: Solutions by Substitutions Bernoulli's Equation		
II		**Linear Differential Equations**		
	7	Section 3.1: Theory of Linear Equations 3.1.2 Homogenous Equations, Linear Dependence and Independence, Solutions of Differential Equations,	11	Min 15
	8	Section 3.1: Theory of Linear Equations 3.1.3 Nonhomogeneous Equations, Complementary Function		
	9	Section 3.3: Homogeneous Linear Equations with Constant Coefficients Introduction, Auxiliary Equation.		
	10	Section 3.4: Undetermined Coefficients Introduction, Method of Undetermined Coefficients (Topics up to and including Example 4.)		
	11	Section 3.6: Cauchy-Euler Equations Cauchy-Euler Equation (Second Order Only), Method of Solution.		
III		**Fourier Series**		
	12	Section 12.2: Fourier Series Trigonometric Series (Definition 12.2.1 onwards), Convergence of a Fourier Series, Periodic Extension	13	Min 15
	13	Section 12.3: Fourier Cosine and Sine Series Introduction, Even and Odd Functions, Properties, Cosine and Sine Series (Definition 12.3.1 onwards).		
	14	Section 12.3: Fourier Cosine and Sine Series Half-Range Expansions.		

	15	Section 13.1: Separable Partial Differential Equations Introduction, Linear Partial Differential Equation, Solution of a PDE, Separation of Variables.		
	16	Section 13.1: Separable Partial Differential Equations Classification of Equations.		
IV		**Introduction to Complex Analysis**		
	17	Section 17.1: Complex Numbers Introduction, A definition, Terminology, Arithmetic Operations, Conjugate, Geometric Interpretation		
	18	Section 17.2: Powers and Roots Introduction, Polar Form, Multiplication and Division, Integer Powers of z.		
	19	Section 17.2: Powers and Roots DeMoivre's Formula, Roots.		
	20	Section 17.3: Sets in the Complex Plane Introduction, Terminology.	**14**	**Min 15**
	21	Section 17.4: Functions of a Complex Variable Introduction, Functions of a Complex Variable, Limits and Continuity, Derivative, Analytic Functions.		
	22	Section 17.5: Cauchy- Riemann Equations Introduction, A Necessary Condition for Analyticity, Harmonic Functions, Harmonic- Conjugate Functions.		
V		**Module V (Open Ended)**	**12**	
		Initial Value Problems		
		Differential Equations as Mathematical Models		
		Method of Variation of Parameters in solving DE		
		Solving DE with the Runge-Kutte Method		
		Interpolation, Extrapolation		
		Classical PDEs and Boundary Value Problems		
		Heat Equation		
		Wave Equation		
		Fourier Transform		
References				
	1	Advanced Engineering Mathematics, Erwin Kreyszig, 8^{th} Edition, Wiley Student Edition.		
	2	Mathematics For Engineers and Scientist, Alan Jeffrey, Sixth Edition		
	3	Complex Analysis A First Course with Applications (3/e), Dennis Zill & Patric Shanahan Jones and Bartlett, Learning (2015) ISBN 1-4496-9461-6		

Note: Proofs of all the results are also exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	3	2	3	3	3	1	2
CO 2	3	1	3	2	3	3	3	1	2
CO 3	3	2	3	2	3	3	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT3MN205			
Course Title	**OPTIMIZATION TECHNIQUES**			
Type of Course	**Minor**			
Semester	III			
Academic Level	200 - 299			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Basic understanding of linear algebra and introductory optimization concepts.			
Course Summary	This course provides a comprehensive exploration of linear programming and optimization techniques, focusing on graphical methods, the simplex method, and specialized problems like transportation and assignment. Students will gain practical skills in formulating, solving, and analyzing linear programming models, with applications in various optimization scenarios.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe the fundamental properties and types of linear programming models, distinguishing between maximization and minimization models, and explain various methods used for solving linear programming problems including graphical methods.	U	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO2	Apply the simplex method to solve both maximization and minimization linear programming problems, compare the graphical method with the simplex method in terms of efficiency and applicability, and demonstrate problem-solving skills through worked-out examples.	Ap	P	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO3	Evaluate and solve transportation and assignment problems using specific techniques such as the North-West corner method, Least Cost cell method, Vogel's approximation method, and the Hungarian method, while also comparing the transportation model with general linear programming models.	An	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam

Detailed Syllabus:

Text book	Operations Research (2/e), P Rama Murthy ,New Age International Publishers			
Module	Unit	Content	Hrs (48 +12)	Ext. Marks (70)
I		**Linear Programming Models: (Graphical Method)**	10	Min 15
	1	Section 2.1- Introduction, 2.2- Properties of Linear Programming Model		
	2	Section 2.3-Maximization Models		
	3	Section 2.4- Minimization Models		
	4	Section 2.5- Methods for the Solution of a Linear Programming Problem (up to Problem 2.9)		
	5	Section 2.5- Methods for the Solution of a Linear Programming Problem (From Problem 2.9)		
II		**Linear Programming Models: (Simplex Method)**	13	Min 15
	6	Section 3.1- Introduction, 3.2- Comparison Between Graphical and Simplex Methods		
	7	Section 3.3- Maximisation Case		
	8	Section 3.4- Minimisation Case		
	9	Section 3.5- Worked Out Problems- Maximization		
	10	Section 3.7- Minimisation Problems		
III		**Linear Programming Models: (Two Phase Simplex Method and Transportation Problem)**	11	Min 15
	11	Section 3.8- Mixed Problems		
	12	Section 3.10- Artificial Variable Method or Two Phase Method		
	13	Section 3.11- Degeneracy in Linear Programming Problems		
	14	Section 4.1 , 4.2 Transportation model		
	15	Section 4.3 – Comparison between Transportation model and general linear programming model, 4.4- Approach to solution to a transportation problem by Transportation Algorithm.		
IV		**Linear Programming Models: (Transportation Problem and Assignment Problem)**	14	
	16	Section 4.4.3- Basic feasible solution by North -West corner method		Min 15
	18	Section 4.4.4- Solution by Least Cost cell method		
	19	Section 4.4.5- Solution by Vogel's approximation method		
	20	Section 4.4.6- Optimality test- Stepping stone method (Modified distribution method is in open ended module)		
	21	Section 5.1, 5.2 – Assignment model,		
	22	Section 5.4- Approach to solution-Hungarian method(Other methods of solution are optional)		
V		**Open Ended Module**	12	
	Simplex method special Cases- Alternate solution. Unbound Solutions ,Problem with Unrestricted Variables Transportation model- Modified distribution method Game theory			

References :

1. KV Mittal and C Mohan, Optimization methods in Operations research and system analysis(3/e)

2. Kanti Swarup, PK Gupta and Manmohan, Operations Research(20/e)

Note: 1) Optional topics are exempted for end semester examination. (2) Proofs of all the results are exempted for external exam. (3) 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	3	2	3	2	3	1	2
CO 2	3	2	3	2	3	2	3	1	2
CO 3	3	2	3	2	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓