FACULTY OF SCIENCE AND HUMANITIES

ACADEMIC CURRICULA

POSTGRADUATE DEGREE PROGRAMME
(REGULATIONS - 2025)

MASTER OF SCIENCE
IN
MATHEMATICS

Two Years (Full-Time)

National Education Policy

Learning Outcomes based Curriculum Framework (LOCF)

National Credit Framework

Academic Year
2025 - 2026

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

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1.	Department Vision Statement
Stmt - 1	*To impart education and disseminate knowledge with high standards in Mathematics, Engineering and Technology in our academic pursuit.*
Stmt - 2	*To emerge as a world class hub of research that creates a center of excellence in mathematics.*
Stmt - 3	*To develop mathematical thinking and applying it to solve problems, designing mathematical modeling for systems involving global level technology.*

2.	Department Mission Statement
Stmt - 1	*To upgrade the student's knowledge to meet the academic changes.*
Stmt - 2	*To equip the students with the necessary mathematical tools to meet the competitive global environment.*
Stmt - 3	*To provide an environment where students can learn and become competent users of mathematics and its applications.*
Stmt - 4	*To enable students pursue more advanced study in pure mathematics, applied mathematics and related areas.*
Stmt - 5	*To develop the students for professional careers in disciplines which make use of the mathematical sciences.*

3.	Program Education Objectives (PEO)
PEO - 1	*Acquire and apply appropriate methods and techniques to extract relevant and important information from Mathematical Sciences*
PEO - 2	*Adapt easily to utilize the mathematical problem solving methods in addressing the practical issues*
PEO - 3	*Conduct research in advanced mathematics, application of mathematical techniques to science and technology and other fields.*
PEO - 4	*Re-equip knowledge, skills, self-confidence and self-awareness actively to pursue their future goals.*
PEO - 5	*Competent with attitude of lifelong learning and skills with ethical and social behavior.*

4. Consistency of PEO's with Mission of the Department					
	Mission Stmt. - 1	Mission Stmt. - 2	Mission Stmt. - 3	Mission Stmt. - 4	Mission Stmt. - 5
PEO - 1	3	3	3	2	2
PEO - 2	3	3	3	2	2
PEO - 3	3	2	3	3	3
PEO - 4	3	3	3	2	3
PEO - 5	3	3	3	3	2

5. Consistency of PEO's with Program Learning Outcomes (PO)												
	Program Learning Outcomes (PO)											
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
PEO - 1	3	3	2	2	2	-	-	-	3	-	-	3
PEO - 2	3	3	2	2	2	-	-	-	3	-	-	3
PEO - 3	3	3	2	2	3	-	-	-	3	-	-	3
PEO - 4	3	3	2	2	2	-	-	-	3	-	-	3
PEO - 5	3	3	2	2	3	-	-	-	3	-	-	3

3 – High Correlation, 2 – Medium Correlation, 1 – Low Correlation

6. Programme Structure (Total Credits : 80 Credits)

1. Professional Core Courses (C)
(10 Courses)

Course Code	Course Title	Hours/ Week L	T	P	C
PMA25101T	Real Analysis	3	1	0	4
PMA25102T	Linear Algebra	3	1	0	4
PMA25103T	Ordinary Differential Equations	3	1	0	4
PMA25104T	Probability Theory and Statistics	3	1	0	4
PMA25205T	Algebra	3	1	0	4
PMA25206T	Complex Analysis	3	1	0	4
PMA25207T	Partial Differential Equations	3	1	0	4
PMA25208T	Topology	3	1	0	4
PMA25309T	Functional Analysis	3	1	0	4
PMA25310T	Calculus of Variations and Mechanics	3	1	0	4
Total Learning Credits					**40**

2. Discipline Elective Courses (D)
(3 Courses)

Course Code	Course Title	Hours/ Week L	T	P	C
PMA25D01T	Advanced Optimization Techniques	3	1	0	4
PMA25D02T	Multivariate Calculus				
PMA25D03J	Introduction to Statistical Learning	3	0	2	
PMA25D04T	Fuzzy Sets and Applications	3	1	0	4
PMA25D05T	Formal Languages and Automata Theory				
PMA25D06J	Introduction to Mathematical Finance	3	0	2	
PMA25D07T	Graph Theory and Algorithms	3	1	0	4
PMA25D08T	Fluid Dynamics				
PMA25D09J	Mathematical Modelling and Simulation	3	0	2	
Total Learning Credits					**12**

3. Generic Elective Courses (G)
(1 Course)

Course Code	Course Title	Hours/ Week L	T	P	C
PCY25G02T	Chemistry of Biomolecules	3	1	0	4
PMA25G01T	Mathematics for Artificial Intelligence				
PMA25G02T	Mathematics for Physicists				
PMA25G03T	Multivariate Analysis and Non-Parametric Test				
PMA25G04T	Research Methodology				
PMA25G05T	Neural Networks, Fuzzy Systems and Evolutionary Mathematics				
PMA25G06T	Data Structures and Algorithms				
Total Learning Credits					**4**

4. Skill Enhancement Courses (S)
(3 Courses)

Course Code	Course Title	Hours/ Week L	T	P	C
PMA25S01J	Scientific Programming using Scilab	1	0	4	3
PMA25S02J	Foundation of R for Mathematical Computing	2	0	2	
PMA25S03J	Scientific Programming using Python	2	0	2	3
PMA25S04L	Machine Learning	0	0	4	2
Total Learning Credits					**8**

5. Project Work, Internship in Industry/Higher Technical Institutions (P)
(2 Courses)

Course Code	Course Title	Hours/ Week L	T	P	C
PMA25P01L	Internship	0	0	0	2
PMA25P02L	Project Work	0	0	20	10
Total Learning Credits					**12**

6. Ability Enhancement Courses (AE)
(2 Courses)

Course Code	Course Title	Hours/ Week L	T	P	C
PCD25AE1T	Comprehensive Skills in Quantitative and Logical Reasoning	2	0	0	2
PCD25AE2T	Soft Skills and Verbal Mastery	2	0	0	2
Total Learning Credits					**4**

7. Implementation Plan

Semester - I					
Code	Course Title	Hours/ Week			C
		L	T	P	
PMA25101T	Real Analysis	3	1	0	4
PMA25102T	Linear Algebra	3	1	0	4
PMA25103T	Ordinary Differential Equations	3	1	0	4
PMA25104T	Probability Theory and Statistics	3	1	0	4
PMA25S01J	Scientific Programming using Scilab	1	0	4	3
PMA25S02J	Foundation of R for Mathematical Computing	2	0	2	
PCD25AE1T	Comprehensive Skills in Quantitative and Logical Reasoning	2	0	0	2
	Total	23			21

Semester - II					
Code	Course Title	Hours/ Week			C
		L	T	P	
PMA25205T	Algebra	3	1	0	4
PMA25206T	Complex Analysis	3	1	0	4
PMA25207T	Partial Differential Equations	3	1	0	4
PMA25208T	Topology	3	1	0	4
PMA25D01T	Advanced Optimization Techniques	3	1	0	4
PMA25D02T	Multivariate Calculus				
PMA25D03J	Introduction to Statistical Learning	3	0	2	
PMA25S03J	Scientific Programming using Python	2	0	2	3
PCD25AE2T	Soft Skills and Verbal Mastery	2	0	0	2
	Total	27			25

Semester - III					
Code	Course Title	Hours/ Week			C
		L	T	P	
PMA25309T	Functional Analysis	3	1	0	4
PMA25310T	Calculus of Variations and Mechanics	3	1	0	4
PMA25D04T	Fuzzy Sets and Applications	3	1	0	4
PMA25D05T	Formal Languages and Automata Theory				
PMA25D06J	Introduction to Mathematical Finance	3	0	2	
PMA25D07T	Graph Theory and Algorithms	3	1	0	4
PMA25D08T	Fluid Dynamics				
PMA25D09J	Mathematical Modelling and Simulation	3	0	2	
PCY25G02T	Chemistry of Biomolecules	3	1	0	4
PMA25G01T	Mathematics for Artificial Intelligence				
PMA25G02T	Mathematics for Physicists				
PMA25G03T	Multivariate Analysis and Non-Parametric Test				
PMA25G04T	Research Methodology				
PMA25G05T	Neural Networks, Fuzzy Systems and Evolutionary Mathematics				
PMA25G06T	Data Structures and Algorithms				
PMA25S04L	Machine Learning	0	0	4	2
PMA25P01L	Internship	0	0	0	2
	Total	26			24

Semester - IV					
Code	Course Title	Hours/ Week			C
		L	T	P	
PMA25P02L	Project Work	0	0	20	10
	Total	20			10

Total Number of Subjects: 21
Total Number of Credits: 80

8. Program Articulation Matrix

Course Code	Course Title	Programme Learning Outcomes (PO)											
		Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
PMA25101T	*Real Analysis*	3	3	2	3	-	-	-	-	2	-	-	3
PMA25102T	*Linear Algebra*	3	3	2	2	-	-	-	-	3	-	-	3
PMA25103T	*Ordinary Differential Equations*	3	3	2	2	-	-	-	-	3	-	-	3
PMA25104T	*Probability Theory and Statistics*	3	3	2	2	-	-	-	-	3	-	-	3
PMA25205T	*Algebra*	3	3	2	2	-	-	-	-	3	-	-	3
PMA25206T	*Complex Analysis*	3	3	2	2	-	-	-	-	3	-	-	3
PMA25207T	*Partial Differential Equations*	3	3	2	2	-	-	-	-	3	-	-	3
PMA25208T	*Topology*	3	3	2	2	-	-	-	-	3	-	-	3
PMA25309T	*Functional Analysis*	3	3	2	2	-	-	-	-	3	-	-	2
PMA25310T	*Calculus of Variations and Mechanics*	3	3	2	2	-	-	-	-	3	-	-	2
PMA25D01T	*Advanced Optimization Techniques*	3	3	2	2	2	-	-	-	3	-	-	3
PMA25D02T	*Multivariate Calculus*	3	3	2	2	2	-	-	-	3	-	-	3
PMA25D03J	*Introduction to Statistical Learning*	3	3	2	2	2	-	-	-	3	-	-	3
PMA25D04T	*Fuzzy Sets and Applications*	3	3	2	2	2	-	-	-	3	-	-	3
PMA25D05T	*Formal Languages and Automata Theory*	3	3	2	2	2	-	-	-	3	-	-	3
PMA25D06J	*Introduction to Mathematical Finance*	3	3	2	2	2	-	-	-	3	-	-	3
PMA25D07T	*Graph Theory and Algorithms*	3	3	2	2	2	-	-	-	3	-	-	3
PMA25D08T	*Fluid Dynamics*	3	3	2	2	2	-	-	-	3	-	-	2
PMA25D09J	*Mathematical Modelling and Simulation*	3	3	2	2	2	-	-	-	3	-	-	3
PCY25G02T	*Chemistry of Biomolecules*	3	3	3	3	3	-	-	-	-	-	-	3
PMA25G01T	*Mathematics for Artificial Intelligence*	3	3	2	2	3	-	-	-	3	-	-	3
PMA25G02T	*Mathematics for Physicists*	3	3	2	2	2	-	-	-	3	-	-	3
PMA25G03T	*Multivariate Analysis and Non-Parametric Test*	3	3	2	2	2	-	-		3	-	-	3
PMA25G04T	*Research Methodology*	3	3	2	2	2	-	-	-	3	-	-	3
PMA25G05T	*Neural Networks, Fuzzy Systems and Evolutionary Mathematics*	3	3	2	2	2	-	-		3	-	-	3
PMA25G06T	*Data Structures and Algorithms*	3	3	2	2	2	-	-	-	3	-	-	3
PMA25S01J	*Scientific Programming using Scilab*	3	3	2	2	3	-	-	-	3	-	-	3
PMA25S02J	*Foundation of R for Mathematical Computing*	3	3	2	2	3	-	-	-	3	-	-	3
PMA25S03J	*Scientific Programming using Python*	3	3	2	2	3	-	-	-	3	-	-	3
PMA25S04L	*Machine Learning*	3	3	2	2	3	-	-	-	3	-	-	3
PCD25AE1T	*Comprehensive Skills in Quantitative and Logical Reasoning*	3	3	2	2	-	-	-	-	3	-	-	-
PCD25AE2T	*Soft Skills and Verbal Mastery*	1	3	2	-	2	2	-	-	3	3	2	2
PMA25P01L	*Internship*	3	2	2	3	3	-	-	-	3	-	-	3
PMA25P02L	*Project Work*	3	3	2	3	3	-	-	-	2	-	-	3
	Program Average	3	3	2	2	2	2	-	-	3	3	2	3

9. Course Structure

Semester	Professional Core Courses (PCC)	Discipline Elective Courses (DEC)	Generic Elective Courses (GEC)	Skill Enhancement Courses (SEC)	Project Work, Internship in Industry/Higher Technical Institutions (P)	Ability Enhancement Courses (AEC)	Total Credits	Total Hours
Sem I	PCC-1(4) PCC-2 (4) PCC-3(4) PCC-4(4)			SEC 1 (3)		AEC 1 (2)	**21**	**23**
Sem II	PCC-5 (4) PCC-6 (4) PCC-7(4) PCC-8(4)	DEC-1 (4)		SEC 2 (3)		AEC 2 (2)	**25**	**27**
Sem III	PCC-9(4) PCC-10(4)	DEC-2(4) DEC-3(4)	GEC-1(4)	SEC 3 (2)	Internship (2)		**24**	**26**
Sem IV					P (10)		**10**	**20**
Total Credits	**40**	**12**	**4**	**8**	**12**	**4**	**80**	**96**

Semester-1
C1

Code	PMA25101T	Title	Real Analysis	Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	Nil

Rationale (CR)	The purpose of learning this course is to:
CR-1	Recall on the importance of real number system and review on preliminaries
CR-2	Learn about differentiation on real numbers and functions
CR-3	Know about the need of Riemann-Stieltjes integral in relation to Riemann integral.
CR-4	Apply various test for uniform convergence of sequence and series of functions.
CR-5	Test the measurability of sets and functions.

Outcomes (CO)	At the end of this course, learners will be able to:	Depth				Attainment		
		1 Conceive	2 Design	3 Implement	4 Operate	1 Level of Thinking	2 Expected Proficiency (%)	3 Expected Attainment (%)
CO-1	Understand the completeness of real number system	✓				3	85	75
CO-2	Determine extreme values of real differentiable functions	✓	✓	✓		3	85	75
CO-3	Apply Riemann-Stieltjes integration wherever Riemann integration is not feasible.		✓			3	85	75
CO-4	Apply uniform convergence in problems related to integration and differentiation	✓	✓	✓	✓	3	85	75
CO-5	Test the measurability of sets and functions.	✓	✓			3	85	75

Program Outcomes (PO)												
1 Disciplinary Knowledge	2 Problem Solving	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethical practices & Social	9 Individual & Team Work	10 Communication	11 Project Management & Finance	12 Life Long Learning
3	3	2	3	-	-	-	-	2	-	-	3
3	3	-	3	-	-	-	-	-	-	-	-
3	3	-	3	-	-	-	-	-	-	-	-
3	3	-	3	-	-	-	-	2	-	-	3
3	3	3	3	-	-	-	-	2	-	-	3

Title & Session Outcomes	*The Real Numbers*	*Differentiability of functions*	*The Riemann-Stieltjes Integral*	*Sequences of Functions*	*Measure Theory.*
Duration (hour)	**12**	**12**	**12**	**12**	**12**
SO-1	*Introduction and Review on real number system, Set operations, functions*	*Differentiability of functions – introduction, Algebra of differentiable functions*	*Introduction and motivation for the Riemann-Stieltjes integral*	*Introduction to sequence and series of functions with illustrative examples.*	*Measure on the real line. Illustrative examples.*
SO-2	*Algebraic properties of R, Order properties of R*	*Characterization of differentiability*	*RS-integral as a generalization to the R-integral, with necessary examples.*	*Pointwise convergence of sequence of functions. Definition and examples.*	*Lebesgue outer measure. Illustrative examples.*

SO-3	*Law of trichotomy, Completeness property of R*	*Chain rule, Rolle's Theorem*	*Partitions, Lower and upper Riemann-Stieltjes sums.*	*Uniform convergence of sequence of functions. Definition and examples.*	*Measurable sets. Illustrative examples.*
SO-4	*Tutorial: Examples of Law of trichotomy, Completeness property of R*	*Tutorial: Examples on Chain rule, Rolle's Theorem*	*Tutorial: Algebra of RS-integrable functions.*	*Tutorial: Pointwise convergence and Uniform convergence-Worked out examples.*	*Tutorial: Examples on Measurable sets. Lebesgue outer measure*
SO-5	*Q is dense in R; existence of irrational numbers between rational numbers*	*Cauchy mean value theorem*	*Lower and upper Riemann-Stieltjes integral. Its properties*	*Necessary and sufficient condition for Uniform convergence. Worked out examples.*	*Regularity. Its properties and illustrative examples.*
SO-6	*Q is countable*	*Darboux theorem*	*Refinement of partitions - Examples*	*Cauchy criterion of Uniform convergence. Illustrative examples*	*Measurable functions. Illustrative examples.* *Worked out theorems.*
SO-7	*R is uncountable*	*L'Hospital rules*	*A condition of integrability, Algebra of RS-integrable functions.*	*Dini's criterion for uniform convergence of a sequence of continuous functions.*	*Sets of measure zero .Algebra of measurable functions.*
SO-8	*Tutorial: Examples on countable and uncountable*	*Tutorial:: Examples on Cauchy mean value theorem and L'Hospital rules*	*Tutorial:: Some important deductions, Worked out examples RS Integral*	*Tutorial:: Tests for uniform convergence. Examples.*	*Tutorial:: Worked out theorems and practice problems.*
SO-9	*Sequence and limits, Limit theorems*	*Taylor's theorem*	*Relation between R-integral and RS-integral*	*Uniform convergence and continuity, Uniform convergence and integration.*	*Borel sets , Boral measurability. Illustrative examples*
SO-10	*Infinite series and nth term test*	*Taylor's theorem: Cauchy form of the remainder*	*Introduction to RS-integral and differentiation. Mean value theorem for integrals.*	*The Weierstrass approximation theorem.*	*Lebesgue measurability. Illustrative examples.*
SO-11	*Cauchy criterion for series, Comparison Test and its Limit form,Root, Ratio and Raabe's tests*	*Convex function, Derivative test of convexity, Taylor's theorem: Cauchy form of the remainder*	*First fundamental theorem of calculus, Second fundamental theorem of calculus*	*Series of functions. Pointwise and uniform convergence. Cauchy criteria for uniform convergence of series of functions.*	*Hausdorff measure. Illustrative examples.*
SO-12	*Tutorial: Problems on Cauchy criterion for series, Comparison Test and its Limit form,Root, Ratio and Raabe's tests*	*Tutorial: Illustration of Taylor's approximation, Examples on convexity*	*Tutorial:: Some methods of integration.*	*Tutorial:: Uniform convergence and continuity and Integration*	*Tutorial:: Worked out problems*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
2	Understand										
3	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
4	Analyze										
5	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
6	Create										
Total		100 %		100 %		100 %		100 %		100 %	

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Resources			
1	*Robert G. Bartle, Donald R. Sherbert, Introduction to real Analysis (4th Edition), John Wiley & Sons., 2018.*	*2*	*Ajit Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014*
3	*Walter Rudin, Principles of Mathematical Analysis, McGraw-Hill, Reprint 2017.*	*4*	*S C Malik, Savitha Arora, Mathematical Analysis, (5th Edition) New Age International Publishers, 2017*
5	*Murray H. Protter Basic Elements of Real Analysis, Springer, 1998.*	*6*	*Stephen Abbott, Understanding Analysis, Springer, 2012.*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	*1*	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	*1*	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
		2		*2*	*Dr. K. Suja, SRMIST, sujak@srmist.edu.in*

C2

Code	PMA25102T	Title	Linear Algebra	Category	C	*Professional Core Course*	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXX

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Understand the foundational concepts of vector spaces and their applications in mathematical problem-solving.*
CR-2	*Explore the significance of linear transformations and matrix representations in diverse fields.*
CR-3	*Analyze eigenvalues and eigenvectors to study the behavior of linear operators.*
CR-4	*Investigate decomposition theorems and their role in simplifying complex mathematical structures.*
CR-5	*Develop a comprehensive understanding of inner product spaces and their use in orthogonality and optimization.*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Depth				Attainment			Program Outcomes (PO)											
		1 Conceive	2 Design	3 Implement	4 Operate	1 Level of Thinking	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Disciplinary Knowledge	2 Problem Solving	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethical practices & Social Responsibility	9 Individual & Team Work	10 Communication	11 Project Management & Finance	12 Life Long Learning
CO-1	*Apply the principles of vector spaces to solve systems of linear equations effectively.*	✓				*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-2	*Demonstrate proficiency in representing and manipulating linear transformations.*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-3	*Solve problems involving eigenvalues, eigenvectors, and their applications in real-world contexts.*		✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-4	*Implement decomposition methods like Jordan and cyclic decomposition for advanced mathematical tasks.*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-5	*Utilize inner product spaces and orthogonalization techniques in theoretical and applied scenarios.*	✓	✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3

Title & Session Outcomes	*Vector Spaces*	*Linear Transformations*	*Elementary Canonical Forms*	*Rational and Jordan Forms*	*Inner Product Spaces*
Duration (hour)	12	12	12	12	12
SO-1	*Vector spaces*	*Linear transformations*	*Eigen values – Characteristic roots*	*Primary decomposition theorem.*	*Inner product spaces*
SO-2	*Subspaces*	*Null spaces and Ranges*	*Eigen values – Characteristic vectors*	*ND decomposition*	*Gram-Schmidt Orthogonalization process*
SO-3	*Linear combinations*	*Matrix representation of Linear Transformation*	*Annihilating polynomials*	*Cyclic subspaces*	*The adjoint of linear operator*

SO-4	*Tutorial: Problems on Vector spaces, subspaces and linear combinations*	*Tutorial: Problems on Linear Transformations, null spaces and ranges.*	*Tutorial: Problems on Eigen Values, Eigen Vectors and Annihilating polynomials*	*Tutorial: Problems on decomposition and Cyclic subspaces*	*Tutorial: Problems on Inner Product spaces, Gram-Schmidt Orthogonalization process, adjoint of linear operator*
SO-5	*Systems of linear equations*	*Composition of Linear Transformation*	*Invariant subspaces*	*Cyclic decomposition*	*Normal and self-adjoint operator*
SO-6	*Linearly dependence*	*Isomorphism*	*Simultaneous triangulation*	*Cyclic decomposition theorem*	*Normal and self-adjoint operator*
SO-7	*Linearly independence*	*Linear functionals*	*Simultaneous diagonalisation*	*Cyclic decomposition theorem*	*Linear fuctionals*
SO-8	*Tutorial: Problems on systems of linear equations, linearly dependence and linearly independence*	*Tutorial: Problems on Composition of Linear Transformation, Isomorphism and linear functionals*	*Tutorial: Problems on Invariant subspaces, Simultaneous triangulation and Simultaneous diagonalisation*	*Tutorial: Problems on Cyclic decomposition*	*Tutorial: Problems on Normal and self-adjoint operator and Linear functionals*
SO-9	*Bases*	*Annihilator*	*direct-sum decompositions*	*Corollaries of CDT*	*Unitary operator*
SO-10	*Dimension*	*Double dual*	*Projection*	*Rational - canonical form*	*Orthogonal operator*
SO-11	*Theorems related to finite dim.*	*Transpose of a linear transformation*	*invariant direct sums*	*Jordan-canonical form*	*Spectral theorem*
SO-12	*Tutorial: Problems on Bases, Dimension*	*Tutorial: Problems on Annihilator, Double Dual and Transpose of linear transformations*	*Tutorial: Problems on direct-sum decompositions, Projections and invariant direct sums*	*Tutorial: Problems on Rational-canonical form and Jordan-canonical form*	*Tutorial: Problems on Unitary operator, Orthogonal and Spectral theorem*

Assessment

Level of Thinking		**Continuous Learning Assessment (CLA)** (50 % weightage)								**Final Exam** (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
2	Understand										
3	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
4	Analyze										
5	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
6	Create										
Total		100 %		100 %		100 %		100 %		100 %	

Strategies

Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Resources			
1	K. Hoffman and R. Kunze, Linear Algebra, 2ndEd. Prentice Hall of India, 2005	2	S. H.Friedberg, A. N. Insel and L. W. Spence Linear Algebra 4thED., Pearson 2015.
3	G.Strang, Introduction to Linear Algebra, Wellesley-Cambridge Press, 1993.	4	https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/video_galleries/video-lectures/
5	S. Lang,Linear Algebra, Springer Undergraduate Texts in Mathematics, 1989.	6	https://archive.nptel.ac.in/courses/111/106/111106135/

Designers					
Professional Experts		Higher Institution Experts		Internal Experts	
1	Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com	1	Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in	1	Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in
2		2		2	Dr. R. Venkatesan, SRMIST, venkater1@srmist.edu.in

C3

Code	PMA25103T	Title	Ordinary Differential Equations	Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXX

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Learn about existence and uniqueness of solutions.*
CR-2	*Understand about second order differential equation.*
CR-3	*Gain knowledge about general solution of homogeneous equations.*
CR-4	*Learn about boundary value problems, sturm-liouville problems*
CR-5	*Understand about bessel functions and its properties.*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Depth				Attainment			Program Outcomes (PO)												
		1 Conceive	2 Design	3 Implement	4 Operate	1 Level of Thinking	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Disciplinary Knowledge	2 Problem Solving	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethical practices & Social Responsibility	9 Individual & Team Work	10 Communication	11 Project Management & Finance	12 Life Long Learning
CO-1	*Derive problems in first order ordinary differential equations*	✓				*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-2	*Derive problems in second order ordinary differential equation with constant and variable coefficients*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-3	*Solve problems in method of variation of parameters*		✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-4	*Derive and solve problems in series solutions*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-5	*Solve problems in eigen values and eigen vectors*	✓	✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3

Title & Session Outcomes	***Second Order Differential Equations***	***Boundary Value Problems***	***Series Solutions and Bessel Functions***	***Legendre's Equation and System of Differential Equations***	***Laplace Transform and Applications***
Duration (hour)	**12**	**12**	**12**	**12**	**12**
SO-1	*Method of Successive Approximations* *Problems based on Successive Approximations*	*Boundary value problems* *Introduction of Boundary value problems*	*Review of Beta and Gamma Function* *Review of Beta and Gamma Function*	*Legendre's Equation,* *Rodrigue's Formula* *Legendre's Polynomials*	*Laplace transform: Introduction of Laplace transform, Laplace transforms of standard functions and properties*
SO-2	*Lipchitz condition* *Convergence of Successive Approximations*	***Sturm comparison theorem*** ***Problems based on Sturm Comparison Theorem***	***Series Solutions*** *Background Knowledge Concerning Power Series*	*Generating Function For $P_n(x)$* *Recurrence relation for $P_n(x)$*	*Differentiation and integration of transforms*

SO-3	*Picard's Theorem*	*Application of Sturm comparison theorem* *Sturm separation Theorem*	*Series Solution of first order equations* *Analytic Equations*	*Orthogonality of Legendre`s Polynomials* *Problems on Legendre's polynomials*	*Inverse Laplace transforms* *properties*
SO-4	*Tutorial session: Problems on Method of Successive Approximations, Lipchitz condition and Picard's Theorem*	*Tutorial session: Boundary value problems and Sturm comparison theorem*	*Tutorial session:* *Series solution of 2nd order equations*	*Tutorial session: Problems on Legendre's polynomials*	*Tutorial session: Convolution theorem*
SO-5	*Problems based on Picard's Theorem* *Second Order Linear Equations*	*Application of Sturm Separation Theorem*	*ordinary points and Regular singular points* *Gauss's Hypergeometric Equations*	*System of Differential Equations* *Dependence on Initial Conditions and Parameters*	*Initial and final values theorems*
SO-6	*Existence and Uniqueness Theorem for Linear First Order ODE's*	*Sturm Oscillation Theorem* *Problems on Sturm Oscillation Theorem*	*Frobenius series solutions*	*Asymptotic Behaviour of Linear and Nonlinear Systems* *Concepts of Stability*	*Laplace transforms of periodic functions*
SO-7	*Second order ODE* *Solution of Homogeneous equation,* *Second order ODE* *Solution of non- Homogeneous equation*	*Sturm-Liouville problems and its Applications, Green's function*	*Power series solution - Bessel's Function, Introduction to Bessel's Function*	*Stability of Linear Systems, Stability of Nonlinear Systems* *Nonlinear Variation of Constants, Dichotomies, Lyapunov's Direct Method for Autonomous Systems*	*Heaviside unit step function*
SO-8	*Tutorial session: Problems on Second Order Linear Equations*	*Tutorial session : Problems on Sturm Oscillation Theorem and Green's function*	*Tutorial session: Problems on Bessel's Function and Frobenius series solutions*	*Tutorial session* *Lyapunov's Direct Method for Non-Autonomous Systems*	*Tutorial session : Problems on Initial and final values theorems, Laplace transforms of periodic functions and Heaviside unit step function*
SO-9	*Homogeneous equations of Legendre's and Euler* *Non-Homogeneous Equations*	*Abel's Theorem* *Problems on Abel's Theorem*	*Recurrence relation of Bessel's Function* *Generating Function for Bessel's Function*	*Stability of Discrete Models in Population Dynamics* *Eigen Vector method of finding solutions*	*Dirac-delta function*
SO-10	*Wronskian* *Wronskian*	*Reduction of Order* *Conservation of Energy*	*Properties of Bessel's function*	*Problems on Eigen vector*	*Solution of ordinary differential equations.*

SO-11	*Problems based on Wronskian* *Method of undetermined co-efficient*	*Euler equidimensional equation* *Riccati's Equation*	*Equations Reducible to Bessel's function* *Orthogonality of Bessel's function*	*Complex Eigen values*	*Solution of Simultaneous ordinary differential equations*
SO-12	*Tutorial session: Wronskian* *Method of undetermined co-efficient*	*Tutorial session : Problems on Euler equidimensional equation ,Riccati's Equation*	*Tutorial session: Problems on Orthogonality of Bessel's function*	*Tutorial session: Problems on complex Eigen values and* *Equal Eigen Values*	*Tutorial session: Problems on Solution of ordinary differential equations.* *and Solution of Simultaneous ordinary differential equations*

Assessment

Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
2	Understand										
3	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
4	Analyze										
5	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
6	Create										
Total		100 %		100 %		100 %		100 %		100 %	

Strategies

Technology		Pedagogy / Andragogy		Sustainable Development	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Resources

1	*E.A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, McGraw-Hill, 1955.*	*2*	*G. Birkhoff and G.-C. Rota, Ordinary Differential Equations, 4th Ed., John Willey and Sons, 1989.*
3	*G.F. Simmons, Differential Equations with Applications and Historical Notes, 2ndEd, McGraw- Hill, 1991.*	*4*	*R.P. Agarwal and D. O'Regan, An Introduction to Ordinary Differential Equations, Springer- Verlag, 2008*
5	*M. Braun, Differential Equations and Their Applications, 3rd Ed., Springer-Verlag, 1983*	*6*	*S. G. Deo, V. Raghavendra, R. Kar and V. Lakshmikantham, Textbook of Ordinary Differential Equations, 3rd Ed., McGraw Hill Education, 2015.*

Designers

Professional Experts		Higher Institution Experts		Internal Experts	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	*1*	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	*1*	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
2		*2*		*2*	*Dr. E.P. Siva, SRMIST, sivae@srmist.edu.in*

C4

Code	PMA25104T	Title	Probability Theory and Statistics	Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Apply the basic rules and theorems of probability*
CR-2	*Appropriately choose, define and/or derive probability special distributions such as Binomial, Poisson and Normal , Beta, Gama distribution etc*
CR-3	*Understanding the concept and applications of sampling techniques and apply in real life problems*
CR-4	*Identify parameter estimation using mini max estimation and maxi min estimation*
CR-5	*Use statistical methodology and tools in reliability complex problems*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Depth				Attainment			Program Outcomes (PO)											
		Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
CO-1	*To motivate the students to address the relevance of relevance of probability concepts using real time problems and Understand the basic concepts of RV*	✓				*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-2	*To analyses distributions and relationship of real data*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-3	*Gain familiarity in deriving probability distributions such as the Binomial, Poisson and Normal distributions etc and apply them in the problems involving Science and Engineering*		✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-4	*To apply estimation and testing methods to make inference and modelling techniques for decision making*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-5	*Analyze complex engineering systems to calculate their probability of failure, identify critical components impacting reliability, model system*	✓	✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3

Title & Session Outcomes	*Probability concepts*	*Theoretical Distributions*	*Sampling Theory*	*Estimation Theory*	*Reliability*
Duration (hour)	12	12	12	12	12
SO-1	*Probability and Events -*	*Sampling Distributions*	*Hypothesis Testing*	*Estimation Theory*	*Reliability: Basic concepts*
SO-2	*Conditional probability* *Baye's theorem – without proof*	*Binomial Distribution*	*Test of significance Large samples, t-test: Single mean, difference of Mean*	*Introduction to Estimation*	*Hazard function*

SO-3	*Properties of Random variables, Discrete Random Variables*	*Poisson Distribution*	*Test of significance: Difference of Proportion*	*criteria for good estimates (un-biasedness*	*Reliabilities of series and parallel systems*
SO-4	*Tutorial: Problems on Probability and events, conditional probability, Bayes theorem and discrete random variables*	*Tutorial: Problems on Binomial and Poisson Distributions*	*Tutorial: Problems on hypothesis testing – Tests of significance*	*Tutorial: Problems on estimation*	*Tutorial: Exercises on reliability*
SO-5	*Continuous random variables and Expected values*	*Exponential*	*Small samples- Test of significance - single mean*	*criteria for good estimates (consistency*	*System Reliability*
SO-6	*Probability mass, Probability density and cumulative distribution function- Mathematical expectation*	*Uniform Distribution*	*Teste of significance of difference of Means*	*Methods of estimation including maximum likelihood estimation.*	*Maintainability*
SO-7	*Moments and MGF*	*Normal Distribution*	*F distribution for mean*	*Problems based on Methods of estimation including maximum likelihood estimation.*	*Preventive and repair Maintenance*
SO-8	*Tutorial: Problems on Continuous random variables, PMF, PDF, CDF, Expectation, Moments and MGF*	*Tutorial: Problems on exponential, uniform and normal distributions*	*Tutorial: Problems on Small samples and tests of significance*	*Tutorial: Problems based on the methods of estimation*	*Tutorial: Exercises in system reliability, maintainability, preventive and repair maintenance*
SO-9	*Covariance and correlation*	*Negative Binomial distribution*	*variance and proportion*	*Concepts of estimator*	*Bayesian Reliability Analysis*
SO-10	*Linear Regression*	*Gamma*	*Chi square test - Goodness of fit*	*Bayes minimax estimator*	*Markov chains in Reliability*
SO-11	*Central limit theorem*	*Weibull distribution applications*	*Chi square test- contingency table*	*Principle of Equivariance*	*Problems on reliability*
SO-12	*Tutorial: Problems on Covariance, correlation, linear regression and central limit theorem*	*Tutorial: Problems on Negative Binomial Distribution, Gamma and Weibull Distributions*	*Tutorial: Problems on variance and proportion and on Chi square test*	*Tutorial: Problems on Estimators*	*Tutorial: Problems on Reliability*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember										
2	Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
3	Apply										
4	Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
5	Evaluate										
6	Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Total		100 %		100 %		100 %		100 %		100 %	

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Resources			
1	*M. Fisz, Probability Theory and Mathematical Statistics, John Wiley and Sons, 2012.*	2	*V.K.Rohatgi and A.K.Md.E. Saleh, An Introduction to Probability and Statistics, Wiley series of probability and statistics, 2nd Ed., 2001*
3	*Veerarajan T., Probability, Statistics and Random Processes, Tata McGraw Hill, Third edition 2017, reprint in march 2021*	4	*R. E. Walpole, R. H. Myers, S. L. Myers, K. Ye, Probability & Statistics for Engineers & Scientists, Pearson Prentice Hall, 8th Ed., 2007.*
5	*Reliability Engineering, E. Balagurusamy, Tata McGraw Hill, Tenth reprint 2017*	6	*Introduction on Mathematical Statistics (Seventh Edition), Rober V. Hogg, J.W. McKean, and Allen T.Craig, Peason Education, Asia (2012)*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	1	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	1	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
2		2		2	*Dr. N. Balaji, SRMIST, balajin@srmist.edu.in*

S1

Code	PMA25S01J	Title	Scientific Programming using Scilab	Category	S	Skill Enhancement Course	L	T	P	C
							1	**0**	4	3

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXXX

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Learn numerical techniques for solutions of algebraic, transcendental and simultaneous equations.*
CR-2	*Utilize the concept of interpolation for finding intermediate values of a well-known data.*
CR-3	*Study the concept of numerical differentiation and integration in physical problems.*
CR-4	*Apply the numerical techniques for solutions of ordinary differential equations.*
CR-5	*Learn the numerical techniques for solutions of partial differential equations.*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Depth				Attainment			Program Outcomes (PO)											
		1 Conceive	2 Design	3 Implement	4 Operate	1 Level of Thinking	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Disciplinary Knowledge	2 Problem Solving	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethical practices & Social Responsibility	9 Individual & Team Work	10 Communication	11 Project Management & Finance	12 Life Long Learning
CO-1	*Construct the programming to solve the algebraic, transcendental and simultaneous equations.*	✓				*3*	*85*	*75*	3	3	2	2	3	-	-	-	3	-	-	3
CO-2	*Identify the programming to find the finite differences and interpolation.*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	3	-	-	-	3	-	-	3
CO-3	*Create the programming to solve numerical differentiation and integration.*		✓			*3*	*85*	*75*	3	3	2	2	3	-	-	-	3	-	-	3
CO-4	*Construct the programming tosolve the numerical solutions of ordinary differential equations.*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	3	-	-	-	3	-	-	3
CO-5	*Identify the program to solve the numerical solutions of partial differential equations.*	✓	✓			*3*	*85*	*75*	3	3	2	2	3	-	-	-	3	-	-	3

Title & Session Outcomes	*Algebraic method*	*Interpolation*	*Numerical differentiation and integration*	*Numerical solutions for ordinary differential equations*	*Numerical solutions for partial differential equations*
Duration (hour)	15	15	15	15	15
SO-1	*Basics of Scilab and mathematical operations. Scilab program for fitting a straight line and parabola by the method of Least Squares. Calculation of the residuals of straight line and parabola by using Scilab program.*	*First and Higher order differences. Forward differences, backward and central tables using Scilab*	*Derivatives of Newton's forward difference formulae using Scilab program.*	*Numerical solutions for ordinary differential equations using Taylor's series method, Euler's method and Modified Euler's with Scilab program.*	*Classification of partial differential equations. Solution of Elliptic Equations and Laplace Equations by Leibmann's Iterative process*

SO-2 - 5	*Practice 1: Program for fitting a curve. Calculation of the residuals of straight line and parabola by using Scilab program.*	*Practice 4: Program for getting the difference table*	*Practice 7: Finding the derivatives using Newton's forward difference formulae with Scilab*	*Practice 10: Solving ordinary differential equations using Taylor's series method, Euler's method and Modified Euler's with Scilab program.*	*Practice 13: Program for solving Elliptic equations, Laplace equations*
SO-6	*Solving algebraic and transcendental equations by Newton-Raphson method, Bisection method and Regula-falsi method with Scilab program.*	*Scilab program for Interpolation – Newton-Gregory Forward and Backward Interpolation formulae.*	*Derivatives of Newton's backward difference formulae using Scilab program.*	*Improved Euler's method and Runge-Kutta method order*	*Poisson Equation and Parabolic equation*
SO 7-10	*Practice 2: Program for finding the root of given equation by Newton-Raphson method, Bisection method and Regula-Falsi method with Scilab program.*	*Practice 5: Program for interpolation with equal interval*	*Practice 8: Finding the derivatives using Newton's backward difference formulae with Scilab*	*Practice 11: Solving ordinary differential equations using Improved Euler's method and Runge-Kutta method of fourth with Scilab program.*	*.* *Practice 14: Program for solving the Poisson equation, parabolic equations*
SO-11	*Solution of system of linear equations Direct Method - Gauss Elimination method, Gauss Jordan method and Gauss-Seidal method by using Scilab program.*	*Scilab program for Divided differences and Lagrange's Interpolation formula. Inverse interpolation*	*Evaluation of Integration using Trapezoidal rule, Simpson's 1/3 rule and Simpson's 3/8 rule with Scilab.*	*Predictor corrector method-Milne-Thomson and Adam's Bash forth Methods*	*Bender-Schmidt and Crank-Nicolson method with Scilab*
SO-12 - 15	*Practice 3: Program for finding the root of given system of equation.*	*Practice 6: Program for interpolation with equal interval*	*Practice 9: Using Scilab to evaluate the Integration using Trapezoidal rule, Simpson's 1/3 rule and Simpson's 3/8 rule with Scilab.*	*Practice 12: Solving ordinary differential equations using Predictor corrector method-Milne-Thomson and Adam's Bash forth Methods with Scilab program.*	*Practice 15: Program for solving partial differential equations using Bender-Schmidt method, Crank-Nicolson method.*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1.	Remember	20%	20%	15%	15%	15%	15%	20%	20%	20%	20%
2.	Understand										
3.	Apply	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
4.	Analyze										
5.	Evaluate	10%	10%	15%	15%	15%	15%	10%	10%	10%	10%
6.	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

Strategies					
Technology		Pedagogy / Andragogy		Sustainable Development	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Resources			
1	*S.S. Sastry, Introductory Methods of Numerical Analysis, PHI, 5th edition, 2012.*	2	*E. Balagurusamy, Computer Oriented Statistical and Numerical Methods – Tata McGraw Hill., 2002.*
3	*M.K.Jain, SRK Iyengar and R.L.Jain, Numerical Methods for Scientific and Engineering Computation, Wiley Eastern Ltd., 8th edition, 2022.*	4	*S. PAL, Numerical Methods: Principles, Analysis, And Algorithms, Oxford University Press 1ST Edition, 2009.*
5	*For Practicing laboratory using Scilab https://cloud.Scilab.in/*	6	*Rohan Verma, Numerical Methods Kit for MATLAB, Scilab and OCTAVE Users, University of Delhi, 2020.*

Designers					
Professional Experts		Higher Institution Experts		Internal Experts	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	1	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	1	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
2		2		2	*Dr. Gajendran G. SRMIST, gajendrg@srmist.edu.in*

S2

Code	PMA25S02J	Title	Foundation of R for Mathematical Computing	Category	S	Skill Enhancement	L	T	P	C
							2	0	2	3

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXXX

Rationale (CR)	The purpose of learning this course is to:	Depth				Attainment			Program Outcomes (PO)												
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
CR-1	*Basic understanding of mathematical concepts such as algebra, calculus, and Probability*																			
CR-2	*Willingness to work with real-world datasets for visualization tasks.*																			
CR-3	*Ability to work with mathematical computations and logic.*																			
CR-4	*Willingness to apply probability and statistical concepts in real-world scenarios.*																			
CR-5	*Ability to interpret mathematical models and algorithms using R*																			

Outcomes (CO)	At the end of this course, learners will be able to:	Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CO-1	*Understand the fundamentals of R programming and its applications in mathematics.*	✓				3	85	75	3	3	2	2	3	-	-	-	3	-	-	3
CO-2	*Apply different types of plots, including histograms, scatter plots, box plots, and bar charts for data visualization and mathematical computations*	✓	✓	✓		3	85	75	3	3	2	2	3	-	-	-	3	-	-	3
CO-3	*Understand the fundamentals of R programming and its applications in mathematics*		✓			3	85	75	3	3	2	2	3	-	-	-	3	-	-	3
CO-4	*Perform correlation and regression analysis to study relationships between variables.*	✓	✓	✓	✓	3	85	75	3	3	2	2	3	-	-	-	3	-	-	3
CO-5	*Develop classification models such as Logistic regression, decision trees, Randon forest, SVMs*	✓	✓			3	85	75	3	3	2	2	3	-	-	-	3	-	-	3

Title & Session Outcomes	*Introduction to R Basics*	*Data Handling and Visualization using R*	*Computational Mathematics in R*	*Probability and Statistics using R*	*Classification of Algorithm*
Duration (hour)	**12**	**12**	**12**	**12**	**12**
SO-1	*Overview of R and Studio*	*Importing and Exporting data (CSV, Excel, Json)*	*Numerical computation (Rounding, Logarithms, Trigonometric Functions) using R*	*Introduction to Descriptive Statistics using R*	*Introduction to Algorithms*
SO-2	*Introduction, Installation, setup, Data Types and Structures*	*Introduction to Statistical graphs using R*	*Matrix Operations (Determinant, Eigenvalues, Inverse) using R*	*Mean, Median, Variance using R*	*Logistic Regression*

SO 3-4	*Practice 1: Installation and setup R studio*	*Practice 4: Programming different types of visualization basic tools*	*Practice 7: Programming on Matrix operations using R*	*Practice 10: Programming on Descriptive Statistics using R*	*Practice 13: Programming on Logistic Regression using R*
SO-5	*Vectors using R*	*Statistical graphs using R, bar chart, pie chart, Histogram.*	*Solving Linear systems of Equations using R*	*Hypothesis Testing and confidence Intervals*	*Decision Tree Model using R*
SO-6	*Matrices, List Data Frames using R*	*Statistical graphs using R, Boxplots, Heatmaps, etc….*	*Solving 2,3 variables of linear equations using R*	*Correlation Analysis using R*	*Support Vector Machine (SVM)*
SO 7-8	*Practice 2: Programming based on mathematical operators using libraries*	*Practice 5: Programming on Statistical plots for visualization*	*Practice 8: Programming on system of linear equation using R*	*Practice 11: Programming on Hypothesis Testing and confidence Intervals*	*Practice 14: Programming on Decision Tree Model andSupport Vector Machine (SVM) using R*
SO-9	*Conditional statements (if, else)*	*Basic Visualization with ggplot*	*Differentiation and Integration in R*	*Regression Analysis using R*	*Naïve Bayes Classifier*
SO-10	*Loops (for, while, repeat*	*Demonstrating all the plots using ggplot*	*Solving Differential equations using R*	*Errors, MSE, RMSE*	*Basic model evaluation using R*
SO 11-12	*Practice 3: Programming based on conditional loops using R*	*Practice 6: Programs using ggplots*	*Practice 9: Programming on Differential equations using R*	*Practice 12: Programming on Regression Analysis using R*	*Practice 15: Programming on Naïve Bayes Classifier and Basic model evaluation using R*

Assessment

Level of Thinking	Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
	CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Remember										
Understand	20%	20%	15%	15%	15%	15%	20%	20%	20%	20%
Apply										
Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Evaluate										
Create	10%	10%	15%	15%	15%	15%	10%	10%	10%	10%
Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Strategies

Technology		Pedagogy / Andragogy		Sustainable Development	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

Resources			
1	Wickham H, Çetinkaya-Rundel M, Grolemund G, R for data science, O'Reilly Media, Inc, 2023 .	2	Max Kuhn, Kjell Johnson, Applied Predictive Modeling, First edition, Springer New York, NY, 2013
3	Mount J, Zumel N, Practical data science with R, Simon and Schuster; 2019 .	4	Jared P. Lander, "R for Everyone: Advanced Analytics and Graphics", Addison-Wesley Data & Analytics Series, 2018.
5	Gareth J,Daniela W,Trevor H & Robert T, "An Introduction to Statistical Learning: with Applications in R", Springer , 2017	6	C. Touchon, Applied Statistics with R: A Practical Guide for the Life Sciences Oxford University Press, 2021

Designers					
Professional Experts		Higher Institution Experts		Internal Experts	
1	Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com	1	Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in	1	Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in
2		2		2	Dr. N. Balaji, SRMIST, balajin@srmist.edu.in

AE1

Code	PCD25AE1T	Title	Comprehensive Skills in Quantitative and Logical Reasoning	Category	AE	*Ability Enhancement Course*	L	T	P	C
							2	0	0	2

Offering Department	Career Guidance	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	Nil

Rationale (CR)	*The purpose of learning this course is to:*	Depth				Attainment			Program Outcomes (PO)												
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
CR-1	*Build a strong foundation in numerical concepts and arithmetic techniques, enabling learners to solve mathematical problems accurately and efficiently.*																			
CR-2	*Equip learners with essential skills for understanding and solving financial and proportional reasoning problems relevant to real-life scenarios and career needs.*																			
CR-3	*Develop problem-solving skills in time, work, speed, distance, and ratio-based applications, enabling learners to tackle real-world mathematical challenges efficiently.*																			
CR-4	*Enhance learners' logical reasoning and data interpretation skills, enabling them to solve real-life problems involving clocks, calendars, directions, relationships, and data analysis.*																			
CR-5	*Sharpen learners' logical thinking and problem-solving abilities, helping them develop skills in tackling number puzzles, logical puzzles, reasoning-based problems, and coding challenges.*																			

Outcomes (CO)	*At the end of this course, learners will be able to:*	Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CO-1	*Apply numerical methods to solve problems involving number classification, divisibility tests, progressions, HCF & LCM, simplification techniques, and vinculum-based calculations.*	✓	✓	✓	✓	1	85	75	3	3	2	2	-	-	-		3	-	-	-
CO-2	*Calculate interest, analyze profit and loss, and solve problems related to percentages, discounts, permutations, combinations, and probability, enhancing their quantitative reasoning skills.*	✓	✓	✓	✓	3	85	75	3	3	2	2	-	-	-	-	3	-	-	-
CO-3	*Solve problems related to time and work, speed and distance, boats and streams, mixtures and alligations, height and distance, and age-based calculations with accuracy and efficiency.*	✓	✓	✓	✓	4	85	75	3	3	2	2	-	-	-	-	3	-	-	-
CO-4	*Solve problems related to clocks, calendars, directions, blood relations, and interpret data from various graphical representations, including tables, bar charts, pie charts, and line graphs, with accuracy and clarity.*	✓	✓	✓	✓	4	85	75	3	3	2	2	-	-	-	-	3	-	-	-
CO-5	*Solve number puzzles, logical puzzles, sequential output tracing, and reasoning problems, as well as alphanumeric series and coding/decoding problems, with precision and speed.*	✓	✓	✓	✓	5	85	75	3	3	2	2	-	-	-	-	3	-	-	-

Title & Session Outcomes	*Numbers and Basic Arithmetic*	*Business Mathematics and Applications*	*Applied Arithmetic Problems*	*Logical Reasoning and Data Interpretation*	*Reasoning and Puzzle Solving*
Duration (hour)	**6**	**6**	**6**	**6**	**6**
SO-1	*Classification of Numbers & Tests of Divisibility*	*Problems on Averages and Percentage*	*Time and work - Problems*	*Clock - Problems*	*Number Puzzles - Problems*
SO-2	*Unit Digit & Trailing Zeroes*	*Problems on Discount*	*Time, Speed and Distance Problems*	*Problems on Calendar*	*Logical Puzzles –Problems*
SO-3	*Arithmetic Progression* *Geometric Progression*	*Problems on Simple Interest and Compound Interest*	*Boats and Streams - Problems*	*Direction Sense - Problems*	*Sequential Output Tracing - Problems*
SO-4	*Highest Common Factor (HCF) Least Common Multiples (LCM)*	*Profit and Loss - Problems*	*Mixtures and Alligations - Problems*	*Blood relation-Problems*	*Inductive, Logical, Abstract and Diagrammatic Reasoning - Problems*
SO-5	*Simplification - Problems*	*Permutation and Combination – Problems*	*Height and Distance - Problems*	*Data Interpretation – Table and Bar chart*	*Alphanumeric Series - Problems*
SO-6	*Virnaculum - Problems*	*Problems on Probability*	*Problems based on Ages*	*Data Interpretation – Pie Chart and Line graph*	*Coding and Decoding - Problems*

Assessment									
Level of Thinking		**Continuous Learning Assessment (CLA)** (100 % weightage)							
		CLA– 1 (20%)		CLA– 2 (20%)		CLA– 3 (30%)		CLA – 4# (30%)	
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
.	Remember	25%	-	20%	-	30%	-	50%	-
.	Understand								
.	Apply	50%	-	50%	-	40%	-	25%	-
.	Analyze								
.	Evaluate	25%	-	30%	-	30%	-	25%	-
.	Create								
Total		100 %		100 %		100 %		100%	

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies		No Poverty	
Emulations		Group Discussion	✓	Zero Hunger	
Prototypes		Hands-on Practice	✓	Good Health & Well Being	
Hands-on Practice Tools	✓	Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question	✓	Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review			
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Resources			
1	Dr. Agarwal.R.S, Quantitative Aptitude for Competitive Examinations, S. Chand and Company Limited, 2018 Edition	2	Archana Ram, PlaceMentor: Tests of Aptitude for Placement Readiness, Oxford University Press, Oxford, 2018
3	Abhijit Guha, Quantitative Aptitude for Competitive Examinations, Tata McGraw Hill, 5th Edition	4	Edgar Thrope, Test Of Reasoning for Competitive Examinations, Tata McGraw Hill, 6th Edition

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	Mr. Varadha Rajan M (External Expert), Assistant Manager – Human Resources, Justdial Limited, Chennai – 600015 varadha1723@gmail.com	1	Dr. Premavathy M, Associate Professor , Department of English Center for Distance and Online Education, Bharathidasan University, Tiruchirappalli – 620024 drmpremavathy@bdu.ac.in	1	Dr. Deepalakshmi S, HoD, Department of Career Guidance Cell, FSH, SRMIST
				2	Dr. Sathish K, Assistant Professor, Department of Career Guidance Cell, FSH, SRMIST
				3	Dr. Aarthi S, Assistant Professor, Department of Career Guidance Cell, FSH, SRMIST

Semester-2

C5

Code	PMA25205T	Title	Algebra	Category	C	*Professional Core Course*	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXX

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Learn about basic arithmetic.*
CR-2	*Understand about groups*
CR-3	*Gain knowledge about rings and fields.*
CR-4	*Gain knowledge algebraic closures*
CR-5	*Gain knowledge field extension* *Understand solvability of polynomials and Galois theory*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Depth				Attainment			Program Outcomes (PO)												
		1 Conceive	2 Design	3 Implement	4 Operate	1 Level of Thinking	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Disciplinary Knowledge	2 Problem Solving	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethical practices & Social Responsibility	9 Individual & Team Work	10 Communication	11 Project Management & Finance	12 Life Long Learning
CO-1	*Derive equations of basic arithmetics*	✓				*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-2	*Derive and understand the properties of groups*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-3	*Able to get the knowledge of cyclic groups and group homomorphism*		✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-4	*Derive and solve Sylow's theorem and their applications*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-5	*Derive and solve problems in homomorphism and Cayley's theorem , Derive solutions in cryptography and real life problem*	✓	✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3

Title & Session Outcomes	***Basic Review of Group Theory***	***p-group and Sylow Theorem***	***Introduction to ring Theory.***	***Basic Field Theory***	***Introduction To Galois Theory***
Duration (hour)	**12**	**12**	**12**	**12**	**12**
SO-1	*Introduction to laws of algebra , Basic problems in laws of algebra*	*Introduction to p-groups , The rationale behind this unit will be discussed*	*Introduction to laws of group , Basic problems in group*	*Introduction of extension of rings , Basic properties of fields*	*Introduction to system of Congruence , Definition of congruence with examples*
SO-2	*The rationale behind this unit*	*Definition of p-subgroup , Problems in finding p-subgroup and simple groups*	*Need of studying ring theory , Definition of rings with examples*	*Definition of Characteristic of a field. Introduction to finite fields from Z*	*Definition of normal extension and examples*

	will be discussed , Definition of group and properties				
SO-3	*Classification of groups , Problems in number system based on groups*	*Centre of a group , Normalizer of a group. Introduction to basic Group action*	*Definition of commutative ring Problems in commutative rings Definition of ideals, prime ideals*	*Difference between rings and fields Problems in fields*	*Problems based on Normal extension*
SO-4	*Tutorial Session: Problems on laws of algebra and groups*	*Tutorial Session: Problems on P- subgroups and Normalizer*	*Tutorial Session: Problems on groups, rings and commutative rings*	*Tutorial Session: Problems on fields*	*Tutorial Session: Problems on Normal extension*
SO-5	*Problems in groups, subgroups , Introduction of Normal subgroups*	*Class equation , Proof of class equation*	*Definition of maximal ideals and prime ideals , Theorems in maximal ideal*	*Introduction to extensions ,Theorem and proof in algebraic extensions*	*Definition of normal closure.*
SO-6	*Lagranges Theorem, Properties and corollary in Lagranges theorem*	*Problems based on centre of a group , Problems based on centre of a group and normalizer of a group*	*Quotient rings , Basic Properties of quotient rings*	*Theorem Algebraic closures s based on algebraic Extensions ,*	*Basic concepts of field Extensions , Finding basics of field extensions*
SO-7	*Define generator of a group. Finding no generator of a group using Euler phi function*	*Definition of Sylow p- Subgroup , Find sylow p-subgroup of some fields Sylow First theorem*	*fundamental theorem of arithmetic , Factorization domain and Ideal domain*	*existence of algebraic closure and field extension , Basic theorems in algebraic closures and field extension, cardinality of algebraic closure*	*Basic concepts of normal splitting Fields, Definition of Galois group and Application of Galois group*
SO-8	*Tutorial Session: Problems on Subgroups, Normal Subgroups and generator of a group*	*Tutorial Session: Problems Problems based on centre of a group and Find sylow p-subgroup of some fields Sylow First theorem*	*Tutorial Session: Problems on maximal ideals, prime ideals, Factorization domain and Ideal domain*	*Tutorial Session: Problems on extensions*	*Tutorial Session: Problems on field extensions, normal splitting Fields and Galois group*
SO-9	*permutation groups , Concept of quotient function , Problems in finding quotient function*	*Sylow second theorem , Prove sylow second theorem*	*Principal ideal domain Euclidean domain , Properties and basic theorems in ideal and Euclidean domain*	*Definition and examples of finite fields and splitting fields.*	*Fundamental theorem of Galois Group, The rationale behind this Galois group will be discussed*
SO-10	*Homomorphism definition and fundamental theorems , automorphisms*	*Sylow third theorem , Proof of Sylow third theorem*	*polynomial rings , Finding the polynomial rings Problems*	*Problems in splitting fields , Problems in splitting fields*	*Definition of Galois Group, Describe explicitly the basics of Galois group.*

SO-11	*Cayley's theorem, proof, properties*	*Application of Sylow theorems and simple groups , Application of Sylow theorems and simple groups*	*irreducibility criteria of polynomials , Application of Gauss lemma to check irreducible polynomial*	*Definition of characteristic Functions Problems in characteristic functions ,*	*Fundamental theorem of Galois theory (Statement Only).*
SO-12	*Tutorial Session: Problems on quotient function, automorphism and Cayley's theorem*	*Tutorial Session: Problems on Sylow theorems and simple groups*	*Tutorial Session: Problems on polynomial rings*	*Tutorial Session: Problems on splitting fields*	*Tutorial Session: Problems on Galois Group*

Assessment

Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember										
2	Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
3	Apply										
4	Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
5	Evaluate										
6	Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Total		100 %		100 %		100 %		100 %		100 %	

Strategies

Technology		Pedagogy / Andragogy		Sustainable Development	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Resources

1	*D. S. Dummit and R. M. Foote, Abstract Algebra, John-Wiley, 2 nd Ed., 1999.*	*2*	*J.A. Gallian, Contemporary Abstract Algebra, Narosa, 4 th Ed., 1999.*
3	*I. N. Herstein, Topics in Algebra, John-Wiley, 1995*	*4*	*M.Artin, Algebra, Prentice Hall Inc., 1994.*
5	*Andrée Vary, Algebra 1, first edition, McGraw-Hill Education, 2012*	*6*	*J. B.Fraleigh,A First Course in Abstract Algebra, Pearson, 7 th Ed., 2003.*

Designers

Professional Experts		Higher Institution Experts		Internal Experts	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	*1*	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	*1*	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
		2		*2*	*Dr. Provanjan Mallick, SRMIST, Provanjm@srmist.edu.in*

C6

Code	PMA25206T	Title	Complex Analysis	Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXX

Rationale (CR)	The purpose of learning this course is to:	Depth				Attainment			Program Outcomes (PO)												
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
CR-1	Understand the fundamental concepts of complex analysis.																			
CR-2	Learn the concepts of stereographic projection and point set topology.																			
CR-3	Know about the analytical concepts of complex functions.																			
CR-4	Learn the concepts of different types of singularities via theoretical as well as series expansions.																			
CR-5	Gain knowledge about the applications of the concept of residues. To understand the evaluation of integrals of different types.																			

Outcomes (CO)	At the end of this course, learners will be able to:	Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CO-1	Explain the transformation concepts in complex variable. Explain the fundamental concepts in complex analysis such as analyticity, transformation, singularities and contour integration.	✓				3	85	75	3	3	2	2	-	-	-	-	3	-	-	3
CO-2	Check whether a function is analytic and be able to evaluate integrals in relation to Cauchy's theorems and formula.	✓	✓	✓		3	85	75	3	3	2	2	-	-	-	-	3	-	-	3
CO-3	Relate the singularities of different types and determine the power series expansion of Taylor's and Laurent's series.		✓			3	85	75	3	3	2	2	-	-	-	-	3	-	-	3
CO-4	Understand the multivaluedness of complex function with branch cut and branch points	✓	✓	✓	✓	3	85	75	3	3	2	2	-	-	-	-	3	-	-	3
CO-5	Able to know and classify bilinear transformation, and find fixed points, magnification factor, cross-ratio in order to apply conformality.	✓	✓			3	85	75	3	3	2	2	-	-	-	-	3	-	-	3

Title & Session Outcomes	*Introduction to Complex Numbers and Functions*	*Analytic Functions and Cauchy-Riemann Equations*	*Cauchy's Integral Theorem and Primitives*	*Singularities and Contour Integration*	*Conformal Mapping and Harmonic Functions*
Duration (hour)	12	12	12	12	12
SO-1	*Motivation of studying complex number. Intersection of curve and straight line.*	*Differentiability of a complex function. Examples of function from R to C and C to R. Their differentiability properties. Worked out examples.*	*Parametrized Curve, Closed curve, simple curve, Jordan curve, piecewise smooth curve, smooth curve. Illustrations and worked out examples.*	*Analysis of singularities through Laurent series. Illustrative examples and worked out problems. Maximum and minimum modulus theorems with proofs.*	*Conformal mapping. Definition and examples. Motivation. Isogonal mapping. Examples.*

SO-2	*Introduction to complex numbers and their geometric representations.*	*Definition of holomorphic and differentiability of complex function*	*Concept of primitive. For function having primitive, whose integral along closed curve is zero.*	*Application of Laurent series. Worked out problems. Motivation about open mapping theorem*	*Linear fractional/Biilinear transformation. Illustrative examples and worked out problems.* *Matrix interpretation of a Mobius transformation.*
SO-3	*Polar representations of complex numbers. Worked out examples.*	*Equivalence between complex differentiation f'(z_0) and real differentiation jacobian matrix*	*Cauchy's weak theorem. Cauchy-Goursat theorem. Its proof. Worked out example.*	*The open-mapping theorem. Its proof and worked out problems.*	*Fixed points of Bilinear transformation. Worked out examples. Applications.*
SO-4	*Tutorial: Problems on complex numbers, Intersection of curves and straight line*	*Tutorial: Problems on Differentiability of a complex function, holomorphic complex function and Equivalence between complex differentiation f'(z_0) and real differentiation jacobian matrix*	*Tutorial: Problems on Parametrized Curve, Closed curve, simple curve, Jordan curve, piecewise smooth curve, smooth curve, Cauchy's weak theorem and Cauchy-Goursat theorem.*	*Tutorial: Problems on Analysis of singularities through Laurent series and open-mapping theorem.*	*Tutorial: Problems on Conformal mapping, Linear fractional/Biilinear transformation and Fixed points of Bilinear transformation.*
SO-5	*Introduction to stereographic projection. Inverse points with respect to a circle.*	*Necessary condition of analyticity, Cauchy Riemann equation and its different form. (Cartesian, polar, function of z bar)*	*Contour integral. Cauchy's theorem and its proof. Worked out examples.*	*Schwarz lemma. Schwarz pick lemma. Illustrative examples and worked out examples.*	*Normal form or canonical form of a Bilinear transformation. Its classification and examples.* *Cross ratio. Related theorems and worked out problems.*
SO-6	*Stereographic projection and chordal distance. Worked out examples.*	*Introduction to singularity of a complex valued function. Its relation with analyticity of the same. Worked out problems.*	*Cauchy's integral formula for the derivative of an analytic function and the related theorem for higher order derivatives with proof. Worked out examples.*	*Residues, Calculation of residues. Worked out examples.*	*Special linear fractional transformation. Worked out examples.* *Riemann surface. Illustrative examples.*
SO-7	*Point set topology and relationship between R^2*	*Entire function. Results on analyticity. Worked out examples. Harmonic function, Harmonic conjugate. Definition and worked out examples.*	*Morera's theorem. Analytic function on simply connected domain. Cauchy's inequality. Worked out examples.*	*Real definite integration using residues, Fourier transform of Gaussian through residues*	*Automorphisms on a unit disk. Illustrative examples. Theorem related to it. Reflection/inverse maps. Illustrative examples. Symmetry principal Mobius maps.*
SO-8	*Tutorial: Problems on Stereographic projection and chordal distance and Point set topology and relationship between R^2*	*Tutorial: singularity of a complex valued function , Harmonic function and Harmonic conjugate*	*Tutorial: Problems on Contour integral, Morera's theorem and Cauchy's inequality*	*Tutorial: Problems on Residues, Real definite integration using residues and Fourier transform of Gaussian through residues*	*Tutorial: Problems on Special linear fractional transformation, Riemann surface and Automorphisms on a unit disk*

SO-9	*Motivation between difference between differentiability of real function and complex function.*	*Construction of an analytic function. Milne-Thomson method.*	*Liouvilles's theorem, its proof and worked out examples and results. Generalized version of Liouville's theorem. Examples.*	*Evaluation of Integral of the type* $\int_0^{2\pi} f(\cos\theta, \sin\theta)d\theta$. *Jordan's lemma. Worked out problems.*	*Local exact differentials and complex integration*
SO-10	*Limit and continuity of complex function. Relationship between R^2.*	*Power series of a complex valued function. Its radius of convergence. Power series definition of analytic function. Examples. Worked out problems.*	*Taylor's series expansion. Theorems and propositions related to it. Illustrations and worked out examples. Identity/Uniqueness theorem. Illustrative examples and worked out problems.*	*Evaluation of Integral of the type* $\int_{-\infty}^{\infty} f(x)\sin axdx, a>0$ *Evaluation of Integral of the type* $\int_{-\infty}^{\infty} f(x)\cos axdx, a>0$ *Evaluation of Integral of the type* $\int_{-\infty}^{\infty} \frac{p(x)}{q(x)}dx$	*Mean value property, harmonic function, Harnack's principle*
SO-11	*Some important deductions related to continuity of a complex function. Worked out examples.*	*Branch point. Multi-valued functions. Worked out examples.*	*Laurent Theorem. Results and propositions related to Laurent theorem. Worked out problems.*	*Argument theorem. Illustrative examples. Worked out problems. Rouche's theorem. Illustrative examples. Worked out problems.*	*Dirichlet problem, sub harmonic function, solution of dirichlets problem*
SO-12	*Tutorial: Problems on Limit and continuity of complex function and deductions related to continuity of a complex function*	*Tutorial:Problems on Power series of a complex valued function, radius of convergence and Branch point. Multi-valued functions*	*Tutorial: Problems on Liouvilles's theorem, Taylor's series expansion and Laurent Theorem*	*Tutorial: Problem on Jordan's lemma, Argument theorem and Rouche's theorem*	*Tutorial: Problems on Local exact differentials and complex integration, sub harmonic function and Dirichlet problem*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
2	Understand										
3	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
4	Analyze										
5	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
6	Create										
Total		100 %		100 %		100 %		100 %		100 %	

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Resources			
1	*Ahlfors, Lars Valerian, and Lars V. Ahlfors. Complex analysis. Vol. 3. New York: McGraw-Hill, 1979.*	2	*Stein, Elias M., and Rami Shakarchi. Complex analysis. Vol. 2. Princeton University Press, 2010.*
3	*Needham, Tristan. Visual complex analysis. Oxford University Press, 2023.*	4	*S.Ponnusamy,Foundations of Complex Analysis,Narosa Publishing House,New Delhi,2nd edition,2013.*
5	*James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw – Hill International Edition, 2009.*	6	*Joseph Bak and Donald J. Newman, Complex analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 3rd edition 2010.*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	1	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	1	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
2		2		2	*Dr. Swaraj Paul, SRMIST, swarajp@srmist.edu.in*

C7

Code	PMA25207T	Title	Partial Differential Equations	Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXX

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Learn about simultaneous differential equations of first order and first degree.*
CR-2	*Learn about origins and classification of first order PDE*
CR-3	*Gain knowledge about origin of second order PDE*
CR-4	*Gain knowledge about One dimensional wave equation*
CR-5	*Gain knowledge about solutions of Laplace equation in Cartesian and polar coordinates*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Depth				Attainment			Program Outcomes (PO)												
		1 Conceive	2 Design	3 Implement	4 Operate	1 Level of Thinking	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Disciplinary Knowledge	2 Problem Solving	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethical practices & Social Responsibility	9 Individual & Team Work	10 Communication	11 Project Management & Finance	12 Life Long Learning
CO-1	*Able to construct the general solution of simultaneous differential equations of first order and first degree*	✓				*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-2	*Able to derive the uniqueness and existence of solution of second order PDE*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-3	*Able to reduce the given second order PDEs to canonical form and construct the solutions*		✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-4	*Able to solve one dimensional wave problems for different cases*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-5	*Able to derive the solution of BVP like Laplace equation, Diffusion equation*	✓	✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3

Title & Session Outcomes	*Simultaneous differential equations of first order and first degree*	*Classification of first order PDEs*	*Classification of second order PDEs*	*Second order PDEs and Fourier Transformation*	*Boundary Value Problems(B.V.P)*
Duration (hour)	12	12	12	12	12
SO-1	*Introduction*	*Origins and classification of first order PDE*	*Introduction about Origin of second order PDE*	*Introduction to wave equation*	*Introduction of types B.V.P*
SO-2	*Simultaneous differential equations of first order and first degree*	*First order quasi- linear PDE*	*Parabolic, hyperbolic and elliptic PDEs*	*One dimensional wave equation*	*Maximum-minimum principle*
SO-3	*Integral Curves*	*Initial value problem for quasi-linear PDE*	*Characteristic curves of second order PDE*	*Vibration of finite, semi- infinite and infinite string*	*Solutions of Laplace equation*

SO-4	*Tutorial: Examples on simultaneous differential equations*	*Tutorial: Examples on classification of first order PDE*	*Tutorial: Examples on classification of second order PDE*	*Tutorial: Modelling of wave equation*	*Tutorial: example on types of B.V.P*
SO-5	*System of curves on a surface*	*Existence and uniqueness of solutions*	*Reduction into canonical form- Parabolic PDE*	*Reflection method for half-line*	*Weak solution of Laplace equation*
SO-6	*Orthogonal trajectories*	*Types of solutions of nonlinear PDE of first order*	*General solution from canonical form*	*Inhomogeneous wave equation*	*Existence of weak solutions*
SO-7	*Orthogonal trajectories*	*Cauchy's method of characteristic*	*Reduction into canonical form- Hyperbolic PDE*	*Definition of Fourier transform*	*Lax–Milgram Theorem*
SO-8	*Tutorial: Problems on Orthogonal trajectories*	*Tutorial: Examples on existence and uniqueness of solutions*	*Tutorial: Examples on general solution from canonical form*	*Tutorial: Examples on reflection method for half-line*	*Tutorial: Examples on existence of weak solutions*
SO-9	*Pfaffian differential equation*	*Compatible systems of first order equations*	*General solution from canonical form*	*Basic properties of Fourier transform*	*One dimensional diffusion equation*
SO-10	*Method-I for solving Pdx+Qdy+Rdz=0*	*Charpit's method*	*Reduction into canonical form- Elliptic PDE*	*Solution of wave equation using Fourier transform*	*Maximum- minimum principle for the diffusion equation*
SO-11	*Method-II solution of homogeneous equation Pdx+Qdy+Rdz=0*	*Charpit's method*	*General solution from canonical form*	*Fourier sine and cosine transform and solution of semi-infinite string problems*	*Diffusion equation on the half and whole line*
SO-12	*Tutorial: problems on Pfaffian differential equation*	*Tutorial: Examples application of charpit's method to solve PDEs*	*Tutorial: Examples on general solution of elliptic PDE from canonical form*	*Tutorial: Examples on the application of Fourier sine and cosine transform to semi-infinite string problems*	*Tutorial: Examples on the solution of one dimensional diffusion equation*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
2	Understand										
3	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
4	Analyze										
5	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
6	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Resources			
1	*I. P. Stavroulakis and S. A. Tersian, Partial Differential Equations- An IIntroduction with Mathematica and Maple, world - Scientific, Singapore, 1999*	2	*I. N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1998*
3	*L. C. Evans, Partial Differential Equations, American Mathematical Society, 2010*	4	*K. S. Rao, Introduction to Partial Differential Equations, Prentice Hall India,2006*
5	*W. E. Williams, Partial differential Equations, Clarendon Press, Oxford, 1980*	6	***T**. Amarnath, An Elementary Course in Partial Differential Equations, Narosa Publishing House, 2nEd., 2012*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	1	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	1	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
2		2		2	*Dr. Bibekananda Bira, SRMIST, bibekan@srmist.edu.in*

C8

Code	PMA25208T	Title	Topology	Category	C	*Professional Core Course*	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXX

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Know about topological spaces, definitions of sets.*
CR-2	*Learn continuous functions, metric topology and quotient*
CR-3	*Be familiar with connected spaces, components and path components.*
CR-4	*Be familiar with compact spaces, local compactness.*
CR-5	*Exposure to countability., Be familiar with topological structures and its applications*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Depth				Attainment			Program Outcomes (PO)												
		1 Conceive	2 Design	3 Implement	4 Operate	1 Level of Thinking	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Disciplinary Knowledge	2 Problem Solving	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethical practices & Social Responsibility	9 Individual & Team Work	10 Communication	11 Project Management & Finance	12 Life Long Learning
CO-1	*Understand the topological structure and its properties*	✓				*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-2	*Understand the metric topology, quotient topology and product topology*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-3	*Understand the concept of connectedness and its properties.*		✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-4	*Understand the concept of compactness and its properties.*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3
CO-5	*Understand the concept of countability and separation axioms., Understand the topological structures and its applications*	✓	✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	3

Title & Session Outcomes	***Basic Point set Topology***	***Continuous Function and its properties***	***Connectedness***	***Compactness***	***Countability***
Duration (hour)	**12**	**12**	**12**	**12**	**12**
SO-1	*Introduction to point set Theory, Fundamental concepts.*	*Closed sets and its properties ,Examples*	*Connected spaces ,Examples*	*Compact Spaces ,Examples*	*Countability axioms*
SO-2	*Functions and relations, Discussion with examples. Equivalence relation and partial order relation*	*Closure and interior of a set, Properties based on closure and interior.*	*Properties of connected Spaces, Applications of connected spaces*	*Properties of compact spaces, Applications of compact spaces*	*Properties of Countability*

SO-3	*Definition of Topology on a set*	*Limit Points, Hausdorff Space, Properties of Hausdorff space*	*Connected subspaces of the real line, Intermediate value theorem*	*Properties of compact spaces , Tube Lemma*	*Separation axioms , Properties of Separation axioms*
SO-4	*Tutorial Session: Problems on Functions, relations and Topological Spaces*	*Tutorial Session: Problems on Closed sets, Closure and interior of a set, Limit Points and Hausdorff space*	*Tutorial Session: Problems on Connected spaces, Connected subspaces of the real line and Intermediate value theorem*	*Tutorial Session: Problems on Compact Spaces, Properties of compact spaces and Applications of compact spaces*	*Tutorial Session: Problems on Countability axioms and Separation axioms*
SO-5	*Basis for a topology, Examples.*	*Continuity of a function, Homeomorphisms and its properties.*	*Components, Path components Examples , Properties of path component .*	*Finite intersection property, Compact subspace of the real line, Extreme Value theorem.*	*Regular Space definition and Examples*
SO-6	*Basis for a topology and its properties., Sub basis and its properties*	*Construction of continuous function, Pasting Lemma*	*Applications of path component , Locally connected*	*Lebesgue number lemma, Uniformly continuous, properties.*	*Normal Spaces ,Definition and examples of Normal Spaces*
SO-7	*Order topology basis for order topology*	*Product topology and box topology , and properties*	*Definition and examples of Locally connected Properties of locally connected*	*Tychonoff's Thorem proof and application*	*Properties of Normal spaces , Applications of normal spaces*
SO-8	*Tutorial Session: Problems on Basis for topology, Sub basis and Order topology basis for order topology*	*Tutorial Session: Problems on Continuity of a function, Homeomorphisms and Product topology*	*Tutorial Session: Problems on Path components and Locally connected Properties of locally connected*	*Tutorial Session: Problems on Compact subspace of the real line, uniform continuity and Tychonoff's thorem*	*Tutorial Session: Problems on Hausdorff space, regular space and Normal Spaces*
SO-9	*Examples of order topology , Examples for Basis.*	*Metric topology , Properties of metric topology*	*Properties of locally Connected , Problems on locally connected spaces*	*Limit point compactness , Properties of limit point compactness*	*Urysohn's Lemma , Proof of Urysohn's Lemma*
SO-10	*Subspace topology , Examples*	*Co-finite, Co-countable topology, properties.*	*Locally path connected , Definition and examples of Locally path connected*	*Applications of limit point in compact space , Locally compact*	*Applications of Urysohn's Lemma*
SO-11	*Properties of Subspace Topology , Basis for Subspace topology.*	*Quotient topology , Properties of quotient topology*	*Properties of locally path Connected , Applications of locally path connected spaces.*	*Properties of locally compact Spaces , Applications of locally compact spaces*	*Urysohn Metrization theorem(Statement only) and application.*

SO-12	*Tutorial Session: Problems on order topology, Subspace topology and Basis for Subspace topology*	*Tutorial Session: Problems on Box topology, Metric topology and Quotient topology*	*Tutorial Session: Problems on locally connected spaces*	*Tutorial Session: Problems on Limit point compactness*	*Tutorial Session: Problems on Urysohn Metrization theorem*

Assessment

Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
2	Understand										
3	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
4	Analyze										
5	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
6	Create										
Total		100 %		100 %		100 %		100 %		100 %	

Strategies

Technology		Pedagogy / Andragogy		Sustainable Development	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Learning Resources

1	*James R. Munkres, Topology, Second Edition,PHI Learning Private Limited, 2009.*	2	*James Dugundji Topology*
3	*. Bredon, Topology and Geometry, Springer 2010.*	4	*G.F. Simmons, Topology and Modern Analysis, 13th reprint ,Mc Graw-Hill, New York, 2010.*
5	*Sheldon W. Davis, Topology, Tata Mc Graw-Hill Edition, 2006.*	6	*K. D. Joshi, " Introduction to General Topology", Second edition, New Age International, New Delhi, 2017.*

Designers

Professional Experts		Higher Institution Experts		Internal Experts	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	1	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	1	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
		2		2	*Dr. Provanjan Mallick, SRMIST, Provanjm@srmist.edu.in*

D1

Code	PMA25D01T	Title	Advanced Optimization Techniques	Category	D	*Discipline Elective Course*	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXX

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Learn the sensitivity analysis for linear programming*
CR-2	*Learn about one dimensional optimization techniques.*
CR-3	*Gain knowledge about multidimensional optimization methods.*
CR-4	*Know the method of Sequential Linear Programming*
CR-5	*Understand the concepts of Integer programming*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Depth				Attainment			Program Outcomes (PO)												
		1 Conceive	2 Design	3 Implement	4 Operate	1 Level of Thinking	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Disciplinary Knowledge	2 Problem Solving	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethical practices & Social Responsibility	9 Individual & Team Work	10 Communication	11 Project Management & Finance	12 Life Long Learning
CO-1	*Gain the knowledge about sensitivity analysis and apply them in problems related to science and engineering.*	✓				*3*	*85*	*75*	3	3	2	2	2	-	-		3	-	-	3
CO-2	*Solve problems in one dimensional optimization using advanced techniques.*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-3	*Derive and solve problems in multidimensional optimization using advanced techniques.*		✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-4	*Sequential Linear Programming*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-5	*Solve problems in Integer programming*	✓	✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3

Title & Session Outcomes	***Linear programming problem and sensitivity analysis***	***Nonlinear programming without constraints***	***Multidimensional optimiszation***	***Sequential linear programming***	***Integer programming***
Duration (hour)	**12**	**12**	**12**	**12**	**12**
SO-1	*Introduction to linear programming*	*One-dimensional Optimization methods*	*Multidimensional Optimization methods*	*Characteristics of a Constrained Problem*	*Introduction to Integer programming*
SO-2	*Two Phase method*	*Uni-modal function*	*Direct search method*	*Random Search Methods*	*Graphical Representation*
SO-3	*Revised Simplex Method*	*Elimination method*	*Univariant Method*	*Complex Method*	*Gomory's cutting plane algorithm*
SO-4	*Tutorial problems on Two Phase method and Revised Simplex Method*	*Tutorial problems on Uni-modal function and Elimination method*	*Tutorial problems on Direct search method and Univariant Method*	*Tutorial problems on Random Search Methods and Complex Method*	*Tutorial problems on Graphical Representation and Gomory's cutting plane algorithm*
SO-5	*Duality*	*Fibonacci method and its problems*	*Pattern search method*	*Sequential Linear Programming*	*Integer Polynomial Programming*

SO-6	*Sensitivity analysis*	*Golden section method*	*Hooke-Jeeves method*	*Problems on Sequential Linear Programming*	*Representation of an Integer Variable by an Equivalent System of Binary Variables*
SO-7	*Changes in the Right-Hand-Side Constants*	*Problems on Golden section method*	*Powell's method*	*Problems on Sequential Linear Programming*	*Conversion of a Zero–One Polynomial Programming Problem into a Zero–One LP Problem*
SO-8	*Tutorial problems on Duality, Sensitivity analysis*	*Tutorial problems on Fibonacci method and Golden section method*	*Tutorial problems on Pattern search method, Hooke-Jeeves method, Powell's method*	*Tutorial problems on Sequential Linear Programming*	*Tutorial problems on Integer Polynomial Programming*
SO-9	*Changes in the Cost Coefficients*	*Quadratic interpolation methods and its problem*	*Gradient of function, Steepest decent method*	*Sequential Quadratic Programming*	*Generalized Penalty Function Method*
SO-10	*Addition of New Variables*	*Cubic interpolation methods and its problem*	*Problems on Steepest decent method*	*Problems on Sequential Quadratic Programming*	*Problems on Generalized Penalty Function Method*
SO-11	*Changes in the Constraint Coefficients*	*Problems on cubic interpolation methods*	*Fletcher reeves method*	*Problems on Sequential Quadratic Programming*	*Problems on Generalized Penalty Function Method*
SO-12	*Tutorial problems on Addition of New Variables and changes in Coefficients*	*Tutorial problems on Quadratic interpolation and Cubic interpolation*	*Tutorial problems on Steepest decent method and Fletcher reeves method*	*Tutorial problems on Sequential Quadratic Programming*	*Tutorial problems on Generalized Penalty Function Method*

Assessment

Level of Thinking		**Continuous Learning Assessment (CLA)** (50 % weightage)								**Final Exam** (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
2	Understand										
3	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
4	Analyze										
5	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
6	Create										
Total		100 %		100 %		100 %		100 %		100 %	

Strategies

Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Resources			
1	S.S.Rao, Engineering Optimization (4th Edition), John Wiley & Sons, Inc.,2009.	2	M.C Joshi, K.M Moudgalya, Optimization: Theory and Practice, Narosa Publications, 2013.
3	Ronald L. Rardin, Optimization in Operations Research, 2nd Edition, Pearson, 2017.	4	Kalyanmoy Deb, Optimization for Engineering Design, PHI Publishers, 2012.
5	Hamdy A. Taha, Operations Research: An Introduction, 10th Edition, Pearson,2017.	6	G. V. Reklaitis, A. Ravindran and K. M. Ragsdell, Engineering Optimization-Methods and Applications, Wiley, 1983.

Designers					
Professional Experts		Higher Institution Experts		Internal Experts	
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2		2		2	Dr. Santosh Kumar, SRMIST, santoshh@srmist.edu.in

D2

Code	PMA25D02T	Title	Multivariate Calculus	Category	D	*Discipline Elective Course*	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXX

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Understand the basic concepts and techniques of differential calculus in functions of several variables*
CR-2	*Be familiar with the concept of maxima and minima in several variables*
CR-3	*Go through the concept of line integrals, vector-valued functions, gradient*
CR-4	*Be familiar with surface and volume integrals and apply Green's theorem*
CR-5	*Compute the curl and divergence of vector fields and apply Stokes's Theorem and Divergence Theorem to evaluate line integrals, surface integrals and flux integrals*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Depth				Attainment			Program Outcomes (PO)											
		1 Conceive	2 Design	3 Implement	4 Operate	1 Level of Thinking	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Disciplinary Knowledge	2 Problem Solving	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethical practices & Social Responsibility	9 Individual & Team Work	10 Communication	11 Project Management & Finance	12 Life Long Learning
CO-1	*Understand the concept of differential calculus in several variable framework*	✓				*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-2	*Find local extreme values of functions of several variables, test for saddle points, examine the conditions for the existence of absolute extreme values*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-3	*Apply the theory to calculate the gradients, divergence, curl and arc length of curves*		✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-4	*Ability to set up and compute multiple integrals in rectangular, polar, cylindrical and spherical coordinates and familiar with vector fields*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-5	*Understand the connection between the line, surface and volume integrals through Green's, Guass' and Stokes' theorem*	✓	✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3

Title & Session Outcomes	***Functions in Several Variables***	***Differential Calculus***	***Line Integrals***	***Multiple Integrals***	***Surface Integrals***
Duration (hour)	**12**	**12**	**12**	**12**	**12**
SO-1	*Introduction to functions of several variables*	*Definition of Maxima and minima*	*Line integrals with respect to arc length*	*Introduction to multiple integrals*	*Parametric representation of a surface*
SO-2	*Limits and Continuity*	*Stationary point, Saddle points*	*Open connected sets*	*Double integral of a function defined and bounded on a rectangle*	*The fundamental vector product*

SO-3	*Directional derivatives*	*Finding maxima and minima*	*Independence of the path, Potential functions*	*Evaluation of a double integral by repeated one-dimensional integration*	*Definition of area of a parametric surface*
SO-4	*Tutorial: Problems on Limits and continuity and Directional Derivatives*	*Tutorial: Problems on finding maxima and minima, stationary points, saddle points.*	*Tutorial: Problems on finding line integrals with respect to arc length, open connected sets, independence of the path and potential functions*	*Tutorial: Problems on double integrals*	*Tutorial: Problems on parametric representation of a surface, fundamental vector product and area of a parametric surface*
SO-5	*The gradient of a scalar field*	*Absolute minimum and relative minimum*	*First fundamental theorem for line integrals*	*Iterated integrals*	*Surface integral*
SO-6	*Level set and Tangent planes*	*The method of Lagrange's multiplier*	*Second fundamental theorem of calculus for line integrals*	*Change of variables formula*	*Stokes' theorem*
SO-7	*Chain rules, Matrix form of the chain rule*	*Applications of Lagrange's multipliers*	*Calculus of vector-valued functions*	*Special cases of the transformation formula*	*The curl and divergence of a vector field*
SO-8	*Tutorial: Problems on gradient of a scalar field, level set and Tangent planes and Chain rules*	*Tutorial: Problems on finding the absolute minimum, relative minimum and Lagrange's multipliers*	*Tutorial: Problems on Fundamental Theorems for line integrals*	*Tutorial: Problems on iterated integrals, change of variables and transformations.*	*Tutorial: Problems on surface integral, Stoke's Theorem, Curl and Divergence of a vector field*
SO-9	*Derivatives of functions defined implicitly*	*Inverse function theorem*	*Gradients*	*Green's theorem*	*The divergence theorem (Gauss' theorem)*
SO-10	*Higher order derivatives*	*Implicit function theorem*	*Necessary conditions for a vector field to be a gradient*	*Introduction to two-dimensional vector fields*	*Application of the divergence theorem*
SO-11	*Application of Taylor's theorem*	*Problems on implicit function theorem*	*Problems related to gradients*	*Examples of two-dimensional vector fields*	*Applications of multivariate calculus in PDEs*
SO-12	*Tutorial: Problems on Derivatives of functions defined implicitly, higher order derivatives and Taylor's Theorem*	*Tutorial: Problems on implicit function theorem*	*Tutorial: Problems on gradients*	*Tutorial: Problems on Green's Theorem and two-dimensional vector fields.*	*Tutorial: Problems on Gauss Theorem and applications in PDE*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1.	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
2.	Understand										
3.	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
4.	Analyze										
5.	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
6.	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Resources			
1	*T.M. Apostol, Calculus, 2nd Ed, John Wiley & Sons, 2003*	2	*F.C. Paliogiannis and M. Moskowitz, Functions of Several Real Variables, 2nd Ed. World Scientific,2011*
3	*H.M. Edwards, Advanced Calculus-A Differential Forms Approach, 3rd Ed, Birkhauser, 1994*	4	*https://archive.nptel.ac.in/courses/111/107/111107108/, NPTEL Course: Multivariable Calculus*
5	*P.D. Lax and M.S. Terrell, Multivariable Calculus with Applications, 1st Ed, Springer International Publishing, 2017*	6	*https://onlinecourses.nptel.ac.in/noc19_ma19/preview, SWAYAM Course: Calculus of Several Real Variables*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	1	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	1	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
2		2		2	*Dr. Sahadeb Kuila, SRMIST, sahadebk@srmist.edu.in*

D3

Code	PMA25D03J	Title	Introduction to Statistical Learning	Category	D	*Discipline Elective Course*	L	T	P	C
							3	0	2	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXXX

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Understand the basic concepts of Statistics and data analysis*
CR-2	*Get ability to solve problems on Linear methods for regression and classifications.*
CR-3	*Understand the concepts of regularizations and smoothing*
CR-4	*Interpret model assessment and to understand maximum likelihood methods.*
CR-5	*Get well versed with unsupervised learning*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Depth				Attainment			Program Outcomes (PO)												
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
		Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CO-1	*Get knowledge on linear regression and supervised learning.*	✓				*3*	*85*	*75*	3	3	2	2	2	-	-		3	-	-	3
CO-2	*Understand linear methods for regression, classifications, indicator matrix, and separating hyper planes*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-3	*Describe regularizations, spline smoothening, wavelet smoothing and Kernel smoothers*		✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-4	*Analyze model assessment, bootstrap methods and EM algorithm*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-5	*Explore the concepts of unsupervised learning*	✓	✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3

Title & Session Outcomes	***Basis Expansions and Regularization***	***Overview of Supervised Learning***	***Unsupervised Learning***	***Linear Methods for Regression***	***Model Assessment and Selection***
Duration (hour)	**15**	**15**	**15**	**15**	**15**
SO-1	*Introduction to basis expansions and regularizations, Piecewise Polynomials and Splines*	*Overview of Statistical learning, Variable Types and Terminology*	*Introduction to unsupervised learning, Association rules*	*Introduction to Linear methods for regression, Linear Regression Models and Least Squares*	*Introduction to Model assessment and bias, Bias, Variance and Model Complexity*
SO-2	*Natural Cubic Splines, Examples*	*Simple approaches for prediction, Least Squares and Nearest Neighbors*	*Market basket analysis, Examples*	*The Gauss–Markov Theorem, Examples*	*The Bias–Variance Decomposition, Examples*

SO-3	*Filtering and Feature Extraction, Examples*	*Linear Models and Least Square, Nearest Neighbour method,*	*The Apriori Algorithm, Unsupervised as Supervised Learning*	*Subset selection, Best Subset Selection*	*Optimism of training error rate, The Bayesian Approach and BIC*
SO 4-5	*Practice 1: Polynomial regression*	*Practice 4: Least Squares and Nearest Neighbors*	*Practice 7: Market basket analysis*	*Practice 10: Linear methods for regression*	*Practice 13: The Bias–Variance Decomposition*
SO-6	*Smoothing Splines, Degrees of Freedom and Smoother Matrices*	*From Least Squares to Nearest Neighbors, Statistical Decision Theory*	*Cluster Analysis, Proximity matrices*	*Forward and backward stepwise selection,* *Forward Stage wise Regression-*	*Minimum Description Length, Vapnik–Chervonenkis Dimension*
SO-7	*Automatic Selection of the Smoothing Parameters, Fixing the Degrees of Freedom*	*Statistical Models, Supervised Learning,* *Function approximation*	*Object Dissimilarity, Clustering Algorithms*	*Shrinkage methods, Ridge Regression, The Lasso*	*Cross-Validation,* *K-Fold Cross-Validation*
SO-8	*The Bias–Variance Tradeof*	*A Statistical Model for the Joint Distribution Pr(X,Y), Structured Regression Models*	*Combinatorial Algorithms, Gaussian Mixtures as Soft K-means Clustering*	*Principal Components Regression, Partial Least Squares*	*Bootstrap Methods, Examples*
SO 9-10	*Practice 2: Degrees of Freedom*	*Practice 5: Statistical Models*	*Practice 8: K-Means Clustering*	*Practice 11: - Ridge Regression and the Lasso*	*Practice 14: K-Fold Cross-Validation*
SO-11	*Nonparametric Logistic Regression, Multidimensional Splines*	*Structured Regression Models, Difficulty of the Problem*	*principal components, curves and surfaces*	*Incremental Forward Stagewise Regression*	*Maximum likelihood methods, A smoothing example*
SO-12	*Regularization and Reproducing Kernel Hilbert Spaces*	*Classes of Restricted Estimators, Roughness Penalty and Bayesian Methods*	*Kernel Principal Components, Sparse Principal Components*	*Piecewise-Linear Path Algorithms, The Dantzig Selector*	*Bayesian Methods, Relationship Between the Bootstrap and Bayesian Inference*
SO-13	*Wavelet Smoothing, Wavelet Bases and the Wavelet Transform*	*Kernel Methods and Local Regression, Basis Functions and Dictionary Methods*	*Non-negative matrix factorization, Archetypal Analysis*	*The Grouped Lasso , Pathwise Coordinate Optimization*	*The EM Algorithm, Two-Component Mixture Model,*
SO 14-15	*Practice 3: Multidimensional Splines*	*Practice 6: Kernel Methods*	*Practice 9: Kernel Principal Components*	*Practice 12: Incremental Forward Stagewise Regression*	*Practice 15: Bayesian methods*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1.	Remember										
2.	Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*20%*	*20%*	*20%*	*20%*
3.	Apply										
4.	Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
5.	Evaluate										
6.	Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*10%*	*10%*	*10%*	*10%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

Resources			
1	*J. H. Friedman, R. Tibshirani and T. Hastie, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer, 2nd Ed., 2009.*	*2*	*E. Kreyszig, Advanced Engineering Mathematics, Wiley, 8th Ed.,1998.*
3	*B. Siegmund, Data Analysis: Statistical and Computational Methods for Scientists and Engineers, Springer, 4th Ed., 2014*	*4*	*James, G., Witten, D., Hastie, T., Tibshirani, R., An Introduction to Statistical Learning with applications in R, Springer, 2013.*
5	*Richard McElreath, Statistical Rethinking: A Bayesian Course with Examples in R and Stan, Chapman And Hall/crc, 2020*	*6*	*Sanjeev kulkarni, Gilbert Harman, An Elementary Introduction To Statistical Learning Theory, John Wiley & sons Inc, 2011.*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	*1*	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	*1*	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
2		*2*		*2*	*Dr. R. Sriraman, SRMIST, sriramar@srmist.edu.in*

S3

Code	PMA25S03J	Title	Scientific Programming using Python	Category	S	*Skill Enhancement*	L	T	P	C
							2	0	2	3

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXXX

Rationale (CR)	*The purpose of learning this course is to:*	Depth				Attainment			Program Outcomes (PO)												
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
		Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CR-1	*Utilize the basic concepts of PYTHON to manipulate the procedural programming*																			
CR-2	*Utilize the basic concepts of PYTHON to manipulate the data types*																			
CR-3	*Utilize the PYTHON to manipulate the collection data types*																			
CR-4	*Utilize the PYTHON to manipulate the control structure and functions*																			
CR-5	*Construct the PYTHON to manipulate the collection data types programming for modules*																			
Outcomes (CO)	*At the end of this course, learners will be able to:*																			
CO-1	*Identify the PYTHON codes to find the procedural programming*	✓				*3*	*85*	*75*	3	3	2	2	3	-	-	-	3	-	-	3
CO-2	*Identify the PYTHON codes for data types in program*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	3	-	-	-	3	-	-	3
CO-3	*Apply the appropriate coding for collection data types*		✓			*3*	*85*	*75*	3	3	2	2	3	-	-	-	3	-	-	3
CO-4	*Apply the appropriate for the control structure and functions*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	3	-	-	-	3	-	-	3
CO-5	*Apply PYTHON programming for modules*	✓	✓			*3*	*85*	*75*	3	3	2	2	3	-	-	-	3	-	-	3

Title & Session Outcomes	*Introduction to Python*	*Strings, Collections, and Exception Handling*	*Data Structures and Functions*	*Object-Oriented Programming and Modules*	*File Handling, Networking, and Advanced Python*
Duration (hour)	**12**	**12**	**12**	**12**	**12**
SO-1	*The Basic elements of Python*	*Identifiers and Keywords*	*Collection Data Types: Sequence Types*	*Control Structures: Conditional Branching & Looping*	*File Handling: File Formats, Encoding, and Persistence*
SO-2	*Creating and Running Python Programs, Data Types*	*Integral Types: Integers and Booleans*	*Set Types: Sets and Frozen Sets*	*Modules and Packages (Standard and Custom Modules)*	*Character Encoding and String Formatting*
SO 3-4	*Practice 1: Program using Data types*	*Practice 4: Integral and Floating-Point Types*	*Practice 7: Program on Sequence Type*	*Practice 10: Program for Control Structures*	*Practice 13: Programs using Modules and Packages*

SO-5	*Object References,*	*Floating-Point Types: Floats and Complex Numbers*	*Set Types: Sets and Frozen Sets*	*Accessing Variables in the Global Scope*	*File, Directory, and Process Handling*
SO-6	*Collection Data Types*	*String Handling: Comparing, Slicing, and Formatting*	*Iterators and Iterable Operations*	*Command-Line Programming*	*Networking and Internet Programming*
SO 7-8	*Practice 2: Logical Operators and Control Flow Statements*	*Practice 5: Programming on Strings*	*Practice 8: Program on Set Type*	*Practice 11: Program on Exception Handling*	*Practice 14: Program for Overview of Python's Standard Library*
SO-9	*Operators (Arithmetic, Logical, and Input/Output)*	*Collections: Lists, Tuples, Named Tuples, and Sets*	*Custom Functions (Arguments, Parameter Unpacking, Docstrings)*	*Assertions and Debugging in Python*	*Overview of Python's Standard Library*
SO-10	*Control Flow Statements (Conditional Statements, Loops)*	*Exception Handling (Catching and Raising Exceptions, Custom Exceptions)*	*Lambda Functions and Copying Collections*	*Mathematics, Numbers, and Date-Time Handling*	*Algorithms and Collection Data Types*
SO 11-12	*Practice 3: Arithmetic Operators, Creating and Calling Functions*	*Practice 6: String and Character Encodings*	*Practice 9: Program on Dictionaries, Iterators, and Copying Collections*	*Practice 12: Program on Custom Exceptions*	*Practice 15: Programming for File Handling and Networking*

Assessment

Level of Thinking		**Continuous Learning Assessment (CLA)** (50 % weightage)								**Final Exam** (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*20%*	*20%*	*20%*	*20%*
2	Understand										
3	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
4	Analyze										
5	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*10%*	*10%*	*10%*	*10%*
6	Create										
Total		100 %		100 %		100 %		100 %		100 %	

Strategies

Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Resources			
1	Mark Summerfield, Programming in Python 3 A Complete Introduction to the Python Language Second Edition, Pearson Education, Inc., 2010.	2	John V. Guttag, Introduction to computation and programming using Python, springer, 2013
3	Y. Daniel Liang, An Introduction to programming Using Python, Pearson, 2013	4	Steven I. Gordon, Brian Guilfoos, Introduction to Modeling and Simulation with Matlab and Python, first edition, Chapman and Hall / CRC, 2017
5	Mark J. Johnson, A Concise Introduction to Programming in Python, second edition, CRC, 2018	6	https://python.org

Designers					
Professional Experts		Higher Institution Experts		Internal Experts	
1	Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com	1	Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in	1	Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in
2		2		2	Dr. M. Suresh, SRMIST, sureshm@srmist.edu.in

AE2

Code	PCD25AE2T	Title	Soft Skills and Verbal Mastery	Category	AE	*Ability Enhancement*	L	T	P	C
							2	0	0	2

Offering Department	Career Guidance	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Help individuals develop key skills for personal and professional growth*
CR-2	*Prepares individuals to navigate daily challenges with confidence, professionalism, and a positive mindset*
CR-3	*Create a strong resume, participate in group discussions, and perform well in interviews*
CR-4	*Enhance vocabulary and verbal reasoning skills*
CR-5	*Develop the skills needed for effective communication and critical thinking in both written and spoken language*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Depth				Attainment			Program Outcomes (PO)												
		Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices &Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	
CO-1	*Gain a deeper understanding of self, including emotional intelligence and career aspirations*	✓	✓	✓	✓	3	85	75	1	-	3	-	3	3	-	-	3	3	2	3	
CO-2	*Apply effective presentation skills for clear, engaging communication*	✓	✓	✓	✓	6	85	75	1	3	3	-	3	2	-	-	3	3	2	3	
CO-3	*Participate confidently and effectively in group discussions and interviews*	✓	✓	✓	✓	3	85	75	1	3	1	-	3	2	-	-	3	3	2	3	
CO-4	*Enhance their ability to understand and use language effectively in different contexts*	✓	✓	✓	✓	2	85	75	1	-	-	-	1	-	-	-	-	3	2	2	
CO-5	*Improve language comprehension and accuracy*	✓	✓	✓	✓	5	85	75	1	-	-	-	1	-	-	-	-	3	2	2	

Title & Session Outcomes	*Personal Development*	*Mastering Workspace Dynamics*	*Career Essentials*	*Verbal Ability*	*Verbal Reasoning and Comprehension*
Duration (hour)	**6**	**6**	**6**	**6**	**6**
SO-1	*Self-analysis through SWOT, The Johari Window*	*Personal, Professional and Social Etiquette*	*Resume Preparation and Activity*	*Synonyms and Antonyms*	*Statement and Assumption*
SO-2	*Goal Setting Importance, Goal Setting based on the Principle of SMART*	*Professional Communication - Presentation Skills*	*E-mail Drafting and Practice*	*One Word Substitution*	*Paragraph Summary*
SO-3	*Emotional Intelligence (Identifying, Managing and Understanding Emotions)*	*Presentation for Internal and External Communication - online & offline Meetings*	*Techniques to Follow in Group Discussion*	*Word Analogy*	*Idioms and Phrases*
SO- 4	*Process of Career Exploration*	*Time Management and Planning Tools*	*Mock Group Discussion*	*Verbal Classification*	*Cloze Test*
SO-5	*STAR Technique (situation, task, approach and response) for Facing an Interview*	*Decision Making Skills*	*Interview Techniques*	*Spotting Errors*	*Theme Detection*
SO-6	*Professional Attitude – Entrepreneurial, Rational, Optimistic Attitude*	*Teamwork in Workspace - Resilience and Stress Management*	*Mock Personal Interview*	*Sentence Correction*	*Reading Comprehension*

Assessment

Level of Thinking	Continuous Learning Assessment (CLA) (100 % weightage)							
	CLA – 1 (20 %)		CLA – 2 (20 %)		CLA – 3 (30 %)		CLA – 4# (30%)	
	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Remember	25%	-	20%	-	30%	-	50%	-
Understand								
Apply	50%	-	50%	-	40%	-	25%	-
Analyze								
Evaluate	25%	-	30%	-	30%	-	25%	-
Create								
Total	100 %		100 %		100 %		100 %	

Strategies

Technology		Pedagogy / Andragogy		Sustainable Development	
Simulations	✓	Case Studies	✓	No Poverty	
Emulations	✓	Group Discussion	✓	Zero Hunger	
Prototypes		Hands-on Practice	✓	Good Health & Well Being	
Hands-on Practice Tools	✓	Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools		Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question	✓	Clean Water & Sanitation	
		Mind Map	✓	Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Resources			
1	*"The Johari Window: A Model for Self-awareness and Personal Growth" by Joseph Luft & Harrington Ingham*	2	*Campus Recruitment complete Reference , Praxis Groups*
3	*"The 7 Habits of Highly Effective People" by Stephen R. Covey*	4	*A Modern Approach to Verbal and Non Verbal Reasoning – Dr A S Agarwal*
5	*"SMART Goals: How to Set and Achieve Your Personal and Professional Goals" by S.J. Scott*	6	*Verbal Ability & Reading Comprehension for CAT - Arun Sharma*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Mr. Varadha Rajan M (External Expert), Assistant Manager – Human Resources, Justdial Limited, Chennai – 600015* *varadha1723@gmail.com*	1	*Dr. Premavathy M, Associate Professor , Department of English Center for Distance and Online Education, Bharathidasan University, Tiruchirappalli – 620024* *drmpremavathy@bdu.ac.in*	1	*Dr. Deepalakshmi S, HoD, Department of Career Guidance Cell, FSH, SRMIST*
				2	*Dr. Muthu Deepa M, Assistant Professor, Department of Career Guidance Cell, FSH, SRMIST*
				3	*Dr. Sam Israel S, Assistant Professor, Department of Career Guidance Cell, FSH, SRMIST*
				4	*Dr Elamathiyan E, Assistant Professor, Department of Career Guidance Cell, FSH, SRMIST*

Semester -3
C9

Code	PMA25309T	Title	Functional Analysis	Category	C	*Professional Core Course*	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Linear Algebra and Real Analysis	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXX

Rationale (CR)	*The purpose of learning this course is to:*	Depth				Attainment			Program Outcomes (PO)												
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
		Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CR-1	*Learn about basics of linear spaces.*																			
CR-2	*Learn about Banach spaces.*																			
CR-3	*Learn about Hilbert spaces.*																			
CR-4	*Learn about operators.*																			
CR-5	*Learn about Spectral theorem*																			
Outcomes (CO)	*At the end of this course, learners will be able to:*																			
CO-1	*Familiar on linear spaces, normed linear space, sequence space and functional space.*	✓				*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	2
CO-2	*Familiar on Banach space, Hahn-Banach theorem, Open mapping theorem, closed graph theorem and uniform bounded principle.*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	2
CO-3	*Familiar on Hilbert space, Cauchy-Schwartz inequality, Bessel's inequality and Riesz representation theorem*		✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	2
CO-4	*Familiar on operator like adjoint, self adjoint, normal and unitary operators and projection theorem*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	2
CO-5	*Familiar on matrix representation of an operator, spectrum of normal operator and spectral theorem.*	✓	✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	2

Title & Session Outcomes	*Normed Linear Space*	*Banach Space*	*Hilbert Space*	*Operators*	*Spectral Theorem on Normal operator*
Duration (hour)	**12**	**12**	**12**	**12**	**12**
SO-1	*Introduction to Linear space with examples.*	*Banach space with examples.*	*Inner product space with examples.*	*Operators and properties of operators.*	*Operators in matrix form*
SO-2	*Linearly independent and linearly dependent set and its related theorems.*	*Bounded linear transformation on Banach space with examples.*	*Hilbert space with examples.*	*Adjoint operator and its properties.*	*Properties.*

SO-3	*Basis and dimension for the linear space and related theorems.*	*Equivalent condition for bounded linear transformations.*	*Cauchy-Schwartz inequality and Relation between Hilbert and Banach space.*	*Self adjoint operator and its properties.*	*Determinant and its properties.*
SO-4	*Tutorial: Problems on Linear space , Basis and dimension for the linear space*	*Tutorial: Problems on Banach space*	*Tutorial: Problems on Inner product space and Hilbert space*	*Tutorial: Problems on Operators and Properties of Operators*	*Tutorial: Problems on Determinants and Properties*
SO-5	*Linear operator, linear transformation and Rank-Nullity theorem.*	*Norm on B(L, L'), B(L, L') is Banach if L' is Banach*	*Orthogonal complement set on Hilbert space and its related theorems.*	*Problems on self adjoint operator.*	*Spectrum of a linear operator.*
SO-6	*Algebra of linear transformations.*	*Linear functionals, Hahn-Banach theorem on linear functionals*	*Orthonormal basis on a Hilbert space and its related theorems.*	*Normal operator and its properties.*	*Problems on spectrum of a linear operator*
SO-7	*Normed linear space with examples.*	*Corollaries and problems on Hahn-Banach theorem.*	*Bessel' s inequality and its related problems.*	*Unitary operator and its properties.*	*Problems on spectrum of an operator*
SO-8	*Tutorial: Problems on Linear operator, linear transformation and Rank-Nullity theorem.*	*Tutorial: Problems on Linear functionals, Hahn-Banach theorem on linear functionals*	*Tutorial: Problems on Orthonormal basis on a Hilbert space and Bessel's inequality*	*Tutorial: Problems on Normal operator and Unitary operator*	*Tutorial: Problems on Spectrum of a linear operator.*
SO-9	*Sequence space with examples.*	*Open mapping theorem for a bounded Linear transformations and its related problems*	*Complete orthonormal set on Hilbert space and its related theorems.*	*Problems on Normal and Unitary operators.*	*Spectral theorem on Normal operator.*
SO-10	*Functional space with examples.*	*Closed Graph theorem and its related problems*	*Riesz-representation theorem on Hilbert space.*	*Projection theorem on Hilbert space.*	*Spectral theorem on Normal operator.*
SO-11	*Completeness on Normed linear space.*	*Uniform boundedness theorem and its related problems.*	*Conjugate space for Hilbert space.*	*Problems on projection theorem.*	*Problems on Spectral theorem of Normal operator.*
SO-12	*Tutorial: Problems on Sequence space, Functional space and Completeness on Normed linear space*	*Tutorial: Problems on Open mapping theorem, Closed Graph theorem and Uniform boundedness theorem*	*Tutorial: Problems on Complete orthonormal set and Hilbert space*	*Tutorial: Problems on Normal and Unitary operators*	*Tutorial: Problems Spectral theorem on Normal operator.*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember										
2	Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
3	Apply										
4	Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
5	Evaluate										
6	Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Total		100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

Resources			
1	*G. F. Simmons, Introduction to Topology and Modern Analysis, 14th edition,Tata McGraw-Hill International, reprint 2010.*	*2*	*B. V. Limaye, Functional Analysis, 2nd edition, New Age International, 1996.*
3	*M. T. Nair, Functional Analysis: A First Course, 2nd edition, Eastern Economy Edition PHI-Learning (Formerly: Prentice-Hall of India), 2002..*	*4*	*Rudin (1991) Functional Analysis.djvu*
5	*W. Rudin, Functional Analysis, 2nd edition, Tata McGraw-Hill International, 2006.*	*6*	*Introduction to Topology and Modern Analysis Simmons.pdf*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	*1*	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	*1*	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
2		*2*		*2*	*Dr. E. Nandakumar, SRMIST, nandakue@srmist.edu.in*

C10

Code	PMA25310T	Title	Calculus of Variations and Mechanics	Category	C	*Professional Core Course*	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXX

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Learn about fundamentals of functionals.*
CR-2	*Understand about the extremum of functionals and curvature of curve*
CR-3	*Gain knowledge about basic principles of generalized coordinate*
CR-4	*Gain knowledge about the relation between Lagrange's, Hamiltonian and Euler dynamical equations*
CR-5	*Learn about rigid body motion and canonical transformation*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Depth: Conceive	Depth: Design	Depth: Implement	Depth: Operate	Attainment: Level of Thinking	Attainment: Expected Proficiency (%)	Attainment: Expected Attainment (%)	PO1 Disciplinary Knowledge	PO2 Problem Solving	PO3 Design & Development	PO4 Analysis, Design, Research	PO5 Modern Tool Usage	PO6 Society & Culture	PO7 Environment & Sustainability	PO8 Ethical practices & Social Responsibility	PO9 Individual & Team Work	PO10 Communication	PO11 Project Management & Finance	PO12 Life Long Learning
CO-1	*Analyze variational problems to deduce key properties of system behavior*	✓				*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	2
CO-2	*Derive equation of extrema of functions of several variables*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	2
CO-3	*Understand necessary conditions for the equilibrium of particles acted upon by various forces and learn the principle of virtual work for a system of coplanar forces acting on a rigid body*		✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	2
CO-4	*Deal with the Hamiltonian –Jacobi differential equations for a complete classical solution to dynamic problems*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	2
CO-5	*Derive and solve problems using change space coordinate systems, Lagrange's equation and invariance Lagrange's equation*	✓	✓			*3*	*85*	*75*	3	3	2	2	-	-	-	-	3	-	-	2

Title & Session Outcomes	*Basic concepts of calculus of Variations*	*Extreme of functional and curvature of curve*	*Concepts of Generalised coordinates*	*Hamiltonian principles and equations*	*Canonical transformation*
Duration (hour)	12	12	12	12	12
SO-1	*Introduction to Differential equations*	*Introduction to differential calculus*	*Introduction to coordinate systemand generalized coordinates*	*Introduction to rotating coordinate systems, Motion of a particle related to rotating eart*	*Basics of Canonical transformation*

SO-2	*Basic problems in Differential equations*	*Geodesics*	*Principles of generalized coordinates and Problems in generalized coordinates system*	*Torque free motion of rigid body about a fixed point, Motion of a symmetrical top and theory of small vibrations*	*Equations of Canonical transformation*
SO-3	*Variation of a functional and its properties*	*Finding the extremum of geodesics*	*Virtual work and D'Alembert's principle, Problems using D'Alembert's principle*	*Hamilton's variables, Hamilton canonical equitation*	*Derivation of Time dependent Hamilton-Jacobi equation*
SO-4	*Tutorial:: Problems in differential equations*	*Tutorial: Finding the extremum in Geodesics*	*Tutorial:: Problems in D'Alembertz principle*	*Tutorial:: Problems using Canonical Hamilton equation*	*Tutorial: Problems in Canonical Transformation*
SO-5	*Problems in Variation of a functional*	*Condition for finding the extrema of isoperimetric curves*	*Coriolis force, centrifugal and centripetal force. Holonomic and non- holonomic systems*	*Homogeneity of space and time conservation principles*	*Definition of lagrange's brackets*
SO-6	*Euler –Lagrange equation*	*Condition for finding the extrema of isoperimetric curves*	*Scleronomic and rheonomic systems, Problems in scleronomic and rheonomic systems*	*Neothers theorem*	*Condition of canonical transformation in Lagrange's brackets*
SO-7	*Problems using Euler-Lagrange's equation*	*Proper field and family of extremals*	*Lagrange's equations of first kind*	*Introduction to cyclic coordinates*	*Character transformation in terms of Lagrange's brackets*
SO-8	*Tutorial: problems using Euler's equation*	*Tutorial:: Problems in isoperimetric curves*	*Tutorial::Problems in Scleronomic and Rhenomic system*	*Tutorial:: Problems using Cyclic coordinates*	*Tutorial:: Problems in Lagrange bracket*
SO-9	*Variational problems with moving boundaries*	*Proper field and family of extremals*	*Introduction to energyequation for conservative fields, Euler's dynamical equations*	*Routh's equations and Derivation of Routh's equations*	*Poisson brackets under canonical transformation*
SO-10	*Variational problems with fixed boundaries*	*Central field and family of extremals*	*Introduction to energyequation for conservative fields, Euler's dynamical equations*	*Hamiltonian principles*	*Application of canonical transformation*
SO-11	*Variational problems with moving boundaries*	*Jacobi condition for extremal in a central field*	*Problems in Euler's dynamical equations*	*Poisson bracket and Poisons's identity*	*Application of Poisson's brackets*
SO-12	*Tutorial:: problems in fixed boundary*	*Tutorial:: problems under jacobi condition*	*Tutorial:: problems in dynamical equations*	*Tutorial:: Problems in poisson identity*	*Tutorial:: Problems in Poisson bracket*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
.	Remember										
.	Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
.	Apply										
.	Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
.	Evaluate										
.	Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Total		100 %		100 %		100 %		100 %		100 %	

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Resources			
	L. Elsgolts, Differential Equations and the Calculus of Variations, Mir Publishers, 1977		*N. C. Rana and P.S. Jog, Classical Mechanics, Tata McGraw-Hill Education Pvt.Ltd., 2015*
	M. Gelfand and S. V. Fomin, Calculus of Variations, Prentice Hall, Inc., NJ, 1963.		*H. Goldstein, C. P. Poole, J. L. Safko, Classical Mechanics, 3rd Ed, Addison Wesley, 2001.*
	N. H. Louis and D. F. Janet, Analytical Mechanics, Cambridge University Press, 1998		*P. K. Nayak, A text book of Mechanics, Narosa Publishing House, 2016*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	*1*	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	*1*	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
2		*2*		*2*	*Dr. L.S. Senthilkumar, SRMIST, senthill@srmist.edu.in*

D4

Code	PMA25D04T	Title	Fuzzy Sets and Applications	Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	Nil

Rationale (CR)	The purpose of learning this course is to:
CR-1	Understand basic concepts of fuzzy sets
CR-2	Acquaint knowledge of fuzzy numbers and their arithmetic operations
CR-3	Understanding basic concepts of fuzzy relations and their properties
CR-4	Understand fuzzy decision making and graphs
CR-5	Acquire knowledge in fuzzy logic and Applications to control theory

Outcomes (CO)	At the end of this course, learners will be able to:	Depth				Attainment			Program Outcomes (PO)												
		1 Conceive	2 Design	3 Implement	4 Operate	1 Level of Thinking	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Disciplinary Knowledge	2 Problem Solving	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethical practices & Social Responsibility	9 Individual & Team Work	10 Communication	11 Project Management & Finance	12 Life Long Learning
CO-1	Represent uncertainty using fuzzy sets	✓				3	85	75	3	3	2	2	2	-	-		3	-	-	3
CO-2	Deal with arithmetic operations on fuzzy numbers	✓	✓	✓		3	85	75	3	3	2	2	2	-	-	-	3	-	-	3
CO-3	Apply operations on fuzzy relations		✓			3	85	75	3	3	2	2	2	-	-	-	3	-	-	3
CO-4	Solve problem in LPP and graphs under fuzzy environment	✓	✓	✓	✓	3	85	75	3	3	2	2	2	-	-	-	3	-	-	3
CO-5	Solve problems in Fuzzy logics and control theory	✓	✓			3	85	75	3	3	2	2	2	-	-	-	3	-	-	3

Title & Session Outcomes	*Operations on Fuzzy sets*	*Fuzzy Arithmetic*	*Fuzzy Relations*	*Fuzzy Decision Making*	*Fuzzy Logic*
Duration (hour)	12	12	12	12	12
SO-1	*Sets - Basic definitions* *Fuzzy sets - Basic definitions*	*Introduction to Extension principle* *Extension principle*	*Introduction to binary relations* *Introduction to fuzzy binary relations*	*Introduction to decision making and fuzzy decision making* *Difference between decision making and fuzzy decision making* *Necessity of fuzzy decision making*	*Introduction to logics* *Basic concept of connectivity's*
SO-2	*Fuzzy complements* *Convex theorem – Fuzzy sets*	*Zadeh's Extension principle* *Problems on extension principles*	*Types to binary relations* *Types to fuzzy binary relations*	*Individual decision making* *Multi-person decision making*	*Introduction to fuzzy logics* *Basic concept of fuzzy connectivity's*

	Basic assumption convex fuzzy sets			*Multi-criteria decision making*	
SO-3	*Basic operations on fuzzy sets*	*Application of extension principle*	*Properties of binary relations* *Properties of fuzzy binary relations*	*Multi-stage decision making* *Fuzzy ranking method*	*Tautologies of crisp logics* *Contradiction of crisp logics*
SO-4	*Tutorial: Problems on Fuzzy Complements and operations on fuzzy sets.*	*Tutorial: Problems on extension principle*	*Tutorial: Problems on binary and fuzzy binary relations*	*Tutorial: Fuzzy decision making*	*Tutorial: Problems on fuzzy connectivity and fuzzy logics*
SO-5	*Union operations on fuzzy sets* *Intersection operations on fuzzy sets* *De-morgan's law for fuzzy sets*	*Image of fuzzy sets* *Problems on image of fuzzy sets*	*Equivalence relation* *Fuzzy equivalence relation*	*Introduction to LPP* *Introduction to fuzzy LPP*	*Tautologies of fuzzy logics* *Contradiction of fuzzy logics*
SO-6	*Types of fuzzy sets* *Problems on types of fuzzy sets*	*Inverse image of fuzzy sets* *Problems on inverse image of fuzzy sets*	*Partial ordering relation* *Fuzzy partial ordering relation*	*Problems on fuzzy LPP with crisp objective function* *Problems on fuzzy LPP with fuzzy objective function*	*Quantifiers* *Fuzzy quantifiers*
SO-7	*Cartesian products* *Problems on Cartesian products*	*Fuzzy numbers* *Types of fuzzy numbers*	*Closure of relation* *Fuzzy closure of relation*	*Problems on fuzzy LPP with fuzzy objective function with triangular numbers* *Problems on fuzzy LPP with fuzzy objective function with symmetric triangular numbers and Non- symmetric triangular numbers*	*Linguistic variables* *Fuzzy truth qualifiers*
SO-8	*Tutorial: Problems on Types of fuzzy sets and Cartesian products.*	*Tutorial: Problems on image and inverse image of fuzzy sets and types of fuzzy numbers*	*Tutorial: Problems on fuzzy equivalence relations, fuzzy partial order relations and fuzzy closure of relations*	*Tutorial: Problems on fuzzy LPP*	*Tutorial: Problems on fuzzy quantifiers*
SO-9	*Algebraic products* *Problems on algebraic products*	*Arithmetic operations on Intervals*	*Composition of relations* *Fuzzy composition of relations*	*Introduction to graphs* *Introduction to fuzzy graphs*	*Introduction to control theory* *Introduction to fuzzy control theory*
SO-10	*Bounded sum* *Problems on bounded sum*	*Arithmetic operations on fuzzy numbers* *Problems on arithmetic operations on fuzzy numbers*	*Max- composition of relation* *Min-composition of relation*	*Bellman ford algorithm for graphs* *Bellman ford algorithm for fuzzy graphs*	*Control theory in real world application* *Simple pendulum problems*
SO-11	*Bounded difference* *Problems on bounded difference*	*Solving interval equations* *Solving fuzzy equations*	*Maxi-min composition of fuzzy relation* *Problems on maxi-min composition of fuzzy relation*	*Flody's algorithm for graphs* *Flody's algorithm for fuzzy graphs*	*Problems on fuzzy control theory* *Applications of fuzzy control theory*
SO-12	*Tutorial: Problems on algebraic products, bounded sum and bounded difference*	*Tutorial: Problems on arithmetic operations on intervals and on fuzzy numbers, and problems on solving interval and fuzzy equations*	*Tutorial: Problems on fuzzy composition of relations and max-min composition of fuzzy relations*	*Tutorial: Problems on fuzzy graph algorithms*	*Tutorial: Problems on Control Theory*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1.	Remember										
2.	Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
3.	Apply										
4.	Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
5.	Evaluate										
6.	Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

Resources			
1	*Didier DuBois, Henri M. Prade, "Fuzzy Sets and Systems: Theory and Applications", Academic Press, 1994.*	*2*	*H. J. Zimmermann, Fuzzy set theory and its applications, 4TH edition, Allied publishers Ltd., New Delhi, 2001*
3	*G. J. Klir& B. Yuan, "Fuzzy sets and Fuzzy logic; Theory and Applications", Prentice Hall of India 1995*	*4*	*Trimothy J. Ross, "Fuzzy Logic with Engineering Applications", McGraw Hill, International Editions, 2010.*
5	*Buckley, James J., Eslami, Esfandiar, "An Introduction to Fuzzy Logic and Fuzzy Sets", PhysicaVerlag Heidelberg, 2002.*	*6*	*Guanrong Chen, Trung Tat Pham, "Introduction to fuzzy sets, fuzzy logic, and fuzzy control systems", CRC Press LLC, N.W. Florida, 2000*

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D5

Code	PMA25D05T	Title	Formal Languages and Automata Theory	Category	D	*Discipline Elective Course*	L	T	P	C
							3	1	0	4

Course Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	Nil

Rationale (CR)	*The purpose of learning this course is to:*	Depth				Attainment			Program Outcomes (PO)												
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
CR-1	*Introduce the student to the concepts of theory of computation in computer science*																			
CR-2	*Illustrate finite state machines to solve problems in computing*																			
CR-3	*Explain the hierarchy of problems arising in computer sciences*																			
CR-4	*Acquire insights into the relationship among formal languages , formal grammars and Automata*																			
CR-5	*Familiarize Regular grammars and context free grammars*																			

Outcomes (CO)	*At the end of this course, learners will be able to:*	Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices &Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CO-1	*Demonstrate an Understanding of abstract models of computing including deterministic and non-deterministic and turing machine models*	✓	✓	-	-	*2*	*85*	*75*	3	3	2	2	2	-	-		3	-	-	3
CO-2	*Demonstrate an Understanding of regular expressions and grammars including context -free and context- sensitive grammars*	✓	✓	✓	-	*2*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-3	*Understand the relationships between language classes including regular,context-free, context-sensitive and recursively enumerable languages*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-4	*Employ finite state machines for modeling and solving computing problems*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-5	*Design Turing machine*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3

Title & Content	*Finite Automata*	*Regular Grammars and Languages*	*Context-free grammars and Languages*	*Push Down Automata*	*Turing machine*
Duration (hour)	**12**	**12**	**12**	**12**	**12**
SO-1	*Finite Automata*	*Regular Grammar*	*Context – Free Grammars*	*Pushdown Automata*	*Standard Turing Machine*
SO-2	*Deterministic Finite Automaton and Languages*	*Right and Left linear Grammars*	*Context free languages*	*Deterministic Pushdown Automata*	*Turing Machine as Transducers*
SO-3	*Regular Languages*	*Regular Languages*	*Leftmost and Rightmost Derivations*	*Deterministic context – Free languages*	*Standard Turing Machine*
SO-4	*Tutorial: Problems on Finite Automata and Regular languages*	*Tutorial: Problems regular grammars and languages*	*Tutorial: Problems on context-free grammars and languages*	*Tutorial: Problems on Pushdown automata and deterministic pushdown automata*	*Tutorial: Problems on standard Turing Machines*
SO-5	*Regular Expressions ansd Regular Languages*	*Right linear Grammar for regular Languages*	*Derivation Trees*	*Pushdown Automata for context – Free languages*	*Models of Turing Machines*
SO-6	*Nondeterminstic Accepters*	*Connection between Regular expressions and regular languages*	*Relation between sentential form and Derivation Trees*	*Grammars for Deterministic context free languages*	*Combining Turing Machines for Cornplicated Tasks*
SO-7	*Non- Deterministic Finite Automaton and Language*	*Closure Properties of regular Languages*	*Ambiguity in Grammars and Languages*	*Non-Deterministic Pushdown Automata*	*Turing machine construction*
SO-8	*Tutorial: Regular expressions and regular languages, nondeterministic accpetors and non-deterministic finite automata*	*Tutorial: Problems on Right Linear Grammar for regular languages and closure properties*	*Tutorial: Problems on sentential form anf Derivation trees*	*Tutorial: Problems on Non-Deterministic Pushdown Automata*	*Tutorial: Problems on construction of Turing Machines*
SO-9	*Deterministic Accepters*	*Non Regular languages*	*Method of Transforming Grammars*	*Language accepted by a push down Automata*	*Non deterministic Turing machine*
SO-10	*Equivalence of deterministic and nondeterministic finite accepters*	*Pumping lemma*	*Chomsky Normal Form,*	*Pushdown Automata and context free languages*	*Turing Thesis*
SO-11	*Reduction of number of states in Finite Automata*	*Pumping lemma for context free languages*	*Griebach Normal form*	*Closure properties of Context – Free languages*	*Universal Turing Machine*
SO-12	*Tutorial: Problems on Deterministic acceptors, equivalence of deterministic and nondeterministic finite acceptors and reduction of number of states in finite automata*	*Tutorial: Problems on Pumping lemma*	*Tutorial: Problems on Transforming Grammars, Chomsky Normal Form, Greibach Normal Form*	*Tutorial: Problems on languages accepted by pushdown automata and context-free languages and closure properties*	*Tutorial: Problems on non-determinstc Turing Machines*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
7.	Remember										
8.	Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
9.	Apply										
10	Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
11	Evaluate										
12	Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Resources			
1.	*John E Hopcroft, Rajeev Motwani and Jeffrey D. Ullman, An Introduction to Automata Theory, Languages and Computation, Second Edition, Pearson –Addison Wesley 2001.*	*4.*	*Daniel I.A. Cohen, Introduction to computer theory, Second Edition, Wiley Publication, 1996.*
2.	*Micheal Sisper, Introduction to the theory of computation, Second Edition, Thomson Course Technology, 2006.*	*5.*	*Peter Linz, An Introduction to Formal Languages and Automata, Fifth Edition, Jones & Bartlett Learning ,2010*
3.	*Kamala Krithivasan, Rama R, Introduction to Formal Languages, Automata theory and Computation, Pearson Education ,2009*	*6.*	*Vivek Kulkarni, Theory of Computation, Oxford University Press,2013*

Designers					
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2		*2*		*2*	*2. Dr. Meena Parvathy Shankar, SRMIST, meenap@srmist.edu.in*

D6

Code	PMA25D06J	Title	Introduction to Mathematical Finance	Category	D	*Discipline Elective Course*	L	T	P	C
							3	0	2	4

Offering Department	Mathematics	Pre-requisite Courses	Introductory probability and statistics	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	Nil

Rationale (CR)	*The purpose of learning this course is to:*	Depth				Attainment		
		1	2	3	4	1	2	3
CR-1	*Provide an introductory on Financial Mathematics.*							
CR-2	*Understand Asset Pricing and Stochastic Process under Finance*							
CR-3	*Know the techniques of Black Scholes model, arbitrage, option values, European options, and American option in problem in Financial Engineering*							
CR-4	*Apply the concept of Stochastic differential equations in problems of Financial Engineering*							
CR-5	*Gain knowledge of Brownian motion and Binomial Methods in problems involving the Financial Engineering*							

Outcomes (CO)	*At the end of this course, learners will be able to:*	Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
CO-1	*Gain familiarity in the knowledge Stock Market, Investment and securities, Stock return, Risk, Option and futures.*	✓				*3*	*85*	*75*	3	3	2	2	2	-	-		3	-	-	3
CO-2	*Gain familiarity in the knowledge of Asset Pricing and its properties, Markov property and Martingale property its applications in the problems involving Mathematical Finance*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-3	*Gain knowledge in the solution of Stochastic differential equations, Ito Calculus, One-dimensional diffusion process, and Multidimensional diffusion process Its applications in financial engineering problems*		✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-4	*Gain the knowledge of Black Scholes equation, Arbitrage, European options, and American option in Mathematical Finance*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-5	*Gain the knowledge of Brownian motion, Limit of scaled random walks, and Binomial methods in the problems involving Financial Engineering*	✓	✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3

Title & Session Outcomes	***Introduction to Financial Market and Modern portfolio theory***	***Derivative pricing by replication in Binomial Model***	***Introductory stochastic Calculus***	***Risk neutral pricing in continuous time I***	***Risk neutral pricing in continuous time II***
Duration (hour)	**15**	**15**	**15**	**15**	**15**
SO-1	*Introduction to financial markets and Bonds*	*One-period binomial model with Example*	*Multivariable stochastic calculus*	*Black-Scholes-Merton (BSM) model, BSM equations and formula*	*Girsanov theorem, Risk Neutral pricing of derivatives*

SO-2	*Stocks Returns*	*The Fundamental Theorems of Asset Pricing*	*Stochastic differential equations*	*Scaling time and model parameters*	*MRT and Hedging, Multidimensional Girsanov and MRT*
SO-3	*Risk*	*The Binomial Asset Pricing Model*	*ITA integral and its properties*	*The role of volatility*	*Brownian motion, Limit of scaled random walks*
SO-4	*Tutorial: Exercise on Financial Markets and Bonds, Stocks Returns and Risk*	*Tutorial: Problems on One-period binomial model, Fundamental Theorems of Asset Pricing, Binomial Asset Pricing Model*	*Tutorial: Problems on Multivariate stochastic calculus, stochastic differential equations and ITA integrals*	*Tutorial: Exercises on BSM Model, Scaling time and Model parameters and volatility*	*Tutorial: Problems on Girsanov theorem, Risk Neutral pricing of derivatives, MRT and Hedging, Multidimensional Girsanov and MRT, Brownian motion, Limit of scaled random walks*
SO-5	*Introduction to Options*	*Pricing by replication in a multiperiod Model*	*ITA formula and ITA process*	*Calculation of Arbitrage and option value*	*Quadratic variation of Brownian motion, The problem of integration concerning Brownian motion*
SO-6	*Introduction to futures, forwards and swaps*	*Derivative pricing in Binomial model and Path dependent options*	*ITA formula and ITA process*	*Payoffs and Strategies, Greeks, Change of Measure*	*Binomial methods, Option valuation, Dividend-paying Stock*
SO-7	*Forward contracts*	*Introduction to Weiner process*	*One dimensional diffusion process: Numerical problem*	*Put-Call Parity, Similarity solution and Exact formulae for European options*	*Monte Carlo Simulation: valuation by simulation*
SO-8	*Tutorial: Exercises on Options, Futures, Forwards and Swaps*	*Tutorial: Exercises on Pricing by replication in a multiperiod model and Derivative Pricing in Binomial model and Path dependent options, and Weiner process*	*Tutorial: One- dimensional Diffusion process problems*	*Tutorial: Exercises on Calculation of Arbitrage and option values, payoffs and strategies, Greeks, Change of measure, Put-off parity, Similarity solution and exact formulae for European Options*	*Tutorial: Exercises on Quadratic variation of Brownian motion, The problem of integration concerning Brownian motion, Binomial methods, Option valuation, Dividend-paying Stock, Monte Carlo Simulation*
SO-9	*Interest rates and present values*	*Introduction to Markov property*	*Multidimensional diffusion process*	*American option, Call and Put options*	*Monte Carlo Simulation: valuation by simulation*
SO-10	*Present and future values*	*Martingales derivative Securities*	*Multidimensional diffusion process*	*Binomial Methods: Option valuation*	*Monte Carlo Simulation: valuation by simulation*
SO-11	*Annuities*	*European derivative Securities*	*Poisson Process*	*Dividend-paying stock*	*Grouping by Similarities*
SO-12	*Pricing by no-arbitrage principle considerations*	*The risk-neutral pricing of European derivatives in Binomial model*	*Poisson Process*	*General formulation and implementation*	*Stylized Empirical Facts of Asset Returns*
SO-13	*Market Index*	*The risk-neutral probability measure*	*Properties and problems based on Poisson process*	*General formulation and implementation*	*Stylized Empirical Facts of Asset Returns*
SO-14-15	*Tutorial: Exercises on Options, Pricing by no-arbitrage considerations and Market Index*	*Tutorial: Exercises on Markov Property, Derivative Securites and Risk-neutral probability measure.*	*Tutorial: Problems on multidimensional diffusion process and Poisson process*	*Tutorial: Exercises on American option, Call and Put options, Binomial Methods: Option valuation, Dividend-paying stock, General formulation and implementation*	*Tutorial: Problems on Monte Carlo Simulation, Grouping by Similarities, Stylized Empirical Facts of Asset Returns*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember	20%	20%	15%	15%	15%	15%	20%	20%	20%	20%
2	Understand										
3	Apply	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
4	Analyze										
5	Evaluate	10%	10%	15%	15%	15%	15%	10%	10%	10%	10%
6	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Strategies					
Technology		Pedagogy / Andragogy		Sustainable Development	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

Resources			
1	*D.G. Luenberger Investment Science, Oxford University Press-2009.*	2	*B. Oksendal, Stochastic Differential Equations An Introduction with Application, Springer-Verlag-2003*
3	*S. M. Ross, An Introduction to Mathematical Finance, Cambridge University Press, 1999*	4	*https://archive.nptel.ac.in/courses/111/103/111103126/ NPTEL*
5	*Christian Fries - Mathematical finance Theory, Modeling, Implementation, Wiley-2007*		

Designers					
Professional Experts		Higher Institution Experts		Internal Experts	
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2		2		2	*Dr. Tanmoy Chakraborty, SRMIST, tanmoyc@srmist.edu.in*

D7

Code	PMA25D07T	Title	Graph Theory and Algorithms	Category	D	*Discipline Elective Course*	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	Nil

Rationale (CR)	*The purpose of learning this course is to:*	Depth				Attainment		
		1	2	3	4	1	2	3
CR-1	*Learn about basic definition of Graphs.*							
CR-2	*Understand about Euler Graph, Hamiltonian Graph, Hamiltonian Path*							
CR-3	*Gain knowledge about Fundamental Circuits and Fundamental Cut Sets*							
CR-4	*Gain knowledge about Shortest Path Algorithm*							
CR-5	*Gain knowledge about Breadth First Search Algorithm*							
	Learn the concepts of Graphs and Algorithms							
Outcomes (CO)	*At the end of this course, learners will be able to:*	Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)
CO-1	*Know the application of Graph*	✓				*3*	*85*	*75*
CO-2	*Solve problems in Euler Graph, Hamiltonian Graph*	✓	✓	✓		*3*	*85*	*75*
CO-3	*Solve problems in Trees and Fundamental Circuits*		✓			*3*	*85*	*75*
CO-4	*Solve Problems using Shortest Path Algorithm*	✓	✓	✓	✓	*3*	*85*	*75*
CO-5	*Solve problems in Breadth First Search Algorithm*	✓	✓			*3*	*85*	*75*

Rationale (CR)	Program Outcomes (PO)											
	1	2	3	4	5	6	7	8	9	10	11	12
	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CO-1	3	3	2	2	2	-	-		3	-	-	3
CO-2	3	3	2	2	2	-	-	-	3	-	-	3
CO-3	3	3	2	2	2	-	-	-	3	-	-	3
CO-4	3	3	2	2	2	-	-	-	3	-	-	3
CO-5	3	3	2	2	2	-	-	-	3	-	-	3

Title & Session Outcomes	***Introduction to Graphs***	***Types of Graphs***	***Tree and circuits***	***Algorithms on Simple Graphs***	***Algorithm on Complex Graphs***
Duration (hour)	**12**	**12**	**12**	**12**	**12**
SO-1	*Introduction to Graphs*	*Definition of Euler Graphs and Hamiltonian Graphs*	*Definition of Trees*	*Introductions to Algorithms on Graphs*	*Introduction to Minimum Spanning Tree Algorithm*
SO-2	*Definitions of Graphs*	*Examples of Euler Graphs and Hamiltonian Graphs*	*Some Properties of Trees*	*Shortest Path Algorithms*	*Introduction to Kruskal's Algorithm*

SO-3	*Some Applications of Graphs*	*Theorem on Euler Graphs*	*Theorem on Trees*	*Application on Dijkstra's Algorithm*	*Problems on Breadth First Search Algorithm*
SO-4	*Tutorial:: Problems in application of Graph*	*Tutorial: Problems in Euler Graphs*	*Tutorial::Problems in Trees*	*Tutorial::Problems in Dijkstra"s*	*Tutorial: Problems in Breadth First Search*
SO-5	*Definition and examples of Incidence and Degree*	*Theorem on Hamiltonian Graphs*	*Theorem on Trees*	*Application to Floyd-Warshall's Algorithm*	*BFS Algorithm for construction of a Spanning Tree*
SO-6	*Definition and examples of Complete Graph*	*Introduction to Euler Tour and Euler Graph*	*Definition of Spanning Tree*	*Application to Floyd-Warshall's Algorithm*	*BFS Algorithm for construction of a Spanning Tree*
SO-7	*Definition of Bipartite Graph*	*Examples on Euler Tour and Euler Graph*	*Definition of Fundamental Circuits*	*Definition of Minimum Spanning Tree*	*Introduction to Depth First Search Algorithm*
SO-8	*Tutorial: Problems in Complete Graph*	*Tutorial::Problems in Euler Graph*	*Tutorial::Problems in Spanning Trees*	*Tutorial::Problems in Floyd-Warshall's Algorithm*	*Tutorial:: Problems in Depth First Search Algorithm*
SO-9	*Examples of Bipartite Graph*	*Definition of Hamiltonian Path, Maximal Non-Hamiltonian Graph*	*Theorem on Fundamental Circuits*	*Problems on Minimum Spanning Tree*	*Problems on Depth First Search Algorithm*
SO-10	*Definition of Directed Graph*	*Definition of Complement Graph*	*Properties of Fundamental Cut Sets*	*Objective of Minimum Spanning Tree Problem*	*DFS Algorithm for construction of a Spanning Tree*
SO-11	*Examples of Directed Graph*	*Examples on Complement Graph*	*Problems on Fundamental Cut Sets*	*Problems Solving using Minimum Spanning Tree*	*DFS Algorithm for construction of a Spanning Tree*
SO-12	*Tutorial::Problems in Bipartite Graph, Directed Graph*	*Tutorial::Problems in Hamiltonian Path, Complement Graph*	*Tutorial::Problems in Spanning Trees, Cut Sets*	*Tutorial::Problems in Minimum Spanning Tree*	*Tutorial: Problems in construction of a Spanning Tree using Depth First Search Algorithm*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1.	Remember										
2.	Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
3.	Apply										
4.	Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
5.	Evaluate										
6.	Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Resources			
1	*Santhanu Saha Ray, Graph Theory with Algorithms and its Applications, Springer India 2013*	*2*	*R. Balakrishnan and K Ranganathan, A Textbook of Graph Theory, New Delhi: Springer, 2008*
3	*J. A. Bondy and U.S.R. Murty, Graph Theory, Springer, 2008*	*4*	*J. Clark and D.A. Holton, A First Look At Graph Theory, Singapore: World Scientific, 2005.*
5	*Douglas B. West, Introduction to Graph Theory, Pearson Education(Singapore) ,2002*	*6*	*G. Chatrand and L. Lesniak, Graphs and Digraphs, Fourth Edition, Boca Raton: CRC Press, 2004.*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	*1*	*Prof. Y.V.S.S. Sanyasiraju, **IIT Madras** sryedida@iitm.ac.in*	*1*	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
2		*2*		*2*	*Dr. S. Vidyanandini, SRMIST, vidyanas@srmist.edu.in*

D8

Code	PMA25D08T	Title	Fluid Dynamics	Category	D	*Discipline Elective Course*	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	Nil

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Understand the basic concepts in fluid mechanics*
CR-2	*Understand and apply the conservation laws.*
CR-3	*Familiarize with vortex dynamics, velocity potential and stream functions*
CR-4	*Understand the importance of dimensional analysis*
CR-5	*Acquiring linear stability analysis of benchmark problems in fluid mechanics*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Depth: Conceive	Design	Implement	Operate	Attainment: Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	PO1 Disciplinary Knowledge	PO2 Problem Solving	PO3 Design & Development	PO4 Analysis, Design, Research	PO5 Modern Tool Usage	PO6 Society & Culture	PO7 Environment & Sustainability	PO8 Ethical practices & Social	PO9 Individual & Team Work	PO10 Communication	PO11 Project Management & Finance	PO12 Life Long Learning
CO-1	*Derive equation of continuity and to solve problems on steady and unsteady flow.*	✓				*3*	*85*	*75*	3	3	2	2	2	-	-		3	-	-	2
CO-2	*Derive equation of motion of fluid in different forms and to understand the fluid flow in different geometries.*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	2
CO-3	*Solve problems on two dimensional flows with source, sink and doublets*		✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	2
CO-4	*Derive and solve problems on steady, viscous flow.*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	2
CO-5	*Derive Navier-Stoke's equation and to analyze problems on instability.*	✓	✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	2

Title & Session Outcomes	*Kinematics Of Fluids In Motion*	*Equations Of Fluid Motion*	*Some Two-Dimensional Flows*	*Three-Dimensional Steady Flows*	*Boundary Layer Theory*
Duration (hour)	12	12	12	12	12
SO-1	*Real and ideal fluids, Velocity of fluid*	*Pressure at a point in a fluid, Pascal's law for static fluids*	*Two dimensional flows, Problems on 2D flows*	*Dimensional analysis, Buckingham's pi theorem*	*Boundary layer approximation*
SO-2	*Streamlines*	*Pressure at a point in moving fluid, Boundary conditions of two inviscid immiscible fluids*	*Use of cylindrical polar co-ordinates, Stream function*	*Dynamic similarity, Dimensionless numbers, Reynolds number*	*Boundary layer on a flat plate with a sink at the leading edge: Closed form solution*
SO-3	*Path lines, Steady and unsteady flows*	*Problems on fluid pressure, Euler equation of motion*	*Complex potential for two-dimensional flows, irrotational, incompressible flow*	*Vorticity diffusion, Vorticity for 2 dimensional case*	*Boundary layer on a flat plate: Blasius solution*

SO-4	*Tutorial: Problems on velocity of fluids, streamlines and pathlines*	*Tutorial: Problems on fluid pressure and Euler equation of motion*	*Tutorial: Problems on 2D flows, cylindrical polar co-ordinates, complex potential, irrotational, incompressible flow*	*Tutorial: Problems on dynamic similarity and vorticity diffusion*	*Tutorial: Problems on boundary layers*
SO-5	*Some Vector identities, Results of cartesian tensor analysis*	*Bernoulli's equation, Other forms of Bernoulli's equation*	*Complex potential for standard two-dimensional flows, Uniform stream line source, line sink and Line doublets*	*Analogy between heat and vorticity diffusion.*	*Effect of pressure gradient, Separation*
SO-6	*Problems on velocity potential, streamlines, Vorticity vector*	*Some potential theorems, Potential uniqueness theorems*	*Two dimensional image systems, Milne-Thomson circle theorem, Theorem of Blasius*	*Steady flow between parallel plates*	*Description of flow past a Circular Cylinder*
SO-7	*Local rate of change, particle rate of change*	*Flows involving axial symmetry*	*Conformal Transformation*	*Steady flow in a circular pipe, Steady flow in a circular cross section.*	*Description of flow past a Sphere*
SO-8	*Tutorial: Problems on vector identities, Cartesian tensor analysis and on finding local rate of change and particle rate of change*	*Tutorial: Problems on Bernoulli's equation and potential theorems*	*Tutorial: Problems on complex potential for standard 2D flows, uniform stream line source, line sink and line doublets, 2D image systems, Milne-Thomson circle theorem, Blasius Theorem and Conformal transformation*	*Tutorial: Problems on steady flow*	*Tutorial: Problems on pressure gradient and flow past*
SO-9	*Equation of continuity, Continuity equation for particular cases*	*Discussion of the case of steady motion under conservative body forces*	*Some Hydrodynamical aspects of Conformal Transformation*	*Concentric cylinders*	*Methods of Normal modes, Thermal instability: The Benard problem*
SO-10	*Problems on steady flow, Problems on incompressible flow*	*Impulsive motion*	*The Schwarz-Christoffel Transformation*	*Steady flow between two co-axial cylinders*	*Double-Diffusive Instability*
SO-11	*Conditions at a rigid boundary, Condition for viscous fluid*	*Some Further Aspects of Vortex Motion*	*Vortex Rows, Single infinite Row of Line vortices,*	*Creeping flow around a sphere*	*Kelvin- Helmholtz Instability*
SO-12	*Tutorial: Problems on equation of continuity, steady flow, incompressible flow, conditions at a rigid boundary and viscous fluid*	*Tutorial: Problems on the steady motion under conservative body forces, impulsive motion and vortex motion*	*Tutorial: Problems on Schwarz-Christoffel transformation, Vortex rows, single infinite row of line vortices*	*Tutorial: Problems on steady flow*	*Tutorial: Problems in instability*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1.	Remember										
2.	Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
3.	Apply										
4.	Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
5.	Evaluate										
6.	Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

Resources			
1	*F. Chorlton, Textbook of Fluid Dynamics, CBS Publishers, 1998.*	*2*	*P. K. Kundu and I. M. Cohen, Fluid Mechanics, Academic Press London, 2002.*
3	*Pozrikidis, Fluid dynamics, Springer US, 3rd Edition, 2017.*	*4*	*G. K. Batchelor, An Introduction to Fluid Dynamics, Cambridge Press, 2nd Ed., 2000.*
5	*F. M. White, Fluid Mechanics, McGraw Hill, New York, 8th Ed., 2015*	*6*	*G. Drazin and W. H. Reid, Hydrodynamic Stability, Cambridge Press, 2nd Ed., 2004.*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	*1*	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	*1*	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
		2		*2*	*Dr. J. Sasikumar, SRMIST, sasikumj@srmist.edu.in*

D9

Code	PMA25D09J	Title	Mathematical Modelling and Simulation	Category	D	*Discipline Elective Course*	L	T	P	C
							3	0	2	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXXX

Rationale (CR)	*The purpose of learning this course is to:*	Depth				Attainment			Program Outcomes (PO)												
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
CR-1	*Understand and evaluate the linear and nonlinear models*																			
CR-2	*Emphasize the significance of compartmental models*																			
CR-3	*Gain comprehensive knowledge and sound understanding of phase-plane analysis and linear optimization*																			
CR-4	*Recognize the nonlinear optimization methods- Develop skills on practical, analytical problem solving in some parts of mathematical modelling*																			
CR-5	*Understand the concepts, models of basic Neural Networks*																			

Outcomes (CO)	*At the end of this course, learners will be able to:*	Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CO-1	*Understand the linear models*	✓				*3*	*85*	*75*	3	3	2	2	2	-	-		3	-	-	3
CO-2	*Emphasize the significance of compartmental models*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-3	*Gain comprehensive knowledge and sound understanding of phase-plane analysis and linear optimization*		✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-4	*Recognize the nonlinear optimization methods*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-5	*Understand the concepts, models of Neural Networks*	✓	✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3

Title & Session Outcomes	***Linear and Nonlinear Models***	***Case Studies of Different Models***	***Phase Plane Analysis***	***Optimization Models***	***Basic Neural Networks***
Duration (hour)	**15**	**15**	**15**	**15**	**15**
SO-1	*Modelling with linear systems - Some Vector and Matrix Arithmetic*	*Compartmental models-Introduction - Exponential decay*	*Interacting population models -Model of a battle - Case Study: Rise and fall of civilizations*	*Linear Optimization -The Transportation Problem*	*Basic concepts of Neural Networks-Model of an Artificial Neuron-Neural Network Architectures*
SO-2	*Modelling with linear systems - Stability and Eigenvalues*	*Compartmental models- Case Study: Detecting art forgeries - Scenario: Pacific rats colonise New Zealand*	*Phase-Plane Analysis-Introduction - Phase-plane analysis of epidemic model*	*Linear Optimization -The Assignment Problem and Binary Constraints*	*Single, Multilayer Feedforward Network-Recurrent Networks*

SO-3	*Modelling with linear systems - Stability and Eigenvalues*	*Compartmental models-Lake pollution models- Case Study: Lake Burley Griffin*	*Phase-Plane Analysis- Phase-plane analysis of epidemic model*	*Linear Optimization -The Transportation Problem*	*Characteristics of Neural Networks, Learning Methods-Early Neural Network Architectures*
SO 4-5	*Practice 1: Simulations using Linear and Nonlinear Models*	*Practice 4: Simulations on compartmental models*	*Practice 7: Simulation for the above criteria's*	*Practice 10: Simulation on the above topics*	*Practice 13: Simulation on the above topics*
SO-6	*Modelling with linear systems - Stability and Eigenvalues – Non-homogeneous systems*	*Compartmental models-Drug assimilation into the blood - Case Study: Dull, dizzy or dead?*	*Phase-Plane Analysis- Analysis of a battle model*	*Nonlinear Optimization Introduction*	*Perception and linearly separable tasks, XOR problem*
SO-7	*Nonlinear Equations and Models - Some Nonlinear Models*	*Compartmental models-Cascades of compartments - Case Study: Money makes the world go around*	*Phase-Plane Analysis- Analysis of a battle model - Analysis of a predator-prey model*	*Nonlinear Optimization- Newton's Method*	*ADALINE Network-MADALINE Network*
SO-8	*Nonlinear Equations and Models - Some Nonlinear Models - Autonomous Equations and Their Dynamics*	*Interacting population models – Introduction - Interacting population models- Model for an influenza outbreak*	*Phase-Plane Analysis- Analysis of competing species models - Closed trajectories for the predator-prey*	*Nonlinear Optimization-Newton's Method*	*Application Domains-Backpropagation Network*
SO 9-10	*Practice 2: Simulations using Nonlinear Models*	*Practice 5: Simulations on the above case studies*	*Practice 8: Simulations on the above case studies*	*Practice 11: Simulation for Nonlinear Optimization*	*Practice 14: Simulation on the above topics*
SO-11	*Nonlinear Equations and Models - Autonomous Equations and Their Dynamics*	*Interacting population models -Case Study: Cholera - Predators and prey*	*Phase-Plane Analysis-Case Study: Bacteria battle in the gut*	*Nonlinear -The Golden Section - Nonlinear Optimization -The One-Dimensional Gradient Method*	*Architecture-Perception Model, Single layer Artificial Neural Network-Multilayer Neural Network*
SO-12	*Modelling with Nonlinear Systems - Linearization and Local Dynamics*	*Interacting population models -Scenario: Nile Perch catastrophe - Case Study: It's a dog's life: More on the control of stray dogs*	*Linear Optimization - Introduction - Linear Programming*	*Nonlinear Optimization-Two-Dimensional Gradient Method - Lagrange Multipliers*	*Method of steepest Descent, Effect of Learning Rate 'η' -Backpropogation Algorithm*
SO-13	*Modelling with Nonlinear Systems - Linearization and Local Dynamics*	*Interacting population models - Competing species - Scenario: Aggressive protection of lerps and nymphs*	*Linear Optimization -Linear Programming*	*Nonlinear Optimization-The Traveling Salesman Problem*	*Algorithm BPN ()-Illustration of Algorithm with training sets.*
SO 14-15	*Practice 3: Simulations using Nonlinear Models and Basic ODE Solving techniques*	*Practice 6: Simulations on above case studies*	*Practice 9: Simulations on Linear optimization*	*Practice 12: Simulation on Nonlinear optimization*	*Practice 15: Simulation on the above topics*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1.	Remember										
2.	Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*20%*	*20%*	*20%*	*20%*
3.	Apply										
4.	Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
5.	Evaluate										
6.	Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*10%*	*10%*	*10%*	*10%*
Total		100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

Resources			
1	*Marotto, F. R., "Introduction to Mathematical Modelling using Discrete Dynamical Systems", Thomson Brooks/Cole. (2006)*	*2*	*J. D. Murray, "Mathematical Biology: I. An Introduction, Third Edition" Springer-Verlag Berlin Heidelberg. (2001)*
3	*Albright, B., "Mathematical Modelling with Excel", Jones and Bartlett Publishers. (2010)*	*4*	*Gordon, Steven I.; Guilfoos, Brian "Introduction to Modelling and simulation with MATLAB and Python" Chapman & Hall/CRC (2017)*
5	*Barnes, B. and Fulford, G. R., "Mathematical Modelling with Case Studies", CRC Press, Taylor and Francis Group. (2009)*	*6*	*Allen B. Downey, "Modelling and simulation in Python" Green Tea Press (2017)*
7	*S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks,Fuzzy Logic, And Genetic Algorithms: Synthesis and Applications, PHI Learning Pvt. Lmt., 2011.*	*8*	*S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Systems, And Evolutionary Algorithms: Synthesis andApplications, PHI Learning Pvt. Lmt., 2017.*
9	*Hideyuki Takagi, Introduction to Fuzzy Systems, Neural Networks, and Genetic, Algorithms, Springer Link,*		

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	*1*	*Prof. Y.V.S.S. Sanyasiraju, **IIT Madras** sryedida@iitm.ac.in*	*1*	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
2		*2*		*2*	*Dr. Athithan, SRMIST, athithas@srmist.edu.in*

G1

Course Code	PCY25G02T	Course Name	Chemistry of Biomolecules	Course Category	G	Generic elective course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemistry	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning	Program Learning Outcomes (PLO)

Rationale (CR)	The purpose of learning this course is to:	Depth				Attainment			Program Outcomes (PO)											
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
CLR-1	Provide basic understanding about the biomolecules like amino acids, proteins, nucleic acids, lipids and carbohydrates	Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices &Social	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CLR-2	appreciate the role of these biomolecules in biology.																			
CLR-3	gain knowledge about enzymes and coenzymes																			
CLR-4	apply the information gained about enzymes and coenzymes into organic chemistry applications like molecule synthesis																			
CLR-5	gain knowledge about amino acids and proteins and their structural features																			
Outcomes (CO)	At the end of this course, learners will be able to:																			
CLO-1	apply the information gained about enzymes and coenzymes into organic synthesis.	✓	✓	✓	✓	4	85	75	3	-	-	-	3	-	-	-	-	-	-	2
CLO-2	understand the importance of nucleic acid in bioorganic chemistry	✓	✓	✓	✓	4	85	75	-	-	3	3	3	-	-	-	-	-	-	-
CLO-3	understand the importance of carbohydrate chemistry	✓	✓	✓	✓	4	85	75	-	3	-	3	3	-	-	-	-	-	-	3
CLO-4	understand the significant role of amino acid, peptides and proteins in bioorganic chemistry	✓	✓	✓	✓	4	85	75	2	3	-	3	2	-	-	-	-	-	-	-
CLO-5	understand interactions between amino acids, peptides, nucleic acids and their role in biomolecule structure	✓	✓	✓	✓	4	85	75	3	-	-	2	3	-	-	-	-	-	-	-

Session	CLO-1	CLO-2	CLO-3	CLO-4	CLO-5
	Properties of Amino acids, Peptides and proteins	Importance Enzymes and coenzymes	Introduction to Nucleotides and nucleosides	Fatty Acids and Lipids	Structures and properties Carbohydrates
	(12)	(12)	(12)	(12)	(12)

SLO-1	Classification and structure of amino acids	Enzymes, Classification	Nature of genetic material	Fatty acids classification	Classification of carbohydrates
SLO-2	Configuration of amino acids, acid-base properties and isoelectric point	Kinetics, inhibition	**Structure of purine and pyrimidine**	Nomenclature, structure of fatty acids	Stereo isomerism of sugars
SLO-3	Separation of amino acids	Mechanisms of enzyme action	Nucleotides and nucleosides	Properties of fatty acids	Optical isomerism of sugars
SLO-4	Tutorial: Question answer session	Tutorial: Question answer session	Tutorial: Question answer session	Tutorial: Question answer session	Tutorial: Question answer session
SLO-5	Peptide bonds, disulfide linkages	Cofactors as derived from vitamins, co-enzymes	Types of nucleic acids	**Structure and function of prostaglandins, tri-acyl glycerol**	Mutarotation, occurrence,
SLO-6	Proteins classification based on solubility, shape, composition and function,	Prosthetic, prosthetic group and apoenzymes	Structure of DNA	Structure and functions of phospholipids,	Structure of mono and di saccharides
SLO-7	Structure of polysaccharides	Structure and biological functions of coenzyme-A	Properties of nucleic acids	Spingomyelin	Biological importance of mono, di and polysaccharides
SLO-8	Tutorial: Problem solving	Tutorial: Problem solving	Tutorial: Problem solving	Tutorial: Problem solving	Tutorial: Problem solving
SLO-9	Structure of proteins, Determination of the primary structure of a protein, secondary, tertiary and quaternary structures	Thiamine pyrophosphate, pyridoxal phosphate	Hypo and hyperchromicity	Plasmologens	An introduction to mucopolysaccharides
SLO-10	Determination of the primary structure of a protein, secondary, tertiary and quaternary structures,	NAD+, NADP+ , FAD, lipoic acid	Transcription and translation	Structure and function of glycolipids,	Reactions of carbohydrates due to the presence of hydroxyl, aldehyde and ketone groups.
SLO-11	Protein denaturation.	Overview of reactions catalysed by the above cofactors	Determination of the base sequence of DNA	Cholesterol.	Reactions of carbohydrates due to the presence of hydroxyl, aldehyde and ketone groups.
SLO-12	Tutorial: Practice	Tutorial: Practice	Tutorial: Practice	Tutorial: Practice	Tutorial: Practice

Learning Resources	1. D. 1. Nelson, 2. 2. Cox, Lehninger Principles of Biochemistry, 5th Ed., W. 3. Freeman; New York, USA, 2005. 2. R. K. Murray, D. K. Grammer, Harper's Biochemistry, 29th Ed., McGraw Hill, Lange Medical Books, United Kingdom, 2009. 3. J.1. Jain, S. Jain, N. Jain, Fundamentals of Biochemistry, S. Chand & Company. India, 2013. 4. P. Y. Bruice, Organic Chemistry, 5th Ed., Pearson, 2014.

Assessment						
Bloom's Level of Thinking		Continuous Learning Assessment (CLA) (50% weightage)				Final Assessment (50 % weightage)
		CLA - 1	CLA - 2	CLA - 3	CLA – 4*	
		(10 %)	(10 %)	(20 %)	(10%)	
		Theory (%)	Theory (%)	Theory (%)	Theory (%)	Theory (%)
1	Remember	15	15	10	10	15
2	Understand	15	15	10	10	15
3	Apply	20	25	25	25	25
4	Analyze	20	25	25	25	25
5	Evaluate	15	10	15	15	10
6	Create	15	10	15	15	10
Total (%)		100	100	100	100	100

Strategies					
Technology		Pedagogy / Andragogy		Sustainable Development	
Simulations	-	Clarification/Pauses	✓	Good Health & Well Being	✓
Presentation Tools	-	Group Discussion	✓	Quality Education	✓
Learning Management System	✓	Hands-on Practice	-	Gender Equality	✓
		Debate	-		
		Interactive Lecture	✓		
		Brainstorming	✓		

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

Designers					
Professional Experts		Higher Institution Experts		Internal Experts	
1	Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) || Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com	1	Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in	1	Dr. Priyadip Das, Department of Chemistry, SRMIST Email id: priyadip@srmist.edu.in
		2	Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in	2	Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in

G2

Code	PMA25G01T	Title	Mathematics for Artificial Intelligence	Category	G	*Generic Elective course*	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXX

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Understand the solution methods for solving system of linear equations*
CR-2	*Acquaint knowledge on the concept of Linear transformation*
CR-3	*Understanding the concept of eigenvalues and eigenvectors*
CR-4	*Understand the concept of probability and random variable*
CR-5	*Acquire knowledge in Probability distribution*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Depth				Attainment			Program Outcomes (PO)												
		1 Conceive	2 Design	3 Implement	4 Operate	1 Level of Thinking	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Disciplinary Knowledge	2 Problem Solving	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethical practices & Social Responsibility	9 Individual & Team Work	10 Communication	11 Project Management & Finance	12 Life Long Learning
CO-1	*Apply formulation and solution procedure of system of linear equation*	✓				*3*	*85*	*75*	3	3	2	2	3	-	-	-	3	-	-	3
CO-2	*Gain familiarity with linear transformation*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	3	-	-	-	3	-	-	3
CO-3	*Gain knowledge in decomposition techniques of matrices*		✓			*3*	*85*	*75*	3	3	2	2	3	-	-	-	3	-	-	3
CO-4	*Understand about probability and random variables*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	3	-	-	-	3	-	-	3
CO-5	*Solve problems in probability distributions*	✓	✓			*3*	*85*	*75*	3	3	2	2	3	-	-	-	3	-	-	3

Title & Session Outcomes	***Matrices***	***Linear Algebra***	***Matrix Decomposition***	***Introduction to Probability***	***Probability Distributions***
Duration (hour)	**12**	**12**	**12**	**12**	**12**
SO-1	*Introduction to System of linear equations*	*Linear transformation*	*Determinant and trace*	*Introduction to probability*	*Introduction to probability distributions*
SO-2	*Introduction to Matrices*	*Matrix representation of linear transformation*	*Testing of matrix invertibility*	*Addition and multiplication theorems*	*Binomial distribution*
SO-3	*Matrix addition, multiplication, inverse and transpose*	*Image and Kernel of linear transformation*	*Eigenvalues and eigenvectors*	*Conditional probability*	*Poisson distribution*

SO-4	*Tutorial: Problems in matrix operations*	*Tutorial:: Problems in kernel of linear transformation*	*Tutorial:: Finding eigen values and eigen vectors of given matrix*	*Tutorial:: Problems in conditional probability*	*Tutorial: Problems in Poisson distribution*
SO-5	*Rank of a matrix*	*Rank-nullity theorem*	*Geometric multiplicity*	*Random variable*	*Geometric distribution*
SO-6	*Row reduced echelon form*	*Affine space and mapping*	*Spectral theorem*	*Discrete random variable*	*Uniform distribution*
SO-7	*Inverse of a matrix by Gauss elimination method*	*Norms*	*Eigenvalue decomposition*	*Continuous random variable*	*Normal distribution*
SO-8	*Tutorial: Finding inverse of a matrix*	*Tutorial::Problems in finding norms*	*Tutorial: problems in eigen value decomposition of matrix*	*Tutorial:: Problems in continuous random variable*	*Tutorial:: Problems in Normal distribution*
SO-9	*Vector space and subspace*	*Inner product space*	*Constrained and Unconstrained optimization*	*Expectation*	*Exponential distribution*
SO-10	*Linear dependence and independence*	*Orthogonality*	*Optimization using Gradient Descent*	*Correlation coefficient*	*Exponential distribution*
SO-11	*Linear span and basis*	*Orthonormal basis*	*Optimization using Lagrange's Multiplier*	*Regression lines*	*Negative binomial distribution*
SO-12	*Tutorial::Finding linear span and basis of vectors*	*Tutorial:: Finding orthonormal basis for given vectors*	*Tutorial::Problem solving by Lagrange's multiplier*	*Tutorial::Problems in regression lines*	*Tutorial:: Problems in functions of Exponential and Negative Binomial Distributions*

Assessment

Level of Thinking		**Continuous Learning Assessment (CLA)** (50 % weightage)								**Final Exam** (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
2	Understand										
3	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
4	Analyze										
5	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
6	Create										
Total		100 %		100 %		100 %		100 %		100 %	

Strategies

Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Resources			
1	*Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong, Mathematics for machine learning, Cambridge University press, 2020*	2	*XIAN-DA ZHANG, A Matrix Algebra Approach to Artificial Intelligence, Springer 2020.*
3	*Lipschutz. S and Schiller. J, "Schaum's outlines - Introduction to Probability and Statistics", McGraw-Hill, New Delhi, 1998*	4	*Hoffman and R. Kunze, Linear Algebra, 2nd Ed., Prentice Hall of India, 2005.*
5	*S. Axler, Linear Algebra Done Right, 2nd Ed., Springer UTM, 1997*	6	*T. Veerarajan, "Probability, Statistics and Random Processes", Tata McGraw - Hill Publishing Company Limited, New Delhi, 2004*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	*1*	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	*1*	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
2		*2*		*2*	*S. Mohanaselvi, SRMIST, mohanass@srmist.edu.in*

G3

Code	PMA25G02T	Title	Mathematics for Physicists	Category	G	*Generic Elective Course*	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	Nil

Rationale (CR)	*The purpose of learning this course is to:*	Depth				Attainment			Program Outcomes (PO)												
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
CR-1	*Develop knowledge in mathematical physics and related theorems*																			
CR-2	*Develop expertise in mathematical techniques and the mathematics behind it*																			
CR-3	*Enhance problem solving skills and efficiency with necessary mathematics*																			
CR-4	*Enable students to formulate, interpret and draw logical conclusions from mathematical solutions.*																			
CR-5	*Understand the axiomatic structure of mathematics and untraceable connection between mathematics and physics*																			

Outcomes (CO)	*At the end of this course, learners will be able to:*	Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CO-1	*Understand the probability and the probability distribution in describing the uncertainty in physics*	✓				*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-2	*Understand and develop the solutions for Differential equations*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-3	*Understand Beta, Gamma and Dirac delta functions as very important special functions*		✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-4	*Understand and apply complex analysis techniques*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-5	*Understand and develop the solutions for integral equations*	✓	✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3

Title & Session Outcomes	***Probability Theory***	***Differential equations***	***Some Special functions***	***Analytic functions***	***Integral equations***
Duration (hour)	**12**	**12**	**12**	**12**	**12**
SO-1	*Definition of Probability and Axioms of Probability Theory*	*Differential equation -Introduction*	*Beta Function-Introduction and Convergences of Beta function*	*Analytic function -Introduction*	*Integral Equation: Definition, Examples and Classifications*
SO-2	*Random Experiment , Elementary events and Sample space*	*Formation of differential equation*	*Trigonometric form and Various properties of Beta functions*	*Cauchy-Riemann equation*	*Volterra equations of first kind*

SO-3	*Conditional Probability*	*Exact differential equation*	*Gamma function –Introduction and Convergences of Gamma function*	*Harmonic function*	*Volterra equations of second kind*
SO-4	*Tutorial: Problems in probability*	*Tutorial: Problem in Exact differential equation*	*Tutorial :Beta and Gamma functions*	*Tutorial: Problems in Analytic functions*	*Tutorial: Volterra equations*
SO-5	*Bayes Theorem*	*Leibnitz's differential equation*	*Weierstrass form of Gamma function*	*Construction of analytic function Milne-Thomson method*	*Fredholm integral equations first and second kind*
SO-6	*Binomial Distribution*	*Homogeneous and Non-homogeneous Second order Differential equation*	*Relation between Gamma and Beta function*	*Line integration in complex function*	*Transformation of a differential equation into an integral equation*
SO-7	*Poisson Distribution*	*Complementary function and General method to find the Particular integral*	*Integral representation of Gamma relevant to Bessel function*	*Cauchy integral formula*	*Neumann series*
SO-8	*Tutorial: Problems in Distribution*	*Tutorial: Problems in differential equation with constant coefficient*	*Tutorial: Bessel function*	*Tutorial: Cauchy integral formula*	*Tutorial: Fredholm integral equation and Neumann series*
SO-9	*Gaussian Distribution*	*Non-homogeneous differential equation with variable coefficient*	*Dirac Delta function and its first appearance*	*Taylor's Series and Laurent's Series*	*Separable kernels*
SO-10	*Correlation-correlation coefficient*	*Non-homogenous differential equation with variable coefficient*	*Working definition of Delta function*	*Cauchy residue theorem*	*Non-homogeneous integral equation*
SO-11	*Linear Regression*	*Series solutions- Frobenius method*	*Various properties of Delta function*	*Contour Integration*	*Green's function in one dimension as kernel of integral equation*
SO-12	*Tutorial: Problems in Correlation and Regression*	*Tutorial: Problems using Frobenius method*	*Tutorial: Delta function*	*Tutorial: Contour Integration*	*Tutorial: Greens function*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember										
2	Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
3	Apply										
4	Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
5	Evaluate										
6	Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Resources			
1	*G. Arfken and H.J. Weber, Mathematical Methods for Physicists, 6th Ed., Academic Press, SanDiego, 2005.*	*2*	*P.K. Chattopadhyay, Mathematical Physics, Wiley Eastern, New Delhi, 2005.*
3	*M.R. Spiegel, Schaum's Outline of Advanced Mathematics for Engineers and Scientists, 1st Ed., McGraw Hill, 2009.*	*4*	*M.L. Boas, Mathematical Methods in the Physical Sciences, 3rd Ed., John Wiley, 2005.*
5	*M.R. Spiegel, Seymour Lipschutz, John J. Schiller, and Dennis Spellman, Probability and statistics, 2nd Ed., McGraw Hill, 2009.*	*6*	*P.K. Chattopadhyay, Mathematical Physics, 1st Ed., New Age International, 2009.*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	*1*	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in*	*1*	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
		2		*2*	*Dr. S. Sangeetha, SRMIST, sangeets@srmist.edu.in*

G4

Code	PMA25G03T	Title	Multivariate Analysis and Non-Parametric Test	Category	G	Generic Elective Course	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	Nil

Rationale (CR)	The purpose of learning this course is to:	Depth				Attainment			Program Outcomes (PO)												
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
		Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CR-1	*Develop independent and critical thinking skills with respect to multivariate data.*																			
CR-2	*Understand the appropriateness of advanced statistical concepts.*																			
CR-3	*Learn how to analyze multivariate and multi-dimensional data.*																			
CR-4	*Do data reduction, dimensionality reduction, data handling, data pre-processing and cantering.*																			
CR-5	*Learn and apply various Nonparametric Tests.*																			
Outcomes (CO)	*At the end of this course, learners will be able to:*																			
CO-1	*Gain experience in analyzing multivariate models, methods and techniques.*	✓				*3*	*85*	*75*	3	3	2	2	2	-	-		3	-	-	3
CO-2	*Demonstrate the knowledge and skill of multivariate normal distributions, related probability distributions and their applications.*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-3	*Analyze high-dimensional data sets with suitable regularization techniques.*		✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-4	*Apply dimension reduction techniques in various fields.*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-5	*Make good choices among available nonparametric approaches.*	✓	✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3

Title & Session Outcomes	*Multivariate Data & Random vectors*	*Normal Distribution Theory*	*Factor Analysis*	*Discrimination Analysis*	*Non-Parametric Tests*
Duration (hour)	12	12	12	12	12
SO-1	*Multivariate Data: Introduction*	*Multivariate Normal Distribution-Introduction*	*Applications of Multivariate Analysis*	*Discriminant Analysis*	*Nonparametric Tests: Introduction and Concept*
SO-2	*Multiple regression*	*Multivariate Normal Distribution and its properties.*	*Principal Component Analysis as a Dimensional Reduction Technique*	*Two Group Discriminant Analysis: Analytical approach to DA*	*Test for randomness based on total number of runs*
SO-3	*Multiple and partial correlation coefficients*	*Problems on Multivariate Normal distribution and its properties*	*Analytical approach – Issues relating to PCA.*	*Problems on Discriminant Analysis*	*Test for randomness based on total number of runs*

SO-4	*Tutorial problems on multiple and partial coefficients*	*Tutorial problems on Multivariate normal distribution*	*Tutorial problems on principal component analysis*	*Tutorial problems on discriminant analysis*	*Tutorial problems on randomness based test*
SO-5	*Random Vector: Probability mass/density functions, Distribution function*	*Multinomial Distribution-Introduction*	*Factor Analysis: Two Factor Model*	*Regression approach to DA*	*Empirical distribution function*
SO-6	*Mean vector & Dispersion matrix*	*Multinomial Distribution and its properties.*	*More than TWO Factors*	*Stepwise DA*	*One Sample Tests: Kolmogorov-Smirnov*
SO-7	*Maximum Likelihood Estimation of Mean vector and Dispersion matrix and their Independence*	*Problems based on Multinomial Distribution and its properties.*	*Geometrical view of Factor Analysis (Factor Rotation)*	*Problems on Stepwise DA*	*Sign test*
SO-8	*Tutorial problems on mean vector and dispersion matrix*	*Tutorial problems on multinomial distribution*	*Tutorial problems on factor analysis*	*Tutorial problems on stepwise DA*	*Tutorial problems on Sign test*
SO-9	*Marginal-Introduction and problems*	*Tests for partial correlation coefficients.*	*Estimation of Communalities problem*	*External Validation of the Discriminant Function*	*Signed rank test.*
SO-10	*Conditional distributions- Introduction and problems*	*Tests for Multiple correlation coefficients.*	*Comparison of FA and PCA.*	*Fisher's Linear Discriminant Function.*	*Wilcoxon-Mann-Whitney test.*
SO-11	*Characteristic functions*	*Problems based on Tests for Multiple and partial correlation coefficients.*	*Problems based on FA and PCA.*	*Problems on Fisher's Linear Discriminant Function.*	*Kruskal-Wallis test.*
SO-12	*Tutorial problems on marginal and Conditional distributions*	*Tutorial problems on Tests for Multiple and partial correlation coefficients.*	*Tutorial problems on FA and PCA*	*Tutorial problems on Fisher's Linear Discriminant Function.*	*Tutorial problems on One Sample Tests.*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
2	Understand										
3	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
4	Analyze										
5	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
6	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Strategies					
Technology		Pedagogy / Andragogy		Sustainable Development	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

Resources			
1	*Anderson, T.W., An Introduction to Multivariate Statistical Analysis, 3rdEdn., John Wiley, 2003*	2	*Goon, A.M., Gupta, M.K. and Dasgupta, B., Fundamentals of Statistics, Vol. I, 8th Edn. The World Press, Kolkata, 2002*
3	*Johnson, R.A. And Wichern, D.W., Applied Multivariate Analysis, 6th Edn., Pearson & Prentice Hall, 2007*	4	*Gibbons, J. D. and Chakraborty, S., Nonparametric Statistical Inference. 4th Edition. Marcel Dekker, CRC, 2003*
5	*Subhash Sharma, Applied Multivariate Techniques, John Wiley & Sons, New Delhi, 1996*	6	*Joseph F Hair, William C Black et al.,Multivariate Data Analysis, Pearson Education, 7th edition, 2013*

Designers					
Professional Experts		Higher Institution Experts		Internal Experts	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	1	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	1	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
		2		2	*Dr. D. Prakash, SRMIST, prakashd1@srmist.edu.in*

G5

Code	PMA25G04T	Title	Research Methodology	Category	G	*Generic Elective Course*	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	Statistical Table

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Provide an overview of research methodology and explain how to define a research problem.*
CR-2	*Understand literature search and review, review writing, and key international Intellectual Property Rights instruments.*
CR-3	*Gain knowledge in academic writing and presentation skills.*
CR-4	*Learn the significance of modern statistical tools and methods in research article creation.*
CR-5	*Gain knowledge about Analysis of Data.*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Depth				Attainment			Program Outcomes (PO)											
		Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
CO-1	*Understand some basic concepts of research and its methodologies.*	✓				*3*	*85*	*75*	3	3	2	2	2	-	-		3	-	-	3
CO-2	*Prepare a literature review.*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-3	*Write different type of Research Articles.*		✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-4	*Understanding various statistical tools and techniques for data collection and analysis.*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-5	*Know the importance of research design and various parametric tests.*	✓	✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3

Title & Session Outcomes	***Research Methodology: An Introduction***	***Literature Survey in Research***	***Research Documentation and Presentation***	***Qualitative Research Process***	***Analysis of Data***
Duration (hour)	**12**	**12**	**12**	**12**	**12**
SO-1	*Meaning of Research, Objectives of Research, Motivation in Research*	*Review of articles, Types of Review*	*Research report writing and its Significance.*	*Quantitative Research, Sources of Data*	*Sampling Types, size of sample, sample designs*
SO-2	*Types of Research, Research Approaches*	*Importance of literature review in defining a problem*	*Types of Reports, Layout of the Research Report*	*Methods of data collection*	*Sampling test, Test for single mean and difference of means for small sample test*

SO-3	*Significance of Research, Research Methods versus Methodology*	*Underlying principles of Literature Review, Meta-analysis record of research review*	*Difference steps in Writing Report Precautions for Writing*	*Types of Data – Nominal, Ordinal, Interval, Ratio.*	*Paired t-test, F-test,*
SO-4	*Tutorial: Case study on Research Approaches*	*Tutorial: Case studies on Literature Review*	*Tutorial: Research report writing - Case studies*	*Tutorial: Importance of Quantitative Research - Case study*	*Tutorial: Problems on small sample teste tests*
SO-5	*Research and Scientific Method, Importance of knowing How Research is Done*	*Ethical and Moral Issues in Research*	*Basic knowledge of funding agencies, Proposal submission for funding agencies*	*Data Preparation and presentation, Bar charts, Pie charts*	*Large sample test- test for single mean, two means*
SO-6	*Research Process, Criteria of Good Research*	*Scientific misconducts – falsification, fabrication and plagiarism. Tools to avoid plagiarism*	*Thesis writing and Oral defense*	*Univariate analysis, Frequency tables, Percentages*	*Large sample test- test for single proportion, two proportions*
SO-7	*Necessity of Defining the Problem, Technique involved in defining a problem*	*Intellectual Property Rights, Copy right laws, Patent rights*	*Oral and PPT Presentation*	*Bivariate analysis, Cross tabulations*	*Chi square test for goodness of fit, independence of attributes*
SO-8	*Tutorial: Case study on Criteria of Good Research*	*Tutorial: Scientific misconducts - Case study*	*Tutorial: Communication and Presentation Skills*	*Tutorial: Working problems on Bivariate analysis*	*Tutorial: Problems on Large sample tests*
SO-9	*Development of a research proposal, Theoretical Processes*	*Citation indices, Impact Factor*	*Elements of excellent presentation: Preparation*	*Karl Pearson Coefficient of Correlation*	*Introduction to Design of experiments*
SO-10	*Experimental Processes, Sources of information, Literature search*	*Needs, ways and means of publication of research findings*	*Document preparation (LaTeX)*	*Spearman's Rank Correlation Coefficient*	*Complete Randomized Design (CRD), Randomized Block Design (RBD)*
SO-11	*The computer: Its Role in Research, Online databases, Search tools*	*Accessibility of Journals and other print documents, References*	*Presentation (Beamer)*	*Regression Analysis*	*Latin Square Design (LSD)*
SO-12	*Tutorial: Case study on Online databases, Search tools*	*Tutorial: Case study on publication of research findings*	*Tutorial: Drafting a report*	*Tutorial: Problems on Correlation*	*Tutorial: Problems on Design of experiments*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
2	Understand										
3	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
4	Analyze										
5	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
6	Create										
Total		100 %		100 %		100 %		100 %		100 %	

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Resources			
1	*C.R.Kothari; Research Methodology (second Revised Edition) –New Age Publishers, 2004.*	2	*Ganesan R, Research Methodology for Engineers, MJP Publishers, Chennai. 2011.*
3	*Anderson B.H., Dursaton, and Poole M.: Thesis and assignment writing, Wiley Eastern 1997.*	4	*Graziano, A., M., and Raulin, M.L.: Research Methods – A Process of Inquiry, Pearson, 2013.*
5	*Leedy, P., D.: Practical Research – Planning and Design, Eighth Edition, Pearson, 2019.*	6	*Walpole R.A., Myers R.H., Myers S.L. and Ye, King: Probability & Statistics for Engineers and Scientists, Pearson Prentice Hall, Pearson Education, Inc. 2012.*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	*1*	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	*1*	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
2		*2*		*2*	*Dr. R. Varadharajan, SRMIST, varadhar@srmist.edu.in*

G6

Code	PMA25G05T	Title	Neural Networks, Fuzzy Systems and Evolutionary Mathematics	Category	G	Generic Elective Course	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXX

Rationale (CR)	The purpose of learning this course is to:
CR-1	*Understand the concepts, models of Neural Networks*
CR-2	*Observe and illustrate the BPN, to learn the algorithm of training sets of Neural Network*
CR-3	*Understand the basic mathematical elements of the theory of fuzzy sets.*
CR-4	*Learn evolutionary Mathematics related to fitness function, crossover and Mutations*
CR-5	*Utilize the evolutionary mathematics to calculate the optimal problems*

Outcomes (CO)	At the end of this course, learners will be able to:	Depth				Attainment			Program Outcomes (PO)												
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
		Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CO-1	*Identify the appropriate models to illustrate the algorithm of training sets.*	✓				3	85	75	3	3	2	2	2	-	-		3	-	-	3
CO-2	*Formalize the problem, to solve it by using a Backpropagation Networks*	✓	✓	✓		3	85	75	3	3	2	2	2	-	-	-	3	-	-	3
CO-3	*Apply basic fuzzy inference, fuzzy system modelling and approximate reasoning*		✓			3	85	75	3	3	2	2	2	-	-	-	3	-	-	3
CO-4	*Apply Evolutionary computation methods to find solutions to complex problems*	✓	✓	✓	✓	3	85	75	3	3	2	2	2	-	-	-	3	-	-	3
CO-5	*Apply Genetic algorithm, Neural networks and Fuzzy to solve the optimization problems.*	✓	✓			3	85	75	3	3	2	2	2	-	-	-	3	-	-	3

Title & Session Outcomes	*Introduction to Neural Networks*	*Deep Learning and Neural Network Training*	*Module 3: Fuzzy Logic and Approximate Reasoning*	*Module 4: Evolutionary Mathematics and Optimization Techniques*	*Module 5: Hybrid Computational Intelligence Systems*
Duration (hour)	12	12	12	12	12
SO-1	*Basic concepts of Neural Networks* *Model of an Artificial Neuron*	*Applications of BPN: Design of Journal Bearing; Classification of Soil, Hot extrusion of steel*	*Fuzzy set theory : Fuzzy vs Crisp* *Crisp sets : operations, properties, partition and covering*	*Fundamental concepts of Genetic Algorithm* *Working principle of Genetic Algorithm*	*Neuro-Fuzzy Hybrids, Neuro-Genetic Hybrids, Fuzzy-Genetic Hybrids;* *Fuzzy inference systems*
SO-2	*Neural Network Architectures: Single-layer and Multilayer Feedforward Networks*	*Effect of Tuning Parameters of the BPN; Selection of Various Parameters in BPN: Number of Hidden Nodes, Momentum Coefficient α, Sigmoidal*	*Fuzzy rules and fuzzy reasoning*	*Encoding: Binary encoding, Octal Encoding*	*Genetic Algorithm based Backpropagation Network, Fuzzy-Backpropagation Network*

		Gain λ, Local Minima, Learning coefficient η		*Hexadecimal encoding, Permutation encoding, Value Encoding, Tree Encoding*	*Simplified Fuzzy ARTMAP, Fuzzy Associative Memories, Fuzzy Logic Controlled Genetic Algorithms*
SO-3	*Recurrent Neural Networks (RNN) and Their Characteristics* *Learning Methods: Supervised, Unsupervised, and Reinforcement Learning* *Fuzzy systems and combination of such systems in certain problem areas of IE & OR, XOR problem*	*Effect of Tuning Parameters in BPN;* *Selection of Various Parameters:* *Number of Hidden Nodes* *Momentum Coefficient (α)* *Sigmoidal Gain (λ)*	*Crisp Relations : Cartesian Product, other crisp relations; Fuzzy Relations : Fuzzy Cartesian Product, operations on Fuzzy relations*	*Fitness Function* *Computation of fitness function* *Fuzzy rule generation using neural net approaches*	*GA based weight determination* *Weight extraction, Fitness Function, Reproduction, Convergence*
SO-4	*Tutorial 1: Solving XOR Problem using Perceptron; Understanding Neural Network Architectures Through Examples*	*Tutorial1: Augmented Backpropagation Networks* *Perceptrons and Backpropagation Learning* *Associative Memory Classes of Neural Networks*	*Tutoria 1:: Fuzzy Systems: Crisp Logic* *Laws of Propositional Logic* *Inference in Propositional Logic*	*Tutorial 1: Fitness Function:* *Computation of Fitness Function* *Fuzzy Rule Generation Using Neural Net Approaches*	*Tutorial 1: Application: K-factor Determination* *Application: Electrical Load Forecasting*
SO-5	*ADALINE Network* *MADALINE Network, Application Domains*	*Augmented Backpropagation Networks;* *Perceptions; back propagation learning*	*Fuzzy Systems: Crisp Logic* *Laws of Propositional logic, Inference in Propositional logic*	*Reproduction* *Roulette-wheel Selection, Bolzmann Selection*	*Application : K- factor Determination* *Application : Electrical Load Forecasting*
SO-6	*Backpropagation Network, Architecture* *Perception Model, Single layer Artificial Neural Network*	*Associative memory classes of neural networks, radial basis function networks* *Auto correlators : Recognition of stored patterns, Recognition of noisy patterns*	*Temporal fuzzy logic; fuzzy systems*	*Tournament Selection, Rank Selection, Steady state selection, Elitism* *Generation gap and Steady-state Replacement*	*Fuzzy Backpropagation Networks: LR-type Fuzzy Number, Operations* *Fuzzy Neuron, Fuzzy BP Architecture*
SO-7	*Multilayer Neural Network* *Backpropagation learning: Input, Output Layer Computation, Calculation of Error*	*Augmented Backpropagation Networks Perceptron Networks and Backpropagation Learning*	*Fuzzy logic: Fuzzy propositions, Fuzzy connectives* *Fuzzy Quantifiers, Fuzzy Inference*	*Genetic Modeling: Inheritance Operators* *Cross over: Single-site, 111two-point, Multi-point Cross Over*	*Learning in Fuzzy BP* *Inference by Fuzzy BP, Application*
SO-8	*Tutorial 2: Hands-on Implementation of Backpropagation Algorithm; Hyperparameter Tuning in Neural Networks*	*Tutorial2: Algorithm and Working of Multiple Training Encoding Strategy with Correlation Matrix* *Exponential Bidirectional Associative Memory*	*Tutorial 2: Fuzzy Rule-Based System and Defuzzification*	*Tutorial 2: Uniform Crossover* *Matrix Crossover* *Crossover Rate in Genetic Modeling*	*Tutorial 2:: Fuzzy Neuron* *Fuzzy BP Architecture* *Learning in Fuzzy BP* *Inference by Fuzzy BP* *Application of Fuzzy BP*
SO-9	*Combinatorial optimization, systems modeling;*	*Boltzmann machines; Mean Field theory Energy Function for Bidirectional Associative Memory*	*Fuzzy Rule based System and Defuzzification*	*Uniform Cross Over*	*Fuzzy neural networks*

	Training Methods and Fine-Tuning of Hyperparameters	*Problems of Kosko's BAM*	*Mamdani Fuzzy models*	*Matrix Cross Over and Cross Over Rate of Genetic Modeling*	*Adaptive neuro-fuzzy inference systems (ANFIS).*
SO-10	*Method of steepest Descent, Effect of Learning Rate 'η'* *Approximations, prediction, robust control and learning.*	*Temporal processing using feed forward networks;* *Concepts of Multiple Training Encoding Strategy* *Algorithm, working of multiple training encoding strategy with correlation matrix*	*Sugeno Fuzzy Models* *Tsukamoto Fuzzy Models* *Fuzzy associative memories*	*Inversion: Linear end inversion, Continuous inversion, Mass inversion* *Deletion and Duplication, Deletion and Regeneration, Segregation, Cross over and Inversion*	*Fuzzy Associative Memories: Introduction, Single Association FAM* *Fuzzy Hebb FAMs*
SO-11	*Algorithm BPN()* *Illustration of Algorithm with training sets*	*Exponential Bidirectional Associative Memory; Associative memory for real-coded pattern pairs, Application - Character Recognition*	*Input Space Partitioning, Fuzzy Modeling* *Application: Fuzzy Cruise Control System, Air Conditioner Controller.*	*Mutation : Mutation Rate, Bitwise operators in Genetic Algorithm* *Generation Cycle, Convergence of Genetic Algorithm and Applications*	*Fuzzy Associate Memories involving a rule base* *FAM Rules with Multiple;* *Neuro-fuzzy control*
SO-12	*Tutorial 3: Practical Implementation of Neural Networks using Python (TensorFlow/Keras)* *Case Studies: Pattern Recognition, Function Approximation*	*Tutorial 3: Recap of Key Concepts; Problem-Solving Sessions on BPN and Associative Memory Networks*	*Tutorial 3:: Recap of Key Concepts* *Problem-Solving Sessions on Fuzzy Logic and Systems*	*Tutorial 3: Recap of Key Concepts* *Problem-Solving Sessions on Genetic Algorithm Operators and Applications*	*Tutorial 3:: Neuro-Fuzzy Control* *FAM Applications and Problem-Solving*

Assessment

Level of Thinking		**Continuous Learning Assessment (CLA)** (50 % weightage)								**Final Exam** (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
2	Understand										
3	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
4	Analyze										
5	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
6	Create										
Total		100 %		100 %		100 %		100 %		100 %	

Strategies

Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Resources			
1	S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic, And Genetic Algorithms: Synthesis and Applications, PHI Learning Pvt. Lmt., 2011.	2	Hideyuki Takagi, Introduction to Fuzzy Systems, Neural Networks, and Genetic Algorithms, Springer Link,
3	S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Systems, And Evolutionary Algorithms: Synthesis and Applications, PHI Learning Pvt. Lmt., 2017.	4	https://towardsdatascience.com/an-illustrated-guide-to-genetic-algorithm-ec5615c9ebe
5	Jyh-Shing Roger Jang, Chuen-Tsai Sun and Eiji Mizutani,Neuro-Fuzzy and Soft Computing A computational Approach to Learning and Machine Intelligence, Prentice Hall,1997	6	https://www.csd.uwo.ca/~mmorenom/cs2101a_moreno/Class9GATutorial.pdf

Designers					
Professional Experts		Higher Institution Experts		Internal Experts	
1	Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com	1	Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in	1	Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in
2		2		2	Dr. Tapas Barman, SRMIST, tapasb@srmist.edu.in

G7

Code	PMA25G06T	Title	Data Structures and Algorithms	Category	G	*Generic Elective Course*	L	T	P	C
							3	1	0	4

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXX

Rationale (CR)	*The purpose of learning this course is to:*	Depth				Attainment			Program Outcomes (PO)												
		1	2	3	4	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
									Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CR-1	*Utilize the different data types; Utilize searching and sorting algorithms for data search*																			
CR-2	*Utilize linked list in developing applications*																			
CR-3	*Utilize stack and queues in processing data for real-time applications*																			
CR-4	*Utilize tree data storage structure for real-time applications*																			
CR-5	*Utilize algorithms to find shortest data search in graphs for real-time application development*																			

Outcomes (CO)	*At the end of this course, learners will be able to:*	Conceive	Design	Implement	Operate	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)												
CO-1	*Identify linear and non-linear data structures. Create algorithms for searching and sorting*	✓				*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-2	*Create the different types of linked lists and evaluate its operations*	✓	✓	✓		*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-3	*Construct stack and queue data structures and evaluate its operations*		✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-4	*Create tree data structures and evaluate its types and operations*	✓	✓	✓	✓	*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3
CO-5	*Create graph data structure, evaluate its operations, implement algorithms to identify shortest path*	✓	✓			*3*	*85*	*75*	3	3	2	2	2	-	-	-	3	-	-	3

Title & Session Outcomes	***Fundamentals of Data Structures and Algorithms***	***Arrays and Linked Lists***	***Stacks - Implementation and Applications***	***Tree Data Structure***	***Graph and Network Flow***
Duration (hour)	**12**	**12**	**12**	**12**	**12**
SO-1	*Introduction-Basic Terminology and Data Structures*	*Array* *Operations on Arrays – Insertion and Deletion*	*Stack ADT,* *Stack Array Implementation*	*General Trees,* *Tree Terminologies*	*Graph Terminology,* *Graph Traversal*
SO-2	*Data Structure Operations,* *ADT*	*Applications on Arrays* *Multidimensional Arrays- Sparse Matrix*	*Stack Linked List Implementation* *Applications of Stack- Infix to Postfix Conversion*	*Tree Representation,* *Tree Traversal*	*Topological sorting* *Minimum spanning tree – Prims Algorithm*

SO-3	*Algorithms – Searching techniques, Complexity – Time , Space Trade off*	*Linked List Implementation - Insertion Linked List- Deletion and Search*	*Applications of Stack- Postfix Evaluation Applications of Stack- Balancing symbol*	*Binary Tree Representation, Expression Trees*	*Minimum Spanning Tree - Kruskal"s Algorithm ,Network flow problem*
SO-4	*Tutorial: Problems on Data Structures*	*Tutorial: Exercises on Array operations and list implementation*	*Tutorial: Exercises on Stacking*	*Tutorial: Problems on Tree representation*	*Tutorial: Problems on Graphs, minimum spanning trees, Kruskal's algorithm and Network flow problems*
SO-5	*Algorithms - Sorting Complexity – Time , Space Trade off*	*Applications of Linked List Polynomial Arithmetic*	*Applications of Stack- Nested Function Calls, Recursion concept using stack*	*Binary Tree Traversal, Threaded Binary Tree*	*Hashing: Hash functions - Introduction Hashing: Hash functions*
SO-6	*Asymptotic notations - Theta Mathematical functions*	*Applications of Recursion: Tower of Hanoi Queue ADT*	*Applications of Recursion: Tower of Hanoi Queue ADT*	*Binary Search Tree :Construction, Searching, Binary Search Tree : Insertion and Deletion*	*Hashing : Collision avoidance Hashing : Separate chaining*
SO-7	*Mathematical notations, Asymptotic notations-Big O, Omega*	*Cursor Based Implementation – Methodology , Cursor Based Implementation*	*Queue Implementation using array, Queue Implementation using Linked List*	*AVLTrees: Rotations AVL Tree: Insertions*	*Open Addressing , Linear Probing*
SO-8	*Tutorial: Problems on finding complexity*	*Tutorial: Exercises on Recursion, Cursor based implementation*	*Tutorial: Exercises on Queue Implementation*	*Tutorial: Problems on Binary Tree search and AVL Trees*	*Tutorial: Exercises on Hashing*
SO-9	*Data Structures and its Types Linear and Non-Linear Data Structures*	*Applications of Circular List -Joseph Problem, Doubly Linked List*	*Circular Queue, Implementation of Circular Queue*	*B-Trees Constructions, B-Trees Search*	*Open Addressing, Linear Probing*
SO-10	*1D, 2D Array Initialization using Pointers 1D, 2D Array Accessing using Pointers*	*Doubly Linked List Insertion, Doubly Linked List Insertion variations*	*Applications of Queue, Double ended queue*	*B-Trees Deletions Splay Trees*	*Quadratic probing Double Hashing*
SO-11	*Declaring Structure and accessing Declaring Arrays of Structures and accessing*	*Doubly Linked List Deletion, Doubly Linked List Search*	*Priority Queue Priority Queue - Applications*	*Red Black Trees Red Black Trees Insertion*	*Rehashing Extensible Hashing*
SO-12	*Tutorial: Exercises on array initialization and accessing using pointers, declaring structures and arrays*	*Tutorial: Exercises on Circular list and doubly linked list.*	*Tutorial: Exercises on Queueing*	*Tutorial: Problems on B-Trees, Splay Trees and Red Black Trees*	*Tutorial: Exercises on Open addressing, probing, rehashing and extensible hashing*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
2	Understand										
3	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
4	Analyze										
5	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
6	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

Resources			
1	*Seymour Lipschutz, Data Structures with C, McGraw Hill, 2014.*	2	*R.F.Gilberg, B.A.Forouzan, Data Structures, 2nd ed., Thomson India, 2005.*
3	*A.V.Aho, J.E Hopcroft , J.D.Ullman, Data structures and Algorithms, Pearson Education, 2003*	4	*Mark Allen Weiss, Data Structures and Algorithm Analysis in C, 2nd ed., Pearson Education, 2015*
5	*Reema Thareja, Data Structures Using C, 1st ed., Oxford Higher Education, 2011*	1	*Thomas H Cormen, Charles E Leiserson, Ronald L Revest, Clifford Stein, Introduction to Algorithms 3rd ed., The MIT Press Cambridge, 2014*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	1	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras sryedida@iitm.ac.in*	1	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
		2		2	*Dr. E. Suresh, SRMIST, sureshe1@srmist.edu.in*

S4

Code	PMA25S04L	Title	Machine Learning	Category	S	Skill Enhancement Course	L	T	P	C
							0	0	4	2

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXXX

Rationale (CR)	The purpose of learning this course is to:
CR-1	Learn the importance of Pre-processing Techniques in machine learning.
CR-2	Utilize the classification Techniques in Machine learning based Statistical method.
CR-3	Perceive the various Classification Techniques in Machine learning based on gradient method.
CR-4	Study the method of Support vectors and Reinforcement Learning Algorithm to classify the data.
CR-5	Learn various types of optimization technique in Machine learning.

Perceive

Outcomes (CO)	At the end of this course, learners will be able to:	Depth				Attainment			Program Outcomes (PO)											
		1 Conceive	2 Design	3 Implement	4 Operate	1 Level of Thinking	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Disciplinary Knowledge	2 Problem Solving	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethical practices & Social Responsibility	9 Individual & Team Work	10 Communication	11 Project Management & Finance	12 Life Long Learning
CO-1	Able to understand the Pre-processing concepts in Machine Learning.	✓				3	85	75	3	3	2	2	3	-	-	-	3	-	-	3
CO-2	Understanding Classification Techniques in Machine learning based on Statistical method with working knowledge.	✓	✓	✓		3	85	75	3	3	2	2	3	-	-	-	3	-	-	3
CO-3	Gain the working knowledge of classification techniques based on gradient method.		✓			3	85	75	3	3	2	2	3	-	-	-	3	-	-	3
CO-4	Able to model the Support vector and Reinforcement Learning Algorithms.	✓	✓	✓	✓	3	85	75	3	3	2	2	3	-	-	-	3	-	-	3
CO-5	Analyze the various types of optimization technique.	✓	✓			3	85	75	3	3	2	2	3	-	-	-	3	-	-	3

Title & Session Outcomes	*Pre-processing Techniques*	*Statistical Learning method*	*Gradient Learning method*	*Analytical Learning method*	*Optimization technique*
Duration (hour)	12	12	12	12	12
SO-1 -4	*Python programs related to Machine learning*	*Naïve Bayesian Classification*	*Hebbian Learning*	*Support vectors method with kernel function*	*Single Objective Optimization*
SO-5 -8	*Data Normalization*	*K Nearest neighbour learning.*	*Multilayer Feedforward neural networks*	*Reinforcement Learning Algorithms.*	*Multi Objective Optimization*
SO-9-12	*Data reduction*	*Random Forests Classification method*	*Radial Basis function*	*Random Forests Classification method*	*Ant colony optimization*

Assessment											
Level of Thinking		Continuous Learning Assessment (CLA) (50 % weightage)								Final Exam (50% Weightage)	
		CLA – 1 (10 %)		CLA – 2 (10 %)		CLA – 3 (20 %)		CLA – 4# (10 %)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1.	Remember	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*
2.	Understand										
3.	Apply	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*
4.	Analyze										
5.	Evaluate	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*
6.	Create										
Total		100 %		100 %		100 %		100 %		100 %	

Strategies					
Technology		**Pedagogy / Andragogy**		**Sustainable Development**	
Simulations	✓	Case Studies	✓	No Poverty	✓
Emulations	✓	Group Discussion	✓	Zero Hunger	✓
Prototypes		Hands-on Practice	✓	Good Health & Well Being	✓
Hands-on Practice Tools		Inquiry Learning	✓	Quality Education	✓
Mathematical Computing Tools	✓	Interactive Lecture	✓	Gender Equality	
Field Visit		Leading Question		Clean Water & Sanitation	
		Mind Map		Affordable & Clean Energy	
		Minute Paper			
		Peer Review	✓		
		Problem Based Learning	✓		

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Resources			
1	*Tom M. Mitchell, Machine Learning, McGraw-Hill Education (India) Private Limited, 2013.*	2	*EthemAlpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press 2004.*
3	*R NageswaraRao, Core Python Programming, Dream Tech Press, 2017.*	4	*Haykin s., 'Neural Networks, A comprehensive foundation', Second edition. Prentice Hall, 1999.*
5	*KalyanmoyDeb , Multi-Objective Optimization Using Evolutionary Algorithms, John Wiley & Sons, Inc., 2009.*	6	*Marco Dorito and Thomas Stutzle, Ant Colony Optimization,The MIT Press, 2004.*

Designers					
Professional Experts		**Higher Institution Experts**		**Internal Experts**	
1	*Dr. Yogesh Parte, President, CitiusTech, yogesh.parte@ypconsultingservices.com*	1	*Prof. Y.V.S.S. Sanyasiraju, **IIT Madras** sryedida@iitm.ac.in*	1	*Dr. Ritesh Kumar Dubey, SRMIST, riteshkd@srmist.edu.in*
2		2		2	*Dr. Gajendran G. SRMIST, gajendrg@srmist.edu.in*

P1

Code	PMA25P01L	Title	Internship	Category	P	*Project Work, Internship in Industry/Higher Technical Institutions*	L	T	P	C
							-	-	-	2

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXX

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Assist the student's professional skill development useful to employer such as teamwork, communications and work ethics & details*
CR-2	*Provide unique learning opportunities by exposing the student to the environment and expectations of professional performance*
CR-3	*Expand the student's knowledge of a particular area(s) of interest to enhance employability*
CR-4	*Help students to explore career alternatives/opportunities prior to their graduation*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Attainment			Program Outcomes (PO)											
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
		Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CO-1	*Demonstrate the skill gained through work experience with mentors or successful professionals to support the early stages of their career.*	3	85	75	3	2	2	3	3	-	-	-	3	-	-	3

	Continuous Learning Assessment (50% weightage)		Final Evaluation (50% weightage)	
	Review – 1	Review – 2	Project Report	Viva-Voce
Internship	20%	30 %	30 %	20 %

Semester – 4
P2

Code	PMA25P02L	Title	Project Work	Category	P	*Project Work, Internship in Industry/Higher Technical Institutions*	L	T	P	C
							0	0	20	10

Offering Department	Mathematics	Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil	Data Book / Codes/Standards	XXXX

Rationale (CR)	*The purpose of learning this course is to:*
CR-1	*Prepare the student to gain major design and or research experience as applicable to the profession*
CR-2	*Apply knowledge and skills acquired through earlier course work in the chosen project*
CR-3	*Make conversant with the codes, standards, application software and equipment*
CR-4	*Carry out the projects within multiple design constraints*
CR-5	*Incorporate multidisciplinary components*

Outcomes (CO)	*At the end of this course, learners will be able to:*	Attainment			Program Outcomes (PO)											
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
		Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Problem Solving	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethical practices & Social Responsibility	Individual & Team Work	Communication	Project Management & Finance	Life Long Learning
CO-1	*Design a system / process or gain research insight into a defined problem as would be encountered in engineering practice taking into consideration its impact on global, economic, environmental and social context.*	3	85	75	3	3	2	3	3	-	-	-	2	-	-	3

	Continuous Learning Assessment (50% weightage)		Final Evaluation (50% weightage)	
	Review – 1*	Review – 2*	Project Report*	Viva-Voce
Project Work	20%	30 %	30 %	20%

*Include submission of project work in the form of paper for presentation / publication in a conference / journal and / or preliminary filing of a patent with proof.