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**			
	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	Min. 15
	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	BSc Mathematics Honours			
Course Title	**MATRIX ALGEBRA AND VECTOR CALCULUS**			
Course Code	**MAT3MN203**			
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 Calculus and familiarity with Euclidian Geometry.			
Course Summary	This course covers fundamental concepts in vectors, vector calculus, and matrices. Students will explore vectors in 2-space and 3-space, including dot and cross products, as well as lines and planes in 3-space. The vector calculus portion includes vector functions, partial and directional derivatives, tangent planes, normal lines, curl, divergence, line integrals, double integrals, surface integrals, and triple integrals. Additionally, the course delves into matrix algebra, systems of linear equations, matrix rank, and the eigenvalue problem.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Discuss the geometry of Vectors in two- and three-dimensional spaces	U	C	Internal Exam/ Assignment/ Seminar/ Viva / End Sem Exam
CO2	Apply the concepts of vector functions to compute partial derivatives, directional derivatives, tangent planes, and normal lines.	Ap	C	Internal Exam/ Assignment/ Seminar/ Viva / End Sem Exam
CO3	Apply vector calculus operations and evaluate line, surface, and volume integrals.	Ap	C	Internal Exam/ Assignment/ Seminar/ Viva / End Sem Exam
CO4	Discuss the basic concepts of matrices, and evaluate the solutions of system of linear equations using matrices.	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO5	Describe the idea of eigen values and eigen vectors.	U	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: Advanced Engineering Mathematics, 6th Edition, Dennis G. Zill, Jones & Bartlett Learning LLC (2018) ISBN: 978-1-284-10590-2.				
Module	**Unit**	**Content**	**Hrs (60)**	**Ext. Marks (70)**
I	**Vectors**		**11**	**Min. 15**
	1	Section 7.1-Vectors in 2 -Space (quick review)		
	2	Section 7.2-Vectors in 3-Space (quick review)		
	3	Section 7.3- Dot Product up to and including Example 5		
	4	Section 7.4- Cross Product up to and including Example 3		
	5	Section 7.5- Lines and Planes in 3-space- upto and including Example 6		
	6	Section 7.5- Lines and Planes in 3-space- From Planes: Vector Equation onwards		
II	**Vector Calculus**		**15**	**Min. 15**
	7	Section 9.1 – Vector Functions		
	8	Section 9.4 – Partial Derivatives		
	9	Section 9.5 – Directional Derivative – upto and including Example 4.		
	10	Section 9.5 – Functions of Three Variables onwards.		
	11	Section 9.6 – Tangent Planes and Normal Lines – upto and including Example 4		
	12	Section 9.6 – Topics from Normal Line onwards		
	13	Section 9.7 – Curl and Divergence -		
III	**Vector Calculus – contd.**			
	14	Section 9.8 – Line Integrals – upto and including Example 5.		**Min. 15**

	15	Section 9.10 – Double Integrals – upto and including Example 2	**12**	
	16	Section 9.13 – Surface Integrals – upto and including Example 4		
	17	Section 9.15 – Tripple Integrals (Examples 5 and 7 are optional)		
IV	**Matrices**		**10**	**Min. 15**
	18	Section 8.1- Matrix Algebra.		
	19	Section 8.2-Systems of Linear Algebraic Equations. Up to and including Example 7		
	20	Section 8.2-Systems of Linear Algebraic Equations. From Homogeneous Systems onwards till end omit chemical equations		
	21	Section 8.3 -Rank of a Matrix.		
	22	Section 8.8-The Eigenvalue Problem.-Up to and including Example 4		
V	**Open Ended**		**12**	
		Vector Spaces, Gram- Schmidt Orthogonalization (for instance, refer sections 7.6 and 7.7) Green's Theorem, Stocke's Theorem and Divergence Theorem (for instance, refer sections 9.12, 9.14 and 9.16) Complex Eigen Values Eigen Values and Singular Matrices. Eigen Values and Eigen Vectors of inverse of A Improper Integrals,		
		References: **1.** Calculus and Analytic Geometry (9^{th} Edn), George B Thomas, Jr. and Ross L Finney, Addison -Wesley Publishing Company. 2. A Freshman Honors Course in Calculus and Analytic Geometry, Emil Artin (Author), Marvin J Greenberg (Foreword).		

		3. Advanced Engineering Mathematics (10th Edn), Erwin Kreyszig, John Wiley and Sons. 4. Improper Riemann Integrals: Ioannis M. Roussos CRC Press by Taylor & Francis Group, LLC(2014) ISBN: 978-1-4665-8808-0 (ebook -pdf)		

Note: 1) Optional topics are exempted for end semester examination. 2) Proofs of all the results are also exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	0	0	0	2	0	1
CO 2	3	0	0	0	1	0	1
CO 3	3	0	0	0	1	0	2
CO 4	3	1	0	0	2	0	2
CO 5	3	0	0	0	1	0	2

Programme	B. Sc. Mathematics Honours			
Course Code	MAT3MN204			
Course Title	**BOOLEAN ALGEBRA AND SYSTEM OF EQUATIONS**			
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	MAT1MN203 and MAT2MN203			
Course Summary	This course comprises four main modules: Lattice, Boolean Algebra, System of Equations, and Eigenvalue and Eigenvectors. Module I introduce concepts like ordered sets and lattices, while Module II explores Boolean Algebra and its applications. Module III covers linear systems of equations, including Gauss elimination and determinants. Finally, Module IV delves into Eigenvalue and Eigenvectors, offering insights into matrix properties and applications.			

Course Outcome

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the structure and properties of ordered sets and lattices.	U	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Apply the principles of Boolean algebra to simplify logical expressions and evaluate Boolean functions.	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Understand the fundamental operations on matrices	U	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO4	Solve systems of linear equations using matrix methods	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam

CO5	Apply the concept of eigenvalues and eigenvectors to solve matrix problems	Ap	P	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:

Textbook	1. Theory and Problems of Discrete mathematics (3/e), Seymour Lipschutz, Marc Lipson, Schaum's Outline Series. 2. Advanced Engineering Mathematics (10/e), Erwin Kreyzsig, Wiley India.			
Module	**Unit**	**Content**	Hrs (48 +12)	**Ext. Marks (70)**
I		**Lattice (Text 1)**	12	Min 15
	1	14.2 Ordered set		
	2	14.3 Hasse diagrams of partially ordered sets		
	3	14.5 Supremum and Infimum		
	4	14.8 Lattices		
	5	14.9 Bounded lattices, 14.10 Distributive lattices		
	6	14.11 Complements, Complemented lattices		
II		**Boolean Algebra (Text 1)**	10	Min 15
	7	15.2 Basic definitions		
	8	15.3 Duality		
	9	15.4 Basic theorems		
	10	15.5 Boolean algebra as lattices		
	11	15.8 Sum and Product form for Boolean algebras		

	12	15.8 Sum and Product form for Boolean algebras - Complete Sum and Product forms		
III	**System of Equations (Text 2)**		14	Min 15
	13	7.1 Matrices, Vectors: Addition and Scalar Multiplication		
	14	7.2 Matrix Multiplication (Example 13 is optional)		
	15	7.3 Linear System of Equations- Gauss Elimination		
	16	7.4 Linear Independence- Rank of a matrix- Vector Space (Proof Theorem 3 is optional)		
	17	7.5 Solutions of Linear Systems- Existence, Uniqueness (Proof of Theorem 1, Theorem 2 and Theorem 4 are optional)		
IV	**Eigen Value and Eigen Vectors (Text 2)**		12	Min 15
	18	7.6 Second and Third Order Determinants- up to and including Example 1		
	19	7.6 Second and Third Order Determinants- Third order determinants		
	20	7.7 Determinants- Cramer's Rule (Proof of Theorem 1, Theorem 2, Theorem 3 and Theorem 4 are optional)		
	21	7.8 Inverse of a Matrix- Gauss- Jordan Elimination (Proof Theorem 1, Theorem 2, Theorem 3 and Theorem 4 are optional)		
	22	8.1 The Matrix Eigenvalue Problem- Determining Eigenvalues and Eigenvectors (Proof of Theorem 1 and Theorem 2 are optional)		
V	Open Ended Module		12	
	Relation on a set, Equivalence relation and partition, Well- ordered sets, Representation theorem of Boolean algebra, Logic gates, Symmetric, Skew-symmetric and Orthogonal matrices.			

References:

1. Howard Anton & Chris Rorres, Elementary Linear Algebra: Application (11/e) : Wiley

2. Ron Larson, Edwards, David C Falvo : Elementary Linear Algebra (6/e), Houghton Mi_in

Harcourt Publishing Company (2009)

3. Thomas Koshy - Discrete Mathematics with Applications-Academic Press (2003)

4. George Gratzer, Lattice theory: First concepts and distributive lattices. Courier Corporation (2009)

Note: 1) Optional topics are exempted for end semester examination. 2) Proofs of all the results are also exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	0	0	0	3	1	2
CO 2	3	0	1	2	3	0	1
CO 3	3	0	0	1	3	0	1
CO 4	3	0	1	1	3	0	1
CO 5	3	0	0	1	3	0	2

Programme	B. Sc. Mathematics Honours			
Course Code	MAT3FV109(2)			
Course Title	**COMPUTATIONAL LOGIC**			
Type of Course	**VAC**			
Semester	III			
Academic Level	200-299			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	3	3	-	45
Pre-requisites	Nil			
Course Summary	The course will cover the basics of propositional and predicate logic, Compactness, and the Resolution Theory.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category #	Evaluation Tools used
CO1	Determine the satisfiability and validity of propositional formulas and apply equivalence transformations and normal forms.	Ap	C	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
CO2	Analyze the syntax and semantics of predicate logic, including the concepts of structures, models, satisfiability, and validity.	Ap	C	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
CO3	Apply Herbrand's Theorem to analyze the satisfiability of predicate logic formulas.	Ap	C	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam

CO4	Utilize the resolution theorem and unification algorithm to prove the validity of predicate logic formulas.	Ap	C	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
CO5	Explain the principles of logic programming and apply SLD resolution to evaluate Horn clause programs.	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	**Logic for Computer Scientists, U. Schoning, Birkhauser, 2008 (Reprint).**			
Module	**Unit**	**Content**	**Hrs (45 = 36 +9)**	**Ext. Marks (50)**
I	**Propositional Logic (Chapter 1 of Text Book).**		**10**	**Min 10**
	1	Syntax and Semantics, Truth Tables, Satisfiability and Validity.		
	2	Equivalence and Normal Forms, Substitution Theorem		
	3	DNF and CNF forms		
	4	Horn Formulas,		
	5	Compactness Theorem for Propositional Calculus		
	6	Resolution Theorem and Resolution Algorithm		

II	**Introduction to Predicate Logic: Section 2.1, 2.2,** Subsection on Mathematical Theories of Section 2.3		**9**	**Min 10**
	7	Syntax of Predicate Logic		
	8	Semantics - Structures and Models, Satisfiability and Validity		
	9	Equivalence of formulas - Substitution, Variable Renaming.		
	10	Skolem Normal Form		
	11	Mathematical Theories - Axioms and Models.		
III	**Herbrand Theory for Predicate Logic: Section 2.4**		**9**	**Min 10**
	12	Herbrand Universe and Structures		
	13	Herbrand Model and Satisfiability Theorem		
	14	Skolem Lowenheim Theorem		
	15	Herbrand Expansion and Godel-Herbrand-Skolem Theorem		
	16	Compactness and Herbrand's Theorem		
IV	**Resolution for Predicate Logic: Section 2.5**		**8**	**Min 10**
	17	Ground Resolution and Resolvants		
	18	Ground Resolution Theorem		
	19	Robinson's Unification Theorem and Algorithm		

	20	Lifting Lemma		
	21	Resolution Theorem for Predicate Logic		
V	**Logic Programming**		**9**	
	1	Unsolvability of Predicate Logic (Section 2.3 on Text Book)		
	2	SLD Resolution (Section 2.6 of Text Book)		
	3	Introduction to Logic Programming		
	4	Horn Clause Programs		
	5	Evaluation Strategies for Horn Clause Programs.		

References:

1. J. H. Gallier, Logic for Computer Science - Foundations of Automatic Theorem Proving, Dower, 2015.
2. S. Reeves, M Clarke, Logic for Computer Science, Addition Wesley, 1990. coding

Mapping of COs with PSOs and POs :

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