ACADEMIC CURRICULA

POSTGRADUATE DEGREE PROGRAMME
(REGULATIONS 2021)

MASTER OF SCIENCE
(M.Sc MATHEMATICS)

Two Years(Full-Time)

Learning Outcome Based Curriculum Framework (LOCF)

Academic Year

2021 - 2022

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

TABLE OF CONTENTS

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 Educational 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. Program Specific Outcomes (PSO)

PSO - 1	*Graduates will acquire good knowledge and understanding in advanced areas of mathematics.*
PSO - 2	*Graduates will develop and formulate mathematical arguments in the logical and analytical manner.*
PSO - 3	*Graduates will be able to use the facility with mathematical and computational modeling of real world problems*

5. 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	H	H	H	M	M
PEO – 2	H	H	H	M	M
PEO – 3	H	M	H	H	H
PEO – 4	H	H	H	M	H
PEO - 5	H	H	H	H	M

H – High Correlation, M – Medium Correlation, L – Low Correlation

6. Consistency of PEO's with Program Learning Outcomes (PLO)

	Program Learning Outcomes (PLO)														
	1.	2.	3.	4.	5.	6.	7.	8	9.	10.	11.	12.	13.	1	15
	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
PEO – 1	H	H	H	H	M	-	-	-	H	-	H	H	H	H	H
PEO – 2	H	H	H	H	H	M	-	-	H	-	M	H	H	H	H
PEO – 3	H	H	H	H	H	H	H	-	H	-	H	H	H	H	H
PEO – 4	H	H	H	H	H	M	M	-	H	-	H	H	H	M	H
PEO - 5	H	M	H	H	M	H	H	-	H	-	H	H	H	M	M

7. PG Programme Structure (Total Credits:80)

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

Course Code	Course Title	Hours/ Week L	T	P	C
PMA21101T	*Real Analysis*	*3*	*1*	*0*	*4*
PMA21102T	*Linear Algebra*	*3*	*1*	*0*	*4*
PMA21103T	*Ordinary Differential Equations*	*3*	*1*	*0*	*4*
PMA21104T	*Probability Theory and Statistics*	*3*	*1*	*0*	*4*
PMA21205T	*Algebra*	*3*	*1*	*0*	*4*
PMA21206T	*Complex Analysis*	*3*	*1*	*0*	*4*
PMA21207T	*Partial Differential Equations*	*3*	*1*	*0*	*4*
PMA21308T	*Topology*	*3*	*1*	*0*	*4*
PMA21309T	*Functional Analysis*	*3*	*1*	*0*	*4*
PMA21310T	*Calculus of Variations and Mechanics*	*3*	*1*	*0*	*4*
Total Learning Credits					**40**

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

Course Code	Course Title	Hours/ Week L	T	P	C
PMA21D01T	*Advanced Optimization Techniques*	*3*	*1*	*0*	*4*
PMA21D02T	*Multivariate Calculus*				
PMA21D03J	*Introduction to Statistical Learning*	*3*	*0*	*2*	
PMA21D04T	*Fuzzy Sets and Applications*	*3*	*1*	*0*	*4*
PMA21D05T	*Formal Languages and Automata Theory*				
PMA21D06J	*Introduction to Mathematical Finance*	*3*	*0*	*2*	
PMA21D07T	*Graph Theory and Algorithms*	*3*	*1*	*0*	*4*
PMA21D08T	*Fluid Dynamics*				
PMA21D09J	*Mathematical Modelling and Simulation*	*3*	*0*	*2*	
Total Learning Credits					**12**

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

Course Code	Course Title	Hours/ Week L	T	P	C
PPY21G02T	Introduction to Nanotechnology	*3*	*0*	*0*	*3*
PPY21G03T	LASER Physics				
PCY21G02T	Chemistry of Biomolecules				
PMA21G01T	*Mathematics for Artificial Intelligence*				
PMA21G02T	Mathematics for Physicists				
PMA21G03T	*Multivariate Analysis and Non-Parametric Test*				
PMA21G04T	Research Methodology				
PMA21G05T	*Neural Networks, Fuzzy Systems and Evolutionary Mathematics*				
PCS21G06T	*Data Structures and Algorithms*				
Total Learning Credits					**3**

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

Course Code	Course Title	Hours/ Week L	T	P	C
PMA21S01J	*Scientific Programming using Scilab*	*1*	*0*	*4*	*3*
PMA21S02J	*Data Modelling Tools using R Commander*	*2*	*0*	*2*	
PMA21S03J	*Scientific Programming using Python*	*2*	*0*	*2*	*3*
PMA21S04L	*Machine Learning*	*0*	*0*	*4*	*2*
Total Learning Credits					**8**

5. Project Work, Internship In Industry / Higher Technical Institutions(P)

Course Code	Course Title	Hours/ Week L	T	P	C
PMA21I01L	*Massive Open Online Course*	-	-	-	*2*
PMA21I02L	*Internship*	-	-	-	
PMA21P01L	*Project Work*	*0*	*0*	*24*	*12*
Total Learning Credits					14

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

Course Code	Course Title	Hours/ Week L	T	P	C
PCD21AE1T	*Professional Skills and Problem Solving*	*1*	*0*	*0*	***1***
PCD21AE2T	*General Aptitude for Competitive Examinations*	*1*	*0*	*0*	***1***
PCD21AE3T	*Employability Skills*	*1*	*0*	*0*	***1***
Total Learning Credits					***3***

8. Implementation Plan

Semester - I						
Course Code	Course Title	Hours/ Week			C	H
		L	T	P		
PMA21101T	*Real Analysis*	3	1	0	4	4
PMA21102T	*Linear Algebra*	3	1	0	4	4
PMA21103T	*Ordinary Differential Equations*	3	1	0	4	4
PMA21104T	*Probability Theory and statistics*	3	1	0	4	4
PMA21D01T	*Advanced Optimization Techniques*	3	1	0	4	4
PMA21D02T	*Multivariate Calculus*					
PMA21D03J	*Introduction to Statistical Learning*	3	0	2		5
PMA21S01J	*Scientific Programming using Scilab*	1	0	4	3	4
PMA21S02J	*Data Modelling Tools using R Commander*	2	0	2		
PCD21AE1T	*Professional Skills and Problem Solving*	1	0	0	1	1
	Total Learning Credits				24	25

Semester - II						
Course Code	Course Title	Hours/ Week			C	H
		L	T	P		
PMA21205T	*Algebra*	3	1	0	4	4
PMA21206T	*Complex Analysis*	3	1	0	4	4
PMA21207T	*Partial Differential Equations*	3	1	0	4	4
PMA21D04T	*Fuzzy Sets and Applications*	3	1	0	4	4
PMA21D05T	*Formal Languages and Automata Theory*					
PMA21D06J	*Introduction to Mathematical Finance*	3	0	2		5
PMA21S03J	*Scientific Programming using Python*	2	0	2	3	4
PCD21AE2T	*General Aptitude for Competitive Examinations*	1	0	0	1	1
	Total Learning Credits				20	21

Semester – III						
Course Code	Course Title	Hours/ Week			C	H
		L	T	P		
PMA21308T	*Topology*	3	1	0	4	4
PMA21309T	*Functional Analysis*	3	1	0	4	4
PMA21310T	*Calculus of Variations and Mechanics*	3	1	0	4	4
PMA21D07T	*Graph Theory and Algorithms*	3	1	0	4	4
PMA21D08T	*Fluid Dynamics*					
PMA21D09J	*Mathematical Modelling and Simulation*	3	0	2		5
PPY21G02T	Introduction to Nanotechnology	3	0	0	3	3
PPY21G03T	LASER Physics					
PCY21G02T	Chemistry of Biomolecules					
PMA21G01T	*Mathematics for Artificial Intelligence*					
PMA21G02T	*Mathematics for Physicists*					
PMA21G03T	*Multivariate Analysis and Non-Parametric Test*					
PMA21G04T	Research Methodology					
PMA21G05T	*Neural Networks, Fuzzy Systems and Evolutionary Mathematics*					
PCS21G06T	*Data Structures and Algorithms*					
PMA21S04L	*Machine Learning*	0	0	4	2	4
PMA21I01L	***Massive Open Online Course***	-	-	-	2	-
PMA21I02L	***Internship***	-	-	-		
PCD21AE3T	*Employability Skills*	1	0	0	1	1
	Total Learning Credits				24	24

Semester - IV						
Course Code	Course Title	Hours/ Week			C	H
		L	T	P		
PMA21P01L	*Project Work*	0	0	24	12	24
	Total Learning Credits				12	24

Total Learning Credits :80

9. Program Articulation Matrix

Course Code	Course Name	Programme Learning Outcomes														
		Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
PMA21101T	Real Analysis	H	H	H	H	-	-	-	-	H	-	-	H	M	M	M
PMA21102T	Linear Algebra	H	H	M	M	M	-	-	-	M	M	-	H	H	H	M
PMA21103T	Ordinary Differential Equations	H	H	M	M	-	-	-	-	M	-	-	H	H	M	-
PMA21104T	Probability Theory and Statistics	M	H	M	M	M	-	-	-	M	-	-	H	H	H	H
PMA21205T	Algebra	H	H	M	M	M	-	-	-	M	M	-	H	H	H	M
PMA21206T	Complex Analysis	H	H	H	M	-	-	-	-	M	-	-	H	H	H	H
PMA21207T	Partial Differential Equations	H	H	M	M	M				M	M		H	H	M	H
PMA21308T	Topology	H	H	M	M	M				M			H	H	M	M
PMA21309T	Functional Analysis	M	H	M	M	M	-	-	-	M	M	-	H	M	M	M
PMA21310T	Calculus of Variations and Mechanics	M	H	H	M	M	-	-	-	M	M	-	H	H	M	M
PMA21D01T	Advanced Operatimization Techniques	M	H	M	M	M	-	-	-	M	M	-	H	H	M	M
PMA21D02T	Multivariate Calculus	H	H	H	M	M	-	-	-	M	-	-	H	M	M	M
PMA21D03J	Introduction to Statistical Learning	H	H	H	H	H	-	M	-	-	-	-	H	H	M	H
PMA21D04T	Fuzzy Sets and Applications	M	H	M	M	M	-	-	-	M	M	-	H	H	H	M
PMA21D05T	Formal Languages and Automata Theory	M	H	H	M	M	-	-	-	M	-	-	H	H	H	H
PMA21D06J	Introduction to Mathematical Finance	M	H	H	H	H	-	-	-	H	-	H	H	M	M	M
PMA21D07T	Graph Theory and Algorithms	H	H	M	M	M	-	-	-	M	M	-	H	H	H	H
PMA21D08T	Fluid Dynamics	H	H	M	M	M	-	-	-	M	M	-	H	H	H	M
PMA21D09J	Mathematical Modelling and Simulation	M	H	H	H	H	-	-	-	H	-	H	H	M	M	M
PPY21G02T	Introduction to Nanotechnology	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
PPY21G03T	LASER Physics	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
PCY21G02T	Chemistry for Biomolecules	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
PMA21G01T	Mathematics for Artificial Intelligence	M	H	M	M	M	-	-	-	M	-	-	H	H	H	H
PMA21G02T	Mathematics for Physicists	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
PMA21G03T	Multivariate Analysis and Non-Parametric Test	M	H	M	M	M	-	-	-	M	M	-	H	H	H	H
PMA21G04T	Research Methodology	H	H	H	H	H	H	M	H	H	H	H	H	H	H	H
PMA21G05T	Neural Networks, Fuzzy Systems and Evolutionary Mathematics	M	H	H	H	H	M	M	M	M	M	M	H	H	H	H
PCS21G06T	Data Structures and Algorithms	M	H	M	H	M	-	-	-	M	M	-	H	H	H	H
PMA21S01J	Scientific Programming using Scilab	H	H	M	M	H	-	-	-	H	-	-	H	H	H	H
PMA21S02J	Data Modelling Tools using R Commander	M	H	H	H	H	-	-	M	M	M	-	H	M	H	H
PMA21S03J	Scientific Programming using Python	H	H	M	H	H	-	-	M	H	H	M	H	H	H	H
PMA21S04L	Machine Learning	M	M	H	H	H	H	-	-	M	-	H	M	M	-	H
PMA21I01L	Massive Open Online Course	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
PMA21I02L	Internship	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
PMA21P01L	Project Work	H	H	H	H	H	H	H	-	M	H	H	M	H	H	H
PCD21AE1T	Professional Skills and Problem Solving	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
PCD21AE2T	General Aptitude for Competitive Examinations	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
PCD21AE3T	Employability Skills	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
	Program Average	H	H	H	H	H	M	M	M	M	H	M	M	H	H	M

H – High Correlation, M – Medium Correlation, L – Low Correlation

10. Course Structure								
Semester	**Professional Core Courses (PCC)**	**Discipline Specific Elective Courses (DEC)**	**Generic Electives Courses (GEC)**	**Skill Enhancement Courses (SEC)**	**Ability Enhancement Courses (AEC)**	**Project Work, Internship (P)**	**Total Credits**	**Total Hours**
Sem I	PCC-1(4) PCC-2 (4) PCC-3(4) PCC-4(4)	DEC-1 (4)		SEC 1 (4)	AEC 1 (1)		**24**	**25**
Sem II	PCC-5 (4) PCC-6 (4) PCC-7(4)	DEC-2 (5)		SEC 2 (4)	AEC 2 (1)		**20**	**21**
Sem III	PCC-8 (4) PCC-9(4) PCC-10(4)	DEC-3(4)	GEC-1(3)	SEC 3 (4)	AEC 3 (1)	Internship/MOOC (2)	**24**	**24**
Sem IV						P (12)	**12**	**24**
Total Credits	**40**	**12**	**3**	**8**	**3**	**14**	**80**	**94**

Semester 1
PC 1

Course Code	PMA21101T	Course Name	Real Analysis	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

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

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

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Recall on the importance of real number system and review on preliminaries	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-2 :	Learn about differentiation on real numbers and functions																		
CLR-3 :	Know about the need of Riemann-Stieltjes integral in relation to Riemann integral.																		
CLR-4 :	Know limits, the sequence and series of functions and their pointwise and uniform convergence.																		
CLR-5 :	Apply various test for uniform convergence of sequence and series of functions.																		
CLR-6 :	Gain brief knowledge about the measure theory																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Understand the completeness of real number system	3	90	90	H	H	M	-	-	-	-	-	H	-	-	H	M	M	M
CLO-2 :	Determine extreme values of real differentiable functions	3	85	90	H	H	M	M	-	-	-	-	H	-	-	H	M	-	-
CLO-3 :	Apply Riemann-Stieltjes integration wherever Riemann integration is not feasible.	3	85	85	H	H	H	H	-	-	-	-	H	-	-	H	-	-	-
CLO-4 :	Find the Pointwise limit of the sequence of functions.	3	85	80	H	H	H	M	-	-	-	-	M	-	-	H	-	M	M
CLO-5 :	Apply uniform convergence in problems related to integration and differentiation.	3	85	80	H	H	H	H	-	-	-	-	H	-	-	H	M	M	M-
CLO-6 :	Test the measurability of sets and functions.	3	90	80	H	H	H	H	-	-	-	-	H	-	-	H	M	M	M

Duration (hour)		Module -I (12)	Module-II(12)	Module-III(12)	Module-IV(12)	Module- V(12)
S-1	SLO-1	Review on real number system	Differentiability of functions - introduction	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.
	SLO-2	Set operations, functions	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.
S-2	SLO-1	Algebraic properties of R	Algebra of differentiable functions	Partitions, Lower and upper Riemann-Stieltjes sums.	Uniform convergence of sequence of functions. Definition and examples.	Measurable sets. Illustrative examples.
	SLO-2	Order properties of R	Chain rule	Lower and upper Riemann-Stieltjes integral. Its properties.	Consequences of Uniform convergence. Illustrative examples.	Regularity. Its properties and illustrative examples.
S-3	SLO-1	Law of trichotomy, Completeness property of R	Rolle's theorem	The Riemann-Stieltjes integral. Properties of RS-integral.Examples.	Necessary and sufficient condition for Uniform convergence. Worked out examples.	Measurable functions. Illustrative examples. Worked out theorems.
	SLO-2	Q is dense in R; existence of irrational numbers between rational numbers	Mean value theorem	Refinement of partitions - Examples	Cauchy criterion of Uniform convergence. Illustrative examples.	Algebra of measurable functions.
S-4	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-5	SLO-1	Q is countable	Cauchy mean value theorem	Worked out theorems.	Dini's criterion for uniform convergence of a sequence of continuous functions.	Worked out theorems and practice problems.
	SLO-2	R is uncountable	Inverse function theorem	A condition of integrability.	Tests for uniform convergence. Examples.	Sets of measure zero
S-6	SLO-1	Sequence and limits	L'Hospital rules	Some important deductions.	Uniform convergence and continuity.	Cantor set
	SLO-2	Limit theorems	L'Hospital rules	Restrictions of Integrable functions.	Uniform convergence and integration.	Worked out theorems.
S-7	SLO-1	Monotone sequences – subsequences	Darboux theorem	Worked out examples.	Uniform convergence and differentiation.	Borel sets
	SLO-2	Cauchy sequence and Cauchy criterion	Leibniz formula	Algebra of RS-integrable functions.	The Weierstrass approximation theorem.	Examples
S-8	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-9	SLO-1	Infinite series and nth term test	Taylor's theorem	Relation between R-integral and RS-integral.	Series of functions. Pointwise and uniform convergence. Cauchy criteria for uniform	Boral measurability. Illustrative examples

					convergence of series of functions.	
	SLO-2	Cauchy criterion for seires	Illustration of Taylor's approximation	Some classes of RS-integrable functions.	Weierstrass-M test for series for functions.	Worked out theorems.
S-10	SLO-1	Integral test and convergence of p-series for p>1; Comparison test and its limit form	Convex function	Introduction to RS-integral and differentiation. Mean value theorem for integrals.	Dirichlet and Abel test for Uniform convergence of Series of functions.	Lebesgue measurability. Illustrative examples.
	SLO-2	Root, Ratio and Raabe's tests	Derivative test of convexity	First fundamental theorem of calculus.	Uniform convergence and continuity.	Worked out theorems.
S-11	SLO-1	Alternating series	Arithmetic mean-Geometric mean inequality	Second fundamental theorem of calculus.	Uniform convergence and integration.	Hausdorff measure. Illustrative examples.
	SLO-2	Abel's and Dirichlet's tests	Taylor's theorem: Cauchy form of the remainder	Some methods of integration.	Uniform convergence and differentiation.	Worked out theorems.
S-12	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session

Learning Resources	1. Robert G. Bartle, Donald R. Sherbert , Introduction to real Analysis (4th Edition) , John Wiely & Sons., 2018. 2. Ajit Kumar and S. Kumareran, 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.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate 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.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Dr. K. Ganesan, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr. A. Anuradha, SRMIST

PC2

Course Code	PMA21102T	Course Name	Linear Algebra	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

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

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

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Learn about linear systems and vector spaces.	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-2 :	Get a strong background of linear transformations.																		
CLR-3 :	Understand the underlying concepts related to diagonal and triangular forms																		
CLR-4 :	Study about various canonical forms to solve matrix equations.																		
CLR-5 :	Familiarity with the operators in the finite dimensional inner product spaces																		
CLR:6	Learn abstract vector space as a unifying concept for understanding properties of vectors, polynomials and matrices.																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Solve the system of linear equations , to find the basis and dimension of vector spaces	3	85	80	H	H	M	-	-	-	-	-	M	M	-	H	H	H	M
CLO-2 :	Find out matrices corresponding to linear transformations.	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	H	H	M
CLO-3 :	Familiar on elementary canonical forms	3	85	80	H	H	-		-	-	-	-	M	-	-	H	-	M	-
CLO-4 :	Students will understand various methods of canonical forms and utilize in solving system of equations.	3	85	80	H	H	H	M	-	-	-	-	M	M	-	H	M	M	-
CLO-5 :	Students will learn about the inner product spaces and its algebraic properties.	3	85	80	M	H	M	-	-	-	-	-	M	-	-	H	H	H	M
CLO-6 :	Students will learn about the operators and its algebraic applications	3	85	80	H	H	M	M	M	-	-	-	M	M	-	H	H	H	M

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Fields- Introduction	Introduction to Linear transformations	Characteristic value of Linear Transformations	Primary decomposition theorem.	Introduction to inner product spaces
	SLO-2	Fields – Examples	More examples on linear transformations	Characteristic value of Matrix	Nilpotent	Examples of inner product spaces
S-2	SLO-1	Systems of linear equations	Rank – Nullity theorem (RNT)	Diagonalizable	Cyclic subspaces	Polarization identities
	SLO-2	Consistent and inconsistent systems	Problems on RNT	Theorems and problems on Diagonalizable	Annihilator	Parallelogram law
S-3	SLO-1	Matrices and elementary row operations	Matrix representation of Linear Transformation- Definition , examples	minimal polynomial	Cyclic decomposition theorem- Introduction, Definition , Examples	Cauchy – Schwarz inequality
	SLO-2	Row reduced matrices	Related theorems	Theorems	Cyclic decomposition theorem	Orthogonal and orthonormal set
S-4	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-5	SLO-1	Row reduced echelon matrices	Change of basis- Definition, Examples	Cayley-Hamilton theorem	More problems on CDT	Gram-Schmidt Orthogonalization process
	SLO-2	Related theorems on Row reduced Echelon matrices	Problems on Change of basis	Cayley-Hamilton theorem- Problems	More problems on CDT	Gram-Schmidt Process- Problem's
S-6	SLO-1	Vector spaces- Introduction	Isomorphism	Invariant subspaces	Corollaries of CDT	Orthogonal complement
	SLO-2	Vector spaces – Examples	Theorems	Diagonal forms	Corollaries of CDT	Orthogonal projection
S-7	SLO-1	Subspaces	linear functional	Triangular forms	Generalized Cayley Hamilton theorem	Linear functional
	SLO-2	Necessary and sufficient conditions	dual space	Theorems and problems related to diagonal and triangular forms	Generalized Cayley Hamilton theorem	Theorems
S-8	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-9	SLO-1	Spanning sets- Examples	Annihilator- Definition, examples	direct-sum decompositions	Invariant factors	self-adjoint operators
	SLO-2	linear dependence- Examples and Problems	Theorems	Projection	Rational - canonical form	Related theorems
S-10	SLO-1	Bases and Dimension	Double dual	Independent subspaces	Problems on rational forms	Unitary operator

	SLO-2	Bases and Dimension – Examples	Related theorems and problems on double dual	Related theorems	Problems on rational forms	Related theorems
S-11	SLO-1	Related theorems	Transpose of a linear transformation	invariant direct sums	Jordan-canonical form	Normal operators
	SLO-2	Related theorems	Related theorems	Related theorems	Problems on Jordan-canonical form	Related theorems
S-12	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session

Learning Resources	**1.** K. Hoffman and R. Kunze, Linear Algebra, 2ndEd. Prentice Hall of India, 2005. **2.** G.Strang, Introduction to Linear Algebra, Wellesley-Cambridge Press, 1993. **3**. S. H.Friedberg, A. N. Insel and L. W. Spence Linear Algebra 4thED., Pearson 2015.	**4.** S. Kumaresan,Linear Algebra: A Geometric Approach, Prentice-Hall of India, 2004. **5.** S. Axler,Linear Algebra Done Right, 2nd Ed., Springer UTM, 1997. **6.** S. Lang,Linear Algebra, Springer Undergraduate Texts in Mathematics, 1989.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	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.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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PC 3

Course Code	PMA21103T	Course Name	Ordinary Differential Equations	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

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

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

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Learn about existence and uniqueness of solutions.																		
CLR-2 :	Understand about second order differential equation.																		
CLR-3 :	Gain knowledge about general solution of homogeneous equations.																		
CLR-4 :	Learn about boundary value problems, sturm-liouville problems																		
CLR-5 :	Understand about bessel functions and its properties.																		
CLR- 6 :	Gain knowledge about linear and nonlinear ordinary differential equations																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO – 2	PSO – 3
CLO-1 :	Derive problems in first order ordinary differential equations	3	85	80	H	H	M	-	-	-	-	-	M	-	-	H	H	M	-
CLO-2 :	Derive problems in second order ordinary differential equation with constant and variable coefficients	3	85	80	H	H	-	M	-	-	-	-	M	-	-	H	H	M	-
CLO-3 :	Solve problems in method of variation of parameters	3	85	80	H	H	-		-	-	-	-	M	-	-	H	M	M	-
CLO-4 :	Derive and solve problems in series solutions	3	85	80	H	H	H	M	-	-	-	-	M	-	-	H	M	M	-
CLO-5 :	Solve problems in eigen values and eigen vectors	3	85	80	H	H	M	-	-	-	-	-	M	-	-	H	H	M	-
CLO:6	Solve first and higher order linear and nonlinear ordinary differential equations	3	85	80	H	H	M	M	-	-	-	-	M	-	-	H	H	M	-

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Method of Successive Approximations	Boundary value problems	Review of Beta and Gamma Function	Power series solution - Bessel's Function	System of Differential Equations
	SLO-2	Problems based on Successive Approximations	Introduction of Boundary value problems	Review of Beta and Gamma Function	Introduction to Bessel's Function	Dependence on Initial Conditions and Parameters
S-2	SLO-1	Lipchitz condition	Sturm comparison theorem	Series Solutions	Recurrence relation of Bessel's Function	Asymptotic Behaviour of Linear and Nonlinear Systems
	SLO-2	Convergence of Successive Approximations	Problems based on Sturm Comparison Theorem	Background Knowledge Concerning Power Series	Recurrence relation of Bessel's Function	Concepts of Stability
S-3	SLO-1	Picard's Theorem	Application of Sturm comparison theorem	Series Solution of first order equations	Generating Function for Bessel's Function	Stability of Linear Systems, Stability of Nonlinear Systems
	SLO-2	Picard's Theorem	Sturm separation Theorem	Analytic Equations	Properties of Bessel's function	Nonlinear Variation of Constants, Dichotomies, Lyapunov's Direct Method for Autonomous Systems
S-4	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-5	SLO-1	Problems based on Picard's Theorem	Application of Sturm Separation Theorem	Series solution of 2nd order equations	Problem's on Bessel's function	Lyapunov's Direct Method for Non-Autonomous Systems
	SLO-2	Second Order Linear Equations	Application of Sturm Separation Theorem	ordinary points	Problem's on Bessel's function	Stability of Discrete Models in Population Dynamics
S-6	SLO-1	Existence and Uniqueness Theorem for Linear First Order ODE's	Sturm Oscillation Theorem	Regular singular points	Equations Reducible to Bessel's function	Converse Theorems

	SLO-2	Existence and Uniqueness Theorem for Linear Systems	Problems on Sturm Oscillation Theorem	Functions Defined via Differential Equations,	Orthogonality of Bessel's function	Total Stability, Practical Stability,
S-7	**SLO-1**	Second order ODE Solution of Homogeneous equation	Sturm-Liouville problems and its Applications	Problems on Ordinary Points	BER and BEI functions	Eigen Vector method of finding solutions
	SLO-2	Second order ODE Solution of non-Homogeneous equation	Green's function	Solutions Near a Singular Point	Properties of BER and BEI functions	Problems on Eigen vector
S-8	**SLO-1**	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-9	**SLO-1**	Homogeneous equations of Legendre's and Euler	Abel's Theorem	Chebyshev Equation	Legendre's Equation, Rodrigue's Formula	Complex Eigen values
	SLO-2	Non-Homogeneous Equations	Problems on Abel's Theorem	Airy Equation, Laguerre's Equation	Legendre's Polynomials	Mutual Stability
S-10	**SLO-1**	Wronskian	Reduction of Order	Gauss's Hypergeometric Equations	Generating Function For $P_n(x)$	Problems on complex Eigen values
	SLO-2	Wronskian	Conservation of Energy	Functions Defined via Differential Equations	Recurrence relation for $P_n(x)$	Equal Eigen Values
S-11	**SLO-1**	Problems based on Wronskian	Euler equidimensional equation	Frobenius series solutions	Orthogonality of Legendre`s Polynomials	Problems on Equal Eigen Values
	SLO-2	Method of undetermined co-efficient	Euler equidimensional equation	Frobenius series solutions	Problems on Legendre's polynomials	Orthogonal Matrix
S-12	**SLO-1**	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session

Learning Resources	1. E.A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, McGraw-Hill, 1955. 2. G.F. Simmons, Differential Equations with Applications and Historical Notes, 2ndEd, McGraw- Hill, 1991. 3. R.P. Agarwal and D. O'Regan, An Introduction to Ordinary Differential Equations, Springer- Verlag, 2008.	4. G. Birkhoff and G.-C. Rota, Ordinary Differential Equations, 4th Ed., John Willey and Sons, 1989. 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.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	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.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions, maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras. sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Dr. *K. Ganesan*, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr.E.P.Siva, SRMIST

PC4

Course Code	PMA21104T	Course Name	Probability theory and Statistics	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Apply the basic rules and theorems of probability. Learning the techniques to develop discrete and continuous probability distribution and its applications																		
CLR-2 :	Idea of transformation of one and two dimensional random variables and differentiate between them																		
CLR-3 :	Appropriately choose, define and/or derive probability special distributions such as Binomial, Poisson and Normal , Beta, Gama distribution etc																		
CLR-4 :	Understanding the concept and applications of sampling techniques and apply in real life problems																		
CLR-5 :	Identify parameter estimation using mini max estimation and maxi min estimation																		
CLR-6 :	Understanding the concept and applications of sampling techniques and apply in real life problems																		

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO – 2	PSO – 3
CLO-1 :	Pertain the Knowledge of probability basic concepts and applying DRV and CRV	3	85	80	M	H	M	-		-	-	-	M	-	-	H	H	-	-
CLO-2 :	Familiar with the models covariance, correlation and multi variables	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	H	H	H
CLO-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	80	H	H	-	-	-	-	-	-	M	-	-	H	H	-	M
CLO-4 :	Able to solve the models using sequential analysis for hypotheses testing , Gain familiarity in estimate of statistical data	3	85	80	H	H	H	M	-	-	-	-	M	-	-	H	-	H	M
CLO-5 :	Gain knowledge how to apply estimation theory models	3	85	80	M	H	-	-	-	-	-	-	M	-	-	H	H	-	H
CLO-6	Able to solve the problems and taking the decisions in complex situation	3	85	80	M	H	M	M	M	-	-	-	M	-	-	H	H	H	H

Duration (Hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Probability concepts, Types of experiments, Events, sample space	Introduction to Moment generating function	Special Distributions and limit theorem	Sample Moments and their Distribution	Introduction to Estimation
	SLO-2	Axioms and theorems	MGF- discrete random variable	Central limit theorem	Small and large samples	Introduction to Estimation
S-2	SLO-1	Problems on Probability	MGF- continuous random variable	Problems on CLT	Hypothesis Testing	Point estimation
	SLO-2	Probability on complements	MGF-Continuous random variable	Discrete Probability distribution	Large sample test-Test of significance for single proportion	Point estimation
S-3	SLO-1	Conditional probability Baye's theorem – without proof	Problems on MGF	Introduction to Binomial distribution	Test of significance for difference of proportions	Point estimation
	SLO-2	Applications- Baye's Theorem.	Moments and Generating functions from mean		Problems on single and difference of proportions	criteria for good estimates (un-biasedness
S-4	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-5	SLO-1	Random variables – Discrete case	Multiple Random variables	Some special Distribution-Binomial Distribution on n points	Test of significance for single mean	criteria for good estimates (consistency)
	SLO-2	Probability Mass function	Independent Random variables	Negative Binomial distribution	Test of significance for difference of means	criteria for good estimates (consistency)
S-6	SLO-1	Cumulative distribution function	Independent Random variables (two dimensional random variables)	Hypergeometric distribution	Small sample tests	Methods of estimation including maximum likelihood estimation.
	SLO-2	Mathematical expectation , Variance –discrete case	Functions of several Random Variables	Poisson and Multinomial Distribution	Student's t- test for single mean	Methods of estimation including maximum likelihood estimation.
S-7	SLO-1	Probability density function	Functions of several Random Variables	Uniform Distribution	't' test for the difference of means	Problems based on Methods of estimation including maximum likelihood estimation.
	SLO-2	Cumulative distribution function	Covariance	Uniform Distribution	More problems on t- test	Sufficient Statistic: Concept & examples

S-8	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-9	SLO-1	Mathematical expectation, variance-continuous case	Correlation and Moments	Gamma Distribution	Fisher's F-test	Concepts of estimator
	SLO-2	More problems on expectation , variance	Correlation and Moments Conditional Expectation	Gamma Distribution	Test of significance for two sample variances	Bayes minimax estimator
S-10	SLO-1	Introduction to Moments , four moments	Ordered Statistics	Beta Distribution	Chi square test- goodness of fit	Bayes maximin estimator
	SLO-2	First moment -Mean	Ordered Statistics	Beta Distribution	Problems on goodness of fit	Principle of Equivariance
S-11	SLO-1	Second moment-variance	Ordered statistics and their distribution	Normal Distribution (Gaussian law)	Chi square test- for independence of attributes	
	SLO-2	Third moment-skewness Fourth moment-kurtosis	Ordered statistics and their distribution	Normal Distribution (Gaussian law)	More problems on Chi square test- for independence of attributes	Principle of Equivariance
S-12	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Applications of Probability in real world	Tutorial Session	Tutorial Session	Applications and the importance of descriptive statistics	Tutorial Session

Learning 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. B. R. Bhat, Modern Probability Theory, New Age International, 1999.
5. R. E. Walpole, R. H. Myers, S. L. Myers, K. Ye, Probability & Statistics for Engineers & Scientists, Pearson Prentice Hall, 8th Ed., 2007.
6. D. C. Montgomery and G. C. Runger, Applied Statistics and Probability for Engineers, John Wiley & Sons, 3rd Ed., 2003.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
	Analyze										
Level 3	Evaluate	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	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.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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	Dr.B.V. RatishKumar, IIT, Kanpur, bvrk@iitk.ac.in	Dr. N. Balaji, SRMIST

D1

Course Code	PMA21D01T	Course Name	Advanced Optimization Techniques	Course Category	D	Discipline Specific Elective Course	L	T	P	C
							3	1	0	4

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

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

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-1 :	Learn the sensitivity analysis for linear programming																		
CLR-2 :	Learn about one dimensional optimization techniques.																		
CLR-3 :	Gain knowledge about multidimensional optimization methods.																		
CLR-4 :	Know the method of geometric programming																		
CLR-5 :	Understand the concepts of dynamic programming																		
CLR-6 :	Gain knowledge about integer programming.																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Gain the knowledge about sensitivity analysis and apply them in problems related to science and engineering.	3	85	80	H	H	M	-	-	-	-	-	M	M	-	H	H	H	H
CLO-2 :	Solve problems in one dimensional optimization using advanced techniques.	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	H	M	M
CLO-3 :	Derive and solve problems in multidimensional optimization using advanced techniques.	3	85	80	H	H	-		-	-	-	-	M	-	-	H	H	-	-
CLO-4 :	Solve problems in geometric programming	3	85	80	H	H	H	M	-	-	-	-	M	M	-	H	-	-	-
CLO-5 :	Solve problems in dynamic programming	3	85	80	M	H	M	-	-	-	-	-	M	-	-	H	-	M	M
CLO-6 :	Solve problems in integer programming	3	85	80	M	H	M	M	M	-	-	-	M	M	-	H	H	M	M

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Introduction to linear programming	One dimensional Optimization methods	Multidimensional Optimization methods	Lagrange Multiplier method	Introduction to Integer programming
	SLO-2	Two Phase method	One dimensional Optimization methods	Multidimensional Optimization methods	Problems on Lagrange Multiplier method	Graphical Representation
S-2	SLO-1	Two Phase method	Uni-modal function	Direct search method	Introduction to Geometric programming	Graphical Representation
	SLO-2	Revised Simplex Method	Elimination method	Univariant Method	Posynomial	Gomory's cutting plane algorithm
S-3	SLO-1	Revised Simplex Method	Problems on Elimination method	Problems on Univariant Method	Unconstrained Geometric programming problem using differential calculus	Gomory's Method for All-Integer Programming Problems
	SLO-2	Duality	Problems on Elimination method	Problems on Univariant Method	Unconstrained Geometric programming problem using differential calculus	Gomory's Method for All-Integer Programming Problems
S-4	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-5	SLO-1	Duality	Fibonacci method	Pattern search methods	Unconstrained Geometric programming problem using Arithmetic-Geometric inequality	Gomory's Method for All-Integer Programming Problems
	SLO-2	Sensitivity analysis	Problems on Fibonacci method	Hooke-Jeeves method	Unconstrained Geometric programming problem using Arithmetic-Geometric inequality	Gomory's Method for Mixed-Integer Programming Problems
S-6	SLO-1	Changes in the Right-Hand-Side Constants	Problems on Fibonacci method	Problems on Hooke-Jeeves method	Dynamic Programming	Gomory's Method for Mixed-Integer Programming Problems
	SLO-2	Problems on Changes in the Right-Hand-Side Constants	Golden section method	Problems on Hooke-Jeeves method	Multistage decision process	Gomory's Method for Mixed-Integer Programming Problems
S-7	SLO-1	Changes in the Cost Coefficients	Problems on Golden section method	Powell's method	Multistage decision process	Balas' Algorithm for Zero-one Programming Problems
	SLO-2	Problems on Changes in the Cost Coefficients	Problems on Golden section method	Problems on Powell's method	Principles of optimality	Balas' Algorithm for Zero-one Programming Problems
S-8	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session

S-9	SLO-1	Addition of New Variables	Quadratic interpolation methods	Gradient of function	Problems on Principles of optimality	Balas' Algorithm for Zero-one Programming Problems
	SLO-2	Problems on Addition of New Variables	Problems on quadratic interpolation methods	Steepest decent method	Problems on Principles of optimality	Balas' Algorithm for Zero-one Programming Problems
S-10	SLO-1	Problems on Addition of New Variables	Problems on quadratic interpolation methods	Problems on Steepest decent method	Problems on Principles of optimality	Branch and Bound Method
	SLO-2	Changes in the Constraint Coefficients	Cubic interpolation methods	Problems on Steepest decent method	Conversion of final problem to an initial value problem	Problems on Branch and Bound Method
S-11	SLO-1	Problems on Changes in the Constraint Coefficients	Problems on cubic interpolation methods	Fletcher reeves method	Problems on Conversion of final problem to an initial value problem	Problems on Branch and Bound Method
	SLO-2	Problems on Changes in the Constraint Coefficients	Problems on cubic interpolation methods	Problems on Fletcher reeves method	Problems on Conversion of final problem to an initial value problem	Problems on Branch and Bound Method
S-12	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session

Learning 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.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	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.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Dr. K. Ganesan, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr. Anirban Majumdar, SRMIST

D2

Course Code	PMA21D02T	Course Name	Multivariate Calculus	Course Category	D	Discipline Specific Elective Course	L	T	P	C
							3	1	0	4

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

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

		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1:	Understand the basic concepts and techniques of differential calculus in functions of several variables																		
CLR-2:	Be familiar with the concept of maxima and minima in several variables																		
CLR-3:	Go through the concept of line integrals, vector-valued functions, gradient																		
CLR-4:	Be familiar with surface and volume integrals and apply Green's theorem																		
CLR-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																		
CLR-6:	Understand the fundamental concepts of multivariable calculus, multiple integrals and vector calculus																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1:	Understand the concept of differential calculus in several variable framework	3	85	80	H	H	-	-	-	-	-	-	M	-	-	H	H	M	M
CLO-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	80	M	H	-	M	M	-	-	-	M	-	-	H	H	H	M
CLO-3:	Apply the theory to calculate the gradients, divergence, curl and arc length of curves	3	85	80	H	H	-		-	-	-	-	M	-	-	H	-	-	-
CLO-4:	Ability to set up and compute multiple integrals in rectangular, polar, cylindrical and spherical coordinates and familiar with vector fields	3	85	80	H	H	H	M	-	-	-	-	M	-	-	H	M	M	-
CLO-5:	Understand the connection between the line, surface and volume integrals through Green's, Guass' and Stokes' theorem	3	85	80	M	H	-	-	-	-	-	-	M	-	-	H	M	M	M
CLO-6:	Learn differential calculus, line integrals, surface integrals and volume integrals. Also, an understanding of the physical interpretation of these integrals.	3	85	80	H	H	H	M	M	-	-	-	M	-	-	H	M	M	M

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Introduction to functions of several variables	Definition of Maxima and minima	Basic properties of line integrals	Introduction to multiple integrals	Parametric representation of a surface
	SLO-2	**Concept of o**pen balls and open sets	Stationary point	Line integrals with respect to arc length	Partitions of rectangle and step function	Some examples of Parametric representation of a surface
S-2	SLO-1	Limits and Continuity	Finding maxima and minima	Examples of line integral	Definition of the double integral of a step function	The fundamental vector product
	SLO-2	Definition of the derivative of a scalar field with respect to a vector	Problems on maxima and minima	Open connected sets	Related properties	Examples of the fundamental vector product
S-3	SLO-1	Definition of directional derivatives	Saddle points	Independence of the path	The definition of the double integral of a function defined and bounded on a rectangle	The fundamental vector product as a normal to the surface
	SLO-2	Concept of partial derivatives	Absolute minimum and relative minimum	Potential functions	Evaluation of a double integral by repeated one-dimensional integration	Definition of area of a parametric surface
S-4	SLO-1	The total derivative	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-5	SLO-1	The gradient of a scalar field	Examples of saddle points	Special methods for constructing potential functions	Geometric interpretation of the double integral as a volume	Definition of a surface integral

	SLO-2	Level set and Tangent planes	Examples of absolute minimum and relative minimum	Problems on potential functions	Iterated integrals	Notations for surface integrals
S-6	**SLO-1**	Derivatives of vector fields	Introduction to Lagrange's multipliers	First fundamental theorem for line integrals	Applications to area and volume	Stokes' theorem
	SLO-2	Chain rules for derivatives	The method of Lagrange's multiplier	Second fundamental theorem of calculus for line integrals	Applications of double integrals	Application of the stokes' theorem
S-7	**SLO-1**	The chain rule for derivatives of vector fields	Applications of Lagrange's multipliers	Introduction to vector fields	Change of variables formula	The curl and divergence of a vector field
	SLO-2	Matrix form of the chain rule	Applications of Lagrange's multipliers	Calculus of vector-valued functions	Special cases of the transformation formula	Properties of the curl and divergence
S-8	**SLO-1**	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-9	**SLO-1**	Derivatives of functions defined implicitly	Inverse function theorem	Examples of vector functions	Green's theorem	Examples The curl and divergence of a vector field
	SLO-2	Sufficient conditions for the equality of mixed partial derivatives	Examples of inverse function theorem	Examples of vector fields	Applications of Green's theorem	The divergence theorem (Gauss' theorem)
S-10	**SLO-1**	Higher order derivatives	Problems on inverse function theorem	Gradients	Introduction to two-dimensional vector fields	Application of the divergence theorem
	SLO-2	Examples of higher order derivatives	Implicit function theorem	Necessary conditions for a vector field to be a gradient	Examples of two-dimensional vector fields	Application of the divergence theorem
S-11	**SLO-1**	Taylor's theorem	Problems on implicit function theorem	Problems related to gradients	Two-dimensional gradients	Applications of multivariate calculus
	SLO-2	Application of Taylor's theorem	Problems on implicit function theorem	Problems related to gradients	Problems on two-dimensional gradients	Applications of multivariate calculus in PDEs
S-12						
	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session

Learning Resources	**1.** T.M. Apostol, Calculus, Vol. II, John Wiely & Sons, 2nd Ed., 2003. 2. D.V. Widder, Advanced Calculus, PHI Learning, 2nd Ed., 1987. 3. T.M. Apostol, Mathematical Analysis, Narosa Pub. House,2nd Ed., 1997.	4. H.M. Edwards, Advanced Calculus-A Differential Forms Approach, Birkhauser, 1994. 5. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, 2002. 6 P.D. Lax and M.S. Terrell, Multivariable Calculus with Applications, Springer International Publishing, 1st Edition, 2017.

earning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	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.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Dr. N. Parvathi, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr. Sahadeb Kuila, SRMIST

D3

Course Code	PMA21D03J	Course Name	Introduction to Statistical Learning	Course Category	D	Discipline Specific Elective Course	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	The purpose of learning this course is as follows:
CLR-1 :	Understand the basic concepts of Statistics and data analysis
CLR-2 :	Get ability to solve problems on Linear methods for regression and classifications.
CLR-3 :	Understand the concepts of regularizations and smoothing
CLR-4 :	Interpret model assessment and to understand maximum likelihood methods.
CLR-5 :	Get well versed with unsupervised learning
CLR-6	Develop skills on practical problem solving in statistics.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	Get knowledge on linear regression and supervised learning.	3	80	75	H	H	H	-	H	-	M	-	-	-	-	H	H	M	H
CLO-2 :	Understand linear methods for regression, classifications, indicator matrix, and separating hyper planes	3	85	75	H	H	H	-	H	-	M	-	-	-	-	H	H	M	H
CLO-3 :	Describe regularizations, spline smoothening, wavelet smoothing and Kernel smoothers	3	85	75	H	-	-	H	-	-	-	-	-	-	-	H	-	-	-
CLO-4 :	Analyze model assessment, bootstrap methods and EM algorithm	3	85	80	H	H	H	-	H	-	M	-	-	-	-	-	H	M	H
CLO-5 :	Explore the concepts of unsupervised learning	3	80	75	H	H	H	-	H	-	-	-	-	-	-	H	H	M	H
CLO-6	Acquire the knowledge of statistics.	3	80	75	H	H	H	H	H	-	M	-	-	-	-	H	H	M	H

Duration (hour)		Module-I (15)	Module-II (15)	Module-III (15)	Module-IV (15)	Module- V (15)
S-1	SLO-1	Basis expansions and regularizations	Overview of Statistical learning	Unsupervised learning	Linear methods for regression	Model assessment and bias
	SLO-2	Piecewise Polynomials and Splines	Statistical learning	Association rules	LR models and least square	Bias, Variance and Model Complexity
S-2	SLO-1	Natural Cubic Splines	Simple approaches for prediction	Market basket analysis	Examples	The Bias–Variance Decomposition
	SLO-2	Examples	Linear models and least squares	Example	The Gauss–Markov Theorem	Example
S-3	SLO-1	Filtering and Feature Extraction	Nearest Neighbour method	Unsupervised as Supervised Learning	Subset selection	optimism of training error rate
	SLO-2	Filtering and Feature Extraction	Nearest Neighbour method	Unsupervised as Supervised Learning	Best Subset Selection	The Bayesian Approach and BIC
S-4 to S-5	SLO-1	Practice Session- Polynomial regression	Practice Session – Linear regression	Practice Session- Market basket analysis	Practice Session- Linear methods for regression	Practice Session- The Bias–Variance Decomposition
	SLO-2					
S-6	SLO-1	Smoothing Splines	From Least Squares to Nearest Neighbors	Cluster Analysis	Forward and Backward stepwise selection	Minimum Description Length
	SLO-2	Degrees of Freedom and Smoother Matrices	From Least Squares to Nearest Neighbors	Proximity matrices	Forward Stage wise Regression	Vapnik–Chervonenkis Dimension
S-7	SLO-1	Wavelet Bases and the Wavelet Transform	Statistical Decision Theory	Object Dissimilarity	Shrinkage methods	Cross-Validation
	SLO-2	Wavelet smoothing	Statistical Decision Theory	Clustering Algorithms	Coefficient shrinkage	K-Fold Cross-Validation
S-8	SLO-1	Kernel smoothers	Statistical Models	Combinatorial Algorithms	Linear methods for classification	Bootstrap Methods
	SLO-2	Selecting the Width of the Kernel.	A Statistical Model for the Joint Distribution Pr(X,Y)	self-organizing maps	Linear Regression of an Indicator Matrix	Examples
S-9 to S-10	SLO-1	Practice Session- Kernel regression	Practice Session- Statistical Models	Practice Session- K-Means Clustering	Practice Session- Linear methods for classification	Practice Session- K-Fold Cross-Validation
	SLO-2					
S-11	SLO-1	local regression in R^p	Supervised Learning	principal components	Linear Discriminant Analysis	Maximum likelihood methods
	SLO-2	Structured Local Regression Models in R^p	Function approximation	curves and surfaces	Linear Discriminant Analysis	A smoothing example
S-12	SLO-1	Local likelihood and other models	Structured Regression Models	Kernel Principal Components	Logistic Regression	Bayesian Methods
	SLO-2	Kernel Density Estimation and Classification	Difficulty of the Problem	Sparse Principal Components	Examples	Relationship Between the Bootstrap and Bayesian Inference
S-13	SLO-1	Radial basis functions and kernels.	Classes of Restricted Estimators	non-negative matrix factorization	Separating Hyperplanes	The EM Algorithm
	SLO-2	Radial basis functions and kernels	Roughness Penalty and Bayesian Methods	Archetypal Analysis	Optimal Separating Hyperplanes	Two-Component Mixture Model

S-14 to S-15	SLO-1 SLO-2	Practice Session- Radial Basis function	Practice Session- K-Nearest Neighbour	Practice Session- Kernel Principal Components	Practice Session- Logistic Regression	Practice Session- Bayesian methods

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, Wiely, 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.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand										
Level 2	Apply	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Analyze										
Level 3	Evaluate	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
	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.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST, Dr. N. Parvathi, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr. C. Gunasundari, SRMIST

S1

Course Code	PMA21S01J	Course Name	Scientific Programming using Scilab	Course Category	S	*Skill Enhancement Course*	L	T	P	C
							1	0	4	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	Apply the numerical techniques for solutions of algebraic, transcendental and simultaneous equations.
CLR-2 :	Apply the concept of interpolation for finding intermediate values of a well-known data
CLR-3 :	Apply the concept of numerical differentiation and integration in physical problems
CLR-4 :	Apply the numerical techniques for solutions of ordinary differential equations
CLR-5 :	Apply the numerical techniques for solutions of partial differential equations
CLR-6 :	Acquired analytical ability in solving mathematical problems numerically

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO – 1	PSO - 2	PSO - 3
CLO-1 :	Identify the programming to solve the algebraic, transcendental and simultaneous equations.	3	85	80	H	H	-	-	H	-	-	-	H	-	-	H	H	H	H
CLO-2 :	Identify the programming to find the finite differences and interpolation.	3	85	80	H	H	-	M	H	-	-	-	H	-	-	H	H	H	H
CLO-3 :	Construct the programming to solve numerical differentiation and integration	3	85	80	H	H	M	-	H	-	-	-	H	-	-	H	H	H	H
CLO-4 :	Construct the programming to solve the numerical solutions of ordinary differential equations	3	85	80	H	H	M	M	H	-	-	-	H	-	-	H	H	H	H
CLO-5 :	Create a program to solve the numerical solutions of partial differential equations	3	85	80	H	H	-	-	H	-	-	-	H	-	-	H	H	M	H
CLO-6:	Construct the programming to solve the problems numerically in science and engineering	3	85	80	H	H	M	M	H	-	-	-	H	-	-	H	H	H	H

Duration (hour)		Module-I (15)	Module-II(15)	Module-III (15)	Module-IV (15)	Module-V (15)
S-1	SLO-1	Introduction to Curve fitting- Method of Least Squares. Fitting a straight line	Introduction to First and Higher order differences. Forward differences and backward differences. Central Differences	Introduction to Numerical Differentiation: Newton's forward difference formulae to compute first and higher order derivatives.	Introduction to Numerical solutions for ordinary differential equations.	Introduction to Numerical solutions for partial differential equations. Classification of partial differential equations.
	SLO-2	Fitting a parabola. Calculation of the residuals of straight line and parabola.	Operators– Relations between the operators.	Newton's backward differences formulae to compute first and higher order derivatives.	Solution by Taylor's series method. Euler's method.	Solution of Elliptic Equations. Solution of Laplace Equations by Leibmann's Iterative process.
S-2 to S-5	SLO-1	Lab1:Program for fitting a curve	Lab4:Program for getting the difference table	Lab7: Program for finding the solution of differentiation to the given data using Newton's forward and backward difference formula	Lab10: Program for finding the solution of ordinary differential equation by Taylor's series method, Euler's method.	Lab13: Program for solving Elliptic equations, Laplace equations.
	SLO-2					
S-6	SLO-1	Solution to algebraic and transcendental equations: Newton-Raphson method,	Interpolation – Newton-Gregory Forward and Backward Interpolation formulae	Numerical Integration: Trapezoidal rule.	Improved Euler's method. Modified Euler's method	Solution of Poisson Equations.
	SLO-2	Bisection method, Regula falsi method.	Problems on Forward and Backward Interpolation	Problems on Trapezoidal rule	Runge-Kutta method of fourth order.	Solution to Parabolic equations.
S-7 to S-10	SLO-1	Lab2:Program for finding the root of given equation	Lab5:Program for interpolation using Newton Forward and backward interpolation formula	Lab8: Program for finding the solution of integration to the given data using Trapezoidal rule	Lab11: Program for finding the solution of ordinary differential equation by Improved Euler's method, Modified Euler's method, Runge-Kutta method of fourth order	Lab14:Program for solving the Poisson equation, parabolic equations
	SLO-2					
S-11	SLO-1	Solution of system of linear equations Direct Method - Gauss Elimination method. Gauss Jordan method	Divided differences	Simpson's 1/3 rule.	Predictor corrector method-Milne-Thomson Method.	Bender-Schmidt method
	SLO-2	Solution of system of linear equations Iterative Method – Gauss-Seidal method.	Lagrange's Interpolation formula. Inverse interpolation.	Simpson's 3/8 rule.	Adam's Bash forth Method	Crank-Nicolson method. Solution of Hyperbolic equations.
S-12 to S15	SLO-1	Lab3:Program for finding the root of given system of equation	Lab6:Program for interpolation using Lagrange's interpolation formula	Lab9:Program for finding the solution of integration to the given data using Simpson's rule	Lab12:Program for solving ordinary differential equations by multi step methods	Lab15: Program for solving partial differential equations using Bender-Schmidt method, Crank-Nicolson method. Program for finding the solution of Hyperbolic equations.
	SLO-2					

Learning Resources	1. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI, 4th edition, 2005. 2. E. Balagurusamy, Computer Oriented Statistical and Numerical Methods – Tata McGraw Hill., 2000. 3. M.K.Jain, SRK Iyengar and R.L.Jain, Numerical Methods for Scientific and Engineering Computation, Wiley Eastern Ltd., 4th edition, 2003.	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.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand										
Level 2	Apply	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Analyze										
Level 3	Evaluate	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
	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.,
SLO – Session Learning Outcome

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr.A.Govindarajan, SRMIST Dr. K. Ganesan, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr. Radhakrishnan M, SRMIST

S2

Course Code	PMA21S02J	Course Name	Data Modelling Tools using R Commander	Course Category	S	Skill Enhancement Course	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Learn the basics in R Programming in terms of constructs, control statement and string functions And understand the use of R in the role of Big data
CLR-2 :	Learn the procedure of estimate of statistical data and importance o f Testing Hypothesis. To estimate the quality of a product under control or not
CLR-3 :	Estimate the forecasting statistical models using R
CLR-4 :	Learn the basics and importance of non-parametric methods in testing hypothesis
CLR-5 :	Learn the visualization of data for good presentation using R
CLR-6 :	Comprehend the applications of R statistical programming language and acquired the knowledge of statistical modeling using R programming

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO – 1	PSO - 2	PSO - 3
CLO-1 :	Pertain knowledge of Statistical models using R programming	3	85	80	H	H	-	-	H	-	-	-	H	-	-	H	H	H	H
CLO-2 :	Acquire knowledge in testing of Hypothesis	3	85	80	H	H	-	M	H	-	-	-	H	-	-	H	H	H	H
CLO-3 :	Gain familiarity in estimate of statistical data	3	85	80	H	H	M	-	H	-	-	-	H	-	-	H	H	H	H
CLO-4 :	Gaining knowledge in Non parametric methods using R	3	85	80	H	H	M	M	H	-	-	-	H	-	-	H	H	H	H
CLO-5 :	Understanding the concept of data visualization of graphs and charts using R	3	85	80	H	H	-	-	H	-	-	-	H	-	-	H	H	M	H
CLO-6:	Understanding the concept and applications of R statistical programming language and to solve the problems of statistics using R programming	3	85	80	H	H	M	M	H	-	-	-	H	-	-	H	H	H	H

Duration(hours)		Module I (12)	Module II(12)	Module III(12)	Module IV (12)	Module V(12)
S-1	SLO-1	Introduction and Evolution of R – An overview	Introduction to Test of hypothesis	Estimation and simple forecasting models	Non-Parametric Analysis using R	Input Xml data files
	SLO-2	Overview of R-studio, R-commander	Concept & formulation	Bivariate Analysis	Non-parametric Inference	Data frame & Model
S-2	SLO-1	Basic lay out R, Console, History(environment)	Applications and the importance of Testing Hypothesis	Linear Statistical Models - Introduction	Comparison with parametric inference	Data visualization and graphs
	SLO-2	command prompt , Files/Plots/packages/viewer Creating script file in R and Run a program	Type I and Type II errors Working with Data	Simple linear correlation, Correlation coefficient and Simple linear regression	Use of order statistics, Sign test and Wilcoxon signed rank test	R-Pie charts and colors, Slice percentage charts
S-3	SLO-1	LAB Session	LAB Session	LAB Session	LAB Session	LAB Session
	SLO-2					
S4	SLO-1	LAB Session	LAB Session	LAB Session	LAB Session	LAB Session
	SLO-2					
S-5	SLO-1	Introduction to R Data Structures and data frames and variables R – Operators : Arithmetic operators , Logical operators, Relational operator , Boolean operators	One sample t –test using R Univariate : Two grouped –t test using R	multiple correlation	Mann-Whitney	3D Pie charts ,R- Bar charts , Labels , colors
	SLO-2	Data types : Vectors , List , Matrices , arrays	Two grouped –t test using R	multiple correlation	Mann-Whitney	R-Group bar chart , staked chart
S-6	SLO-1	Addition , deletion of rows and columns	Paired t test using R	Multiple regression Analysis	Run test	R- Box plots
	SLO-2	Creating multi dimensional arrays-addition deletions of columns and rows, R-Decision making : if statement	Paired t test using R, Univariate analysis-Chsquare test for good ness of fit using R and Chi square test for Independence using R	Multiple regression Analysis	Run test, Kolmogorov-Smirnov test	R-Line chart title, R-Multiple Line chart title and R-scatter plot
	SLO-1	LAB Session	LAB Session	LAB Session	LAB Session	LAB Session

S-7	SLO-2					
S8	SLO-1	LAB Session	LAB Session	LAB Session	LAB Session	LAB Session
	SLO-2					
S-9	SLO-1	if Else if statement, R-switch statement , R-switch statement R- Loops : Repeat loop , While loop	Introduction Statistical Quality control	Introduction to Analysis of variance	Wilcoxon sign Rank Test	R-Mean median mode
	SLO-2	For Loop, Nested Loop	Introduction to variable charts	One way ANOVA with as well as without interaction	Wilcoxon sign Rank Test	Introduction Data visualization software's
S-10	SLO-1	Loop control statement :Break, Next	X bar and R control chart using R	Problems based on One way ANOVA	Krushkal Wallis test	Creating graphs using R
	SLO-2	R Functions :Built in functions, user defined functions- Calling a function, String construction and manupulation	X bar and S control chart using R. Introduction to Attributes chart, P, np , c control chart	Problems based on Two way ANOVA and Applications of Linear Statistical Models and ANOVA	Krushkal Wallis test, Friedman test	Customizing graphs, Introduction Data visualization software's and Reports presentation using R output graphs
S-11	SLO-1	LAB Session	LAB Session	LAB Session	LAB Session	LAB Session
	SLO-2					
S12	SLO-1	LAB Session	LAB Session	LAB Session	LAB Session	LAB Session
	SLO-2					

Learning Resources	1. Hands-on Programming with R,- Garrett Grolemund, 2014 2. R for Everyone: Advanced Analytics and Graphics, Jared P. Lander, First edition-2013 3. Mark Gardener, " Beginning R - The statistical programming Language-2013	4. Probability and Statistics for Engineers (4th Edition), I.R. Miller, J.E. Freund and R. Johnson, 2015. 5. Fundamentals of Statistics (Vol. I & Vol. II), A. Gun, M. k. Gupta and B.Dasgupta, 2016 6. Using R commander : A point-and-click interface for R ,Chapman & Hall /CRC The R series -2016

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
	Total	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.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Dr.K. Ganesan, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr. N.Balaji, SRMIST

AE-1

Course Code	PCD21AE1T	Course Name	Professional Skills and Problem Solving	Course Category	AE	Ability Enhancement Course	L	T	P	C
							1	0	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Career Development Centre			Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	Utilise success habits to enhance professionalism
CLR-2:	Enable to solve problems and to crack competitive exams.
CLR-3:	Understand and master the mathematical concepts to solve types of problem
CLR-4:	Identify a logically sound and well-reasoned argument
CLR-5:	Expertise in communication and problem-solving skills
CLR-6:	Develop problem solving skills with appropriate strategies

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Disciplinary Knowledge	PLO 2 Critical Thinking	PLO 3 Problem Solving	PLO 4 Analytical Reasoning	PLO 5 Research Skills	PLO 6 Team Work	PLO 7 Scientific Reasoning	PLO 8 Reflective Thinking	PLO 9 Self-Directed Learning	PLO 10 Multicultural Competence	PLO 11 ICT Skills	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO - 3
CLO-1:	Identify success habits and inculcate professional skills	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	Grasp the approaches and strategies to solve problems with speed and accuracy	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	Collectively solve problems in teams and groups	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	Construe and solve an argument through critical thinking	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	Acquire communication and problem- solving skills	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	Apply problem solving techniques and skills	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		Module-I (3)	Module-II (3)	Module-III (3)	Module-IV (3)	Module- V (3)
S-1	SLO-1	Personal profiling	Creative problem solving method	Case study analysis	Emotional Intelligence	Communication skills
	SLO-2	USP& Personal branding	Techniques	Case study analysis	Personal & social competence	Communication skills
S-2	SLO-1	Assumption and strengthening of an argument	Weakening and Inference of an argument	Conclusion and paradox of an argument	Main idea and structure of a passage	Tone and Style of a passage
	SLO-2	Assumption and strengthening of an argument	Weakening and Inference of an argument	Conclusion and paradox of an argument	Main idea and structure of a passage	Tone and Style of a passage
S-3	SLO-1	Arithmetic: Simple equations	Profit, Loss & Discount	Average	Percentage	Mixtures & alligation
	SLO-2	Equation 1 and equation 2	Interest calculation	Average	Percentage	Mixtures & alligation

Learning Resources	
1.Arun Sharma-Quantitative aptitude for CAT, Tata McGraw Hill 2.Dinesh Khattar-The Pearson Guide to QUANTITATIVE APTITUDE for competitive examinations.	3.Manhatten Prep - GRE Reading Comprehension and Essays 4. Seven habits of highly effective people- Steven Covey 5. Manhattan Prep – Critical Reasoning Skills and Techniques

Learning Assessment

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

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

Course Designers		
Experts from Industry	Internal Experts	
1.Mr Ajay Zenne, Career Launcher, ajay.z@careerlauncher.com	Mr. P Priyanand, SRMIST	
	Mrs. Kavitha Srisarann, SRMIST	
2. Mr.Pratap Iyer, Study Abroad Mentors, Mumbai, pratap.iyer30@gmail.com	Mr. Harinarayana Rao, SRMIST	
	Dr. A Clement, SRMIST	

SEMESTER – 2
PC5

Course Code	PMA21205T	Course Name	ALGEBRA	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

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

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

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Learn about basic arithmetic.	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-2 :	Understand about groups																		
CLR-3 :	Gain knowledge about rings and fields.																		
CLR-4 :	Gain knowledge algebraic closures																		
CLR-5 :	Gain knowledge field extension																		
CLR-6 :	Understand solvability of polynomials and Galois theory																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Derive equations of basic arithmetics	3	85	80	H	H	M	-	-	-	-	-	M	M	-	H	H	H	H
CLO-2 :	Derive and understand the properties of groups	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	H	-	-
CLO-3 :	Able to get the knowledge of cyclic groups and group homomorphism	3	85	80	H	H	-		-	-	-	-	M	-	-	H	-	M	M
CLO-4 :	Derive and solve Sylow's theorem and their applications	3	85	80	H	H	H	M	-	-	-	-	M	-	-	H	-	H	M
CLO-5 :	Derive and solve problems in homomorphism and Cayley's theorem	3	85	80	M	H	M	-	-	-	-	-	M	-	-	H	-	-	-
CLO:6	Derive solutions in cryptography and real life problem	3	85	80	H	H	M	M	M	-	-	-	M	M	-	H	H	H	M

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Introduction to laws of algebra	Introduction to p-groups	Introduction to laws of group	Introduction of extension of rings	Introduction to system of congruence
	SLO-2	Basic problems in laws of algebra	The rationale behind this unit will be discussed	Basic problems in group	Basic properties of fields	Definition of congruence with examples
S-2	SLO-1	The rationale behind this unit will be discussed	Definition of p-subgroup	Need of studying ring theory	The rationale behind this unit will be discussed	Chinese remainder theorem
	SLO-2	Definition of group and properties	Problems in finding p-subgroup and simple groups	Definition of rings with examples	Definition of finite fields	Problems based on Chinese Remainder theorem
S-3	SLO-1	Classification of groups	Centre of a group	Definition of commutative rings	Difference between rings and fields	Problems based on Chinese Remainder theorem
	SLO-2	Problems in number system based on groups	Normalizer of a group	Problems in commutative rings Definition of ideals, prime ideals	Problems in fields	Chinese Remainder theorem with examples
S-4	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-5	SLO-1	Problems in groups, subgroups	Class equation	Definition of maximal ideals and prime ideals	Introduction to extensions	Definition of characteristic zero
	SLO-2	Introduction of Normal subgroups	Proof of class equation	Theorems in maximal ideal	Theorem and proof in algebraic extensions	Problems in characteristic zero
S-6	SLO-1	State and prove Lagranges theorem	Problems based on centre of a group	Quotient rings	Theorems based on algebraic extensions	Basic concepts of field extensions
	SLO-2	Properties and corollary in Lagranges theorem	Problems based on centre of a group and normalizer of a group	Basic Properties of quotient rings	Algebraic closures	Finding basics of field extensions
S-7	SLO-1	Introduction to Euler phi function	Definition of Sylow p-subgroup	fundamental theorem of arithmetic	existence of algebraic closure and field extension	Basic concepts of normal splitting fields
	SLO-2	Generating function and cyclic groups and Necessary and sufficient condition for cyclic groups	Find sylow p-subgroup of some fields Sylow First theorem	Factorization domain and Ideal domain	Basic theorems in algebraic closures and field extension, cardinality of algebraic closure	Definition of Galva group and Application of Galva group
S-8	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-9	SLO-1	permutation groups , Concept of quotient function	Sylow second theorem	Principal ideal domain Euclidean domain	Theorems in cardinality of algebraic closures and finite fields	Fundamental theorem of Galva group
	SLO-2	Problems in finding quotient function	Prove sylow second theorem	Properties and basic theorems in ideal and Euclidean domain	Definition and examples of finite fields and splitting fields	The rationale behind this Galois group will be discussed

S-10	SLO-1	homomorphism theorems	Sylow third theorem	polynomial rings	Problems in splitting fields	Statement of Galva Group
	SLO-2	automorphisms	Proof of Sylow third theorem	Finding the polynomial rings	Problems in splitting fields	Describe explicitly the basics of Galois group
S-11	SLO-1	Fundamental theorem of homomorphism	Application of Sylow theorems and simple groups	irreducibility criteria of polynomials	Definition of characteristic functions	Proof of Galois theory
	SLO-2	Cayley's theorem	Application of Sylow theorems and simple groups	Problems in irreducible polynomials	Problems in characteristic functions	Proof of Galois theory
S-12	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session

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

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	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 and attendance etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Dr. K. Ganesan, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr. D.K. Sheena Christy,SRMIST

PC-6

Course Code	PMA21206T	Course Name	Complex Analysis	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

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

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

		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Understand the fundamental concepts of complex analysis.																		
CLR-2 :	Learn the concepts of stereographic projection and point set topology.																		
CLR-3 :	Know about the analytical concepts of complex functions.																		
CLR-4 :	Learn the concepts of different types of singularities via theoretical as well as series expansions.																		
CLR-5 :	Learn to integrate complex valued functions.																		
CLR-6 :	Gain knowledge about the applications of the concept of residues. To understand the evaluation of integrals of different types.																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Explain the transformation concepts in complex variable.	3	85	80	H	H	-	-	-	-	-	-	M	-	-	H	H	H	H
CLO-2 :	Explain the fundamental concepts in complex analysis such as analyticity, transformation, singularities and contour integration.	3	85	80	H	H	-	M	-	-	-	-	M	-	-	H	H	H	H
CLO-3 :	Check whether a function is analytic and be able to evaluate integrals in relation to Cauchy's theorems and formula.	3	85	80	H	H	-		-	-	-	-	M	-	-	H	H	H	H
CLO-4 :	Relate the singularities of different types and determine the power series expansion of Taylor's and Laurent's series.	3	85	80	H	H	H	M	-	-	-	-	M	-	-	H	H	H	M
CLO-5 :	Able to apply the concept of residues in solving practical problems and evaluate the different types of real definite integrals.	3	85	80	H	H	-	-	-	-	-	-	M	-	-	H	H	H	M
CLO-6 :	Able to know and classify bilinear transformation, and find fixed points, magnification factor, cross-ratio in order to apply conformality.	3	85	80	H	H	H	M	-	-	-	-	M	-	-	H	H	H	H

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Introduction to complex numbers and their geometric representations.	Cauchy-Riemann equation. Its derivation. Worked out examples.	Curve, Closed curve, simple curve, Jordan curve, reversal of the curve, smooth curve. Illustrations and worked out examples.	Laurent series expansion. Worked out examples.	Conformal mapping. Definition and examples. Motivation.
	SLO-2	Polar representations of complex numbers. Worked out examples.	Polar and complex form of Cauchy-Riemann equation. Worked out examples	Cauchy's weak theorem. Cauchy-Goursat theorem. Its proof. Worked out example.	Practise problems of Laurent series in relation to integration and Cauchy's results.	Isogonal mapping. Examples.
S-2	SLO-1	Basic results of complex numbers under the modulus operation.	Necessary and sufficient conditions for differentiability of complex valued functions and its proof.	Contour integral. Cauchy's theorem and its proof. Worked out examples.	Analysis of singularities through Laurent series. Illustrative examples and worked out problems.	Magnification factor and scale factor, critical points. Worked out examples and problems.
	SLO-2	Inverse points with respect to a circle. Introduction to stereographic projection.	Introduction to analytic function. Its definition. Worked out examples.	Winding number or index of a curve. Simply connected region. Illustrations. Worked out examples	Residues, Calculation of residues. Worked out examples.	Results, theorems, and propositions related to conformal mapping.
S-3	SLO-1	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.	Cauchy residue theorem with proof. Illustrative example.	Linear fractional/Bilinear transformation. Illustrative examples and worked out problems.
	SLO-2	Point set topology on the complex plane.	Positional Classification of singular points. Worked out problems	Morera's theorem. Analytic function on simply connected domain. Cauchy's inequality. Worked out examples.	Worked out problems on Cauchy residue theorems.	Matrix interpretation of a Mobius transformation.
S-4	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-5	SLO-1	Limit of a complex function. Worked out examples.	Character based Classification of singular points. Worked out problems.	Liouvilles's theorem, its proof and worked out examples and results. Generalized version of Liouville's theorem. Examples.	Real definite integral and its evaluation using the concept of residues.	Fixed points of Bilinear transformation. Worked out examples. Applications.

	SLO-2	Some important deductions related to limit of a complex function. Worked out examples.	Zeros of Analytic function. Essentia singularity. Worked out examples.	Taylor's series expansion. Theorems and propositions related to it. Illustrations and worked out examples.	Evaluation of Integral of the type $\int_0^{2\pi} f(\cos\theta, \sin\theta) d\theta$.	Practise problems.
S-6	SLO-1	Continuity of a function. Worked out examples.	Riemann's removable singularity theorem with proof. Worked out examples.	Identity/Uniqueness theorem. Illustrative examples and worked out problems.	Jordan's lemma. Worked out problems.	Normal form or canonical form of a Bilinear transformation. Its classification and examples.
	SLO-2	Some important deductions related to continuity of a complex function. Worked out examples.	Casorati-Weierstrass's theorem. Its proof. Worked out problems.	Laurent Theorem. Results and propositions related to Laurent theorem. Worked out problems.	Evaluation of Integral of the type $\int_{-\infty}^{\infty} f(x)\sin axdx, a>0$	Cross ratio. Related theorems and worked out problems.
S-7	SLO-1	Uniform continuity and the related worked out problems.	Entire function. Results on analyticity. Worked out examples.	Analysis of singularities through Laurent series. Illustrative examples and worked out problems.	Evaluation of Integral of the type $\int_{-\infty}^{\infty} f(x)\cos axdx, a>0$	Practise problems.
	SLO-2	Differentiability of a complex function. Worked out examples.	Harmonic function, Harmonic conjugate. Definition and worked out examples.	Maximum and minimum modulus theorems with proofs. Worked out problems.	Evaluation of Integral of the type $\int_{-\infty}^{\infty} \frac{p(x)}{q(x)}dx$	Special linear fractional transformation. Worked out examples.
S-8	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-9	SLO-1	Algebra of differentiability of complex functions. Worked out examples.	Construction of an analytic function. Milne-Thomson method.	The open-mapping theorem. Its proof and worked out problems.	Evaluation of Integrals of the form $\int_{-\infty}^{\infty} f(x)dx$	Riemann surface. Illustrative examples.
	SLO-2	**Practise problems** on limit and continuity of complex functions.	Construction of analytic function when the real part is known. Worked out examples.	Schwarz lemma. Schwarz pick lemma. Illustrative examples and worked out examples.	Extended residue formula. Illustrative example. Worked out problems.	Theorems and results related to Riemann surface. Examples.
S-10	SLO-1	**Practise problems** on differentiability of complex functions.	Construction of analytic function when the imaginary part is known. Worked out examples.	Practise problems on Cauchy's theorem and formula.	Practise problems	Brief view on automorphisms of disks and half-planes.
	SLO-2	Difference between limit, continuity and differentiability of a real and complex function.	Power series of a complex valued function. Its radius of convergence. Worked out problems.	Practise problems on Laurent series expansion.	Argument theorem. Illustrative examples. Worked out problems.	Automorphisms on a unit disk. Illustrative examples. Theorem related to it.
S-11	SLO-1	Complex polynomials. Algebra of complex polynomials.	Power series definition of analytic function. Examples. Worked out problems.	Practise problems on analyticity and singularities.	Rouche's theorem. Illustrative examples. Worked out problems.	Symmetric point/ inverse points. Definition and examples.
	SLO-2	Fundamental results related to complex polynomials.	Multi-valued functions. Worked out examples.	Worked out examples.	Practise problems.	Reflection/inverse maps. Illustrative examples. Symmetry principal Mobius maps.
S-12	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session

Learning Resources

1. **S**.Narayanan and T.K.Manicavachagompillai, Complex Analysis, Revised Edition.S.Viswanathan Printers & Publishers,2002.
2. P.Duripandian and LaxmiDuraipandian, Complex Analysis,Emerald Publishers,Chennai, 2006.
3. S.Ponnusamy,Foundations of Complex Analysis,Narosa Publishing House,New Delhi,2nd edition,2013.
4. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw – Hill International Edition, 2009.
5. Joseph Bak and Donald J. Newman, Complex analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 3rd edition 2010.
6. B.S.Thagi, Functions of a Complex variable,Kedarnath Ramnath,Meerut,2015.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	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.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan,SRMIST Dr. N.Parvathi, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr. Saurabh Kumar Katiyar,SRMIST

PC-7

Course Code	PMA21207T	Course Name	Partial Differential Equations	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

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

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

		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Learn about simultaneous differential equations of first order and first degree.																		
CLR-2 :	Learn about origins and classification of first order PDE																		
CLR-3 :	Gain knowledge about origin of second order PDE																		
CLR-4 :	Gain knowledge about One dimensional wave equation																		
CLR-5 :	Gain knowledge about solutions of Laplace equation in Cartesian and polar coordinates																		
CLR-6 :	Gain the knowledge about first order and second order PDEs and the techniques to solve them.																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Able to construct the general solution of simultaneous differential equations of first order and first degree	3	85	80	H	H	M	-	M	-	-	-	M	M	-	H	H	M	H
CLO-2 :	Able to derive the uniqueness and existence of solution of second order PDE	3	85	80	M	H	-	M	-	-	-	-	M	-	-	H	M	M	M
CLO-3 :	Able to reduce the given second order PDEs to canonical form and construct the solutions	3	85	80	M	H	-	-	-	-	-	-	M	-	-	H	M	M	H
CLO-4 :	Able to solve one dimensional wave problems for different cases	3	85	80	H	H	H	M	M	-	-	-	M	M	-	H	H	H	M
CLO-5 :	Able to derive the solution of BVP like Laplace equation, Diffusion equation	3	85	80	H	H	H	H	M	-	-	-	M	H	-	H	H	H	H
CLO-6 :	Able to solve the 1st order and 2nd order PDEs and analyze them in real life applications point of view.	3	85	80	H	H	M	M	M				M	M		H	H	M	H

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Introduction	Introduction of Partial differential equations	Introduction	Introduction to wave equation	Introduction
	SLO-2	Simultaneous differential equations of first order and first degree	Origins and classification of first order PDE	Origin of second order PDE	One dimensional wave equation	Maximum principle
S-2	SLO-1	Examples	First order quasi-linear PDE	Classification of second order equations	D'Alembert's solution	Weak Maximum principle
	SLO-2	Integral Curves	Initial value problem for quasi-linear PDE	Examples	D'Alembert's solution	Strong Maximum principle
S-3	SLO-1	Nature of solution of dx/P = dy/Q = dz/R	Existence and uniqueness of solutions	Second order PDE with variable coefficients	Vibration of infinite string	Solutions of Laplace equation (Elliptic equation)
	SLO-2	Method of solution of dx/P = dy/Q = dz/R	Non-existence and non-uniqueness of solutions	Second order PDE with variable coefficients	Vibration of semi-infinite string	Fundamental solution
S-4	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-5	SLO-1	Rule-I for solving dx/P = dy/Q = dz/R	Integral Surfaces	Characteristic curves of second order PDE	Vibration of finite string	Solution of Laplace equation in rectangular and annular region
	SLO-2	Rule-II for solving dx/P = dy/Q = dz/R	Surfaces orthogonal to a given system of surfaces	Characteristic curves of second order PDE	Reflection method for half-line	Existence of weak solutions: Lax–Milgram Theorem
S-6	SLO-1	Rule-III for solving dx/P = dy/Q = dz/R	Nonlinear PDE of first order	Characteristic curves of second order PDE	Reflection method for half-line	Regularity: Interior and Boundary
	SLO-2	System of curves on a surface	Types of solutions of nonlinear PDE of first order	Characteristic curves of second order PDE	Inhomogeneous wave equation	One dimensional diffusion equation
S-7	SLO-1	Orthogonal trajectories	Cauchy's method of charcteristic	Characteristic of equations in three variables	Inhomogeneous wave equation	Fundamental solution
	SLO-2	Orthogonal trajectories	Cauchy's method of charcteristic	Characteristic of equations in three variables	Inhomogeneous wave equation	Properties of solutions
S-8	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session

S-9	SLO-1	Pfaffian differential equation	Compatible systems of first order equations	Reduction into canonical form-Parabolic PDE	Definition of Fourier transform	Maximum- minimum principle for the diffusion equation
	SLO-2	Method of solution of Pdx+Qdy+Rdz=0	Compatible systems of first order equations	General solution from canonical form	Basic properties of Fourier transform	Diffusion equation on the whole line
S-10	SLO-1	Method-I for solving Pdx+Qdy+Rdz=0	Charpit's method	Reduction into canonical form-Hyperbolic PDE	Fourier transform for partial derivatives	Diffusion on the half-line
	SLO-2	Method-II solution of homogeneous equation Pdx+Qdy+Rdz=0	Charpit's method	General solution from canonical form	Solution of wave equation using Fourier transform	Inhomogeneous equation on the whole line
S-11	SLO-1	Solution of Pdx+Qdy+Rdz=0 taking one variable constant	Solutions satisfying given conditions	Reduction into canonical form-Elliptic PDE	Fourier sine transform and solution of semi infinite string problems	Application of Fourier transform to solve diffusion equations
	SLO-2	Solution of Pdx+Qdy+Rdz=0 if it is exact and degree n is not one	Solutions satisfying given conditions	General solution from canonical form	Fourier cosine transform and solution of semi infinite string problems	Energy methods
S-12	SLO-1	Tutorial	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial	Tutorial session	Tutorial session	Tutorial session	Tutorial session

Learning Resources	1.I. P. Stavroulakis and S. A. Tersian, Partial Differential Equations- An Introduction 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

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	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.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Dr. k. Ganesan, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr.Bibekananda Bira, SRMIST

D-4

Course Code	PMA21D04T	Course Name	Fuzzy Sets and Applications	Course Category	D	Discipline Specific Elective Course	L	T	P	C
							3	1	0	4

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

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

		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Understand basic concepts of fuzzy sets																		
CLR-2 :	Acquaint knowledge of fuzzy numbers and their arithmetic operations																		
CLR-3 :	Understanding basic concepts of fuzzy relations and their properties																		
CLR-4 :	Understand fuzzy decision making and graphs																		
CLR-5 :	Acquire knowledge in fuzzy logic																		
CLR-6 :	Applications to control theory																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Represent uncertainty using fuzzy sets	3	85	80	H	H	M	-	-	-	-	-	M	M	-	H	H	H	M
CLO-2 :	Deal with arithmetic operations on fuzzy numbers	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	H	M	-
CLO-3 :	Apply operations on fuzzy relations	3	85	80	H	H	-		-	-	-	-	M	-	-	H	-	-	-
CLO-4 :	Solve problem in LPP and graphs under fuzzy environment	3	85	80	H	H	H	M	-	-	-	-	M	M	-	H	H	H	M
CLO-5 :	Solve problems in control theory	3	85	80	M	H	M	-	-	-	-	-	M	-	-	H	H	M	M
CLO-6 :	Solve problems in Fuzzy logics	3	85	80	M	H	M	M	M	-	-	-	M	M	-	H	H	H	M

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Fuzzy sets – Basic definitions	Introduction to Extension principle	Introduction to binary relations	Introduction to decision making	Introduction to logics
	SLO-2	Fuzzy sets – Basic definitions	Extension principle	Introduction to fuzzy binary relations	Introduction to fuzzy decision making	Basic concept of connectivity's
S-2	SLO-1	Level sets of fuzzy sets	Zadeh's Extension principle	Types of binary relations	Difference between decision making and fuzzy decision making	Introduction to fuzzy logics
	SLO-2	Basic assumption convex fuzzy sets	Problems on extension principles	Types of fuzzy binary relations	Necessity of fuzzy decision making	Basic concept of fuzzy connectivity's
S-3	SLO-1	Basic operations on fuzzy sets	Application of extension principle	Properties of binary relations	Introduction to LPP	Tautologies of crisp logics
	SLO-2	Basic operations on fuzzy sets	Existence theorems	Properties of fuzzy binary relations	Introduction to fuzzy LPP	Contradiction of crisp logics
S-4	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-5	SLO-1	Union operations on fuzzy sets	Image of fuzzy sets	Equivalence relation	Problems on fuzzy LPP with crisp objective function	Tautologies of fuzzy logics
	SLO-2	Intersection operations on fuzzy sets	Problems on image of fuzzy sets	Fuzzy equivalence relation	Problems on fuzzy LPP with crisp objective function	Contradiction of fuzzy logics
S-6	SLO-1	Types of fuzzy sets	Inverse image of fuzzy sets	Partial ordering relation	Problems on fuzzy LPP with fuzzy objective function	Quantifiers
	SLO-2	Problems on types of fuzzy sets	Problems on inverse image of fuzzy sets	Fuzzy partial ordering relation	Problems on fuzzy LPP with fuzzy objective function with triangular numbers	Fuzzy quantifiers
S-7	SLO-1	Cartesian products	Fuzzy numbers	Closure of relation	Problems on fuzzy LPP with fuzzy objective function with symmetric triangular numbers	Linguistic variables
	SLO-2	Problems on Cartesian products	Types of fuzzy numbers	Fuzzy closure of relation	Problems on fuzzy LPP with fuzzy objective function with non-symmetric triangular numbers	Fuzzy truth qualifiers
S-8	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-9	SLO-1	Algebraic products	Arithmetic operations on fuzzy numbers	Composition of relations	Introduction to graphs	Introduction to control theory
	SLO-2	Problems on algebraic products	Arithmetic operations on fuzzy numbers	Fuzzy composition of relations	Introduction to fuzzy graphs	Introduction to fuzzy control theory
S-10	SLO-1	Boundedsum	Problems on arithmetic operations on fuzzy numbers	Max- composition of relation	Bellman ford algorithm for graphs	Control theory in real world application

	SLO-2	Problems on bounded sum	Problems on arithmetic operations on fuzzy numbers	Min-composition of relation	Bellman ford algorithm for fuzzy graphs	Simple pendulum problems
S-11	SLO-1	Bounded difference	Solving fuzzy equations	Maxi-min composition of fuzzy relation	Flody's algorithm for graphs	Problems on fuzzy control theory
	SLO-2	Problems on bounded difference	Solving fuzzy equations	Problems on maxi-min composition of fuzzy relation	Flody's algorithm for fuzzy graphs	Applications of fuzzy control theory
S-12	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session

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

Learning Assessment											
	Bloom's Level of Thinking	**Continuous Learning Assessment (50% weightage)**								**Final Examination (50% weightage)**	
		CLA – 1 (10%)		**CLA – 2 (10%)**		**CLA – 3 (20%)**		**CLA – 4 (10%)#**			
		Theory	**Practice**	**Theory**	**Practice**	**Theory**	**Practice**	**Theory**	**Practice**	**Theory**	**Practice**
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	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.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.V.Maheshwaran, CTS, Chennai, maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Dr.K. Ganesan,SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr.K. Ganesan,SRMIST

D5

Course Code	PMA21D05T	Course Name	Formal Languages and Automata Theory	Course Category	D	Discipline Specific Elective Course	L	T	P	C
							3	1	0	4

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

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

		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Introduce the student to the concepts of theory of computation in computer science.																		
CLR-2 :	Illustrate finite state machines to solve problems in computing																		
CLR-3 :	Explain the hierarchy of problems arising in the computer sciences																		
CLR-4 :	Acquire insights into the relationship among formal languages, formal grammars, and automata																		
CLR-5 :	Familiarize Regular grammars, context frees grammar.																		
CLR-6 :	Learn to design automata and Turing machine																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Demonstrate an understanding of abstract models of computing, including deterministic (DFA), non-deterministic (NFA), and Turing (TM) machine models.	3	85	80	H	H	-	-	-	-	-	-	M	-	-	H	H	H	H
CLO-2 :	Demonstrate an understanding of regular expressions and grammars, including context-free and context-sensitive gram-mars.	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	H	M	M
CLO-3 :	Understand the relationships between language classes, including regular, context-free, context-sensitive, recursive, and recursively enumerable languages.	3	85	80	H	H	-		-	-	-	-	M	-	-	H	H	H	H
CLO-4 :	Employ finite state machines for modeling and solving computing problems.	3	85	80	H	H	H	M	-	-	-	-	M	-	-	H	-	-	-
CLO-5 :	Design Turing Machine	3	85	80	M	H	-	-	-	-	-	-	M	-	-	H	-	-	-
CLO-6 :	Gain proficiency with mathematical tools and formal methods.	3	85	80	M	H	H	M	M	-	-	-	M	-	-	H	H	H	H

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Introduction to Mathematical Preliminaries and Notation	Regular sets	Context Free Grammars	Turing Machine, definition and examples	Chomsky hierarchy of languages
	SLO-2	Alphabet, Strings, Language, Operations	Regular expressions-Definition and Examples	Ambiguity in context free grammars	Turing Machine: model and ID	Computability of problems
S-2	SLO-1	Mealy Machine AND Moore Machine – Definition and Examples	Language associated with Regular Expressions	Minimization of Context Free Grammars	Design of Turing Machine,	Decidability of problems
	SLO-2	Equivalence of Moore and Mealy machines	Regular Expressions for describing Simple Patterns	Methods for transforming Grammars	Turing Machines as Language Acceptors	The Turing Machine Halting Problem
S-3	SLO-1	Finite Automaton Model	Identity Rules	A useful substitution Rule	Turing Machines as Transducers	Reducing one Undecidable problem to another
	SLO-2	Accepting strings and languages	Constructing Finite Automata for a given regular expression	Elimination of Useless symbols and Unit Productions	Multidimensional Turing Machines	The state entry problem
S-4	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-5	SLO-1	DFA:Definition and Transition Diagrams	Conversion of Finite Automata to Regular expressions	Chomsky normal form	Non deterministic Turing Machines	Undecidable problems for Recursively Enumerable Languages
	SLO-2	DFA: Language Recognizers	Pumping lemma of regular sets	Greiback normal form	A universal Turing Machines	The Post Correspondence Problem
S-6	SLO-1	NDFA: Transition Diagrams	Closure properties of regular sets	Pumping Lemma for Context Free Languages.	Computable functions	Modified Post Correspondence Problem
	SLO-2	NDFA: Language Recognizers	Regular grammars-left and right linear linear grammar	Enumeration of properties of CFL	Recursive and Recursively enumerable languages	Undecidable problems for context free languages
S-7	SLO-1	Reduction of number of states in Finite Automata	Equivalence of Regular Languages and Regular Grammars	Push down automata, definition and examples	Languages that are not Recursively enumerable	A Question of Efficiency
	SLO-2	NFA to DFA Conversion	Equivalence between regular linear grammar and FA	Push down automata, model,ID	Language that is Recursively enumerable but not Recursive	Efficiency of computation
S-8	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session

S-9	SLO-1	NFA with ε Transitions – significance, acceptance of languages	Inter conversion from FA to Regular Grammar	acceptance of CFL by final state and empty state	Church's hypothesis	Language Classes and Complexity Classes
	SLO-2	Conversions and Equivalence : Equivalence between NFA with ε transitions	Inter conversion from Regular Grammar to FA	Designing PDA	Counter machine	The complexity class P and NP
S-10	SLO-1	Conversions and Equivalence : Equivalence between NFA without ε transitions	Right most and Leftmost derivation of strings	Equivalence of CFL and PDA	Unrestricted Grammars	The Hamiltonian Path Problem
	SLO-2	Equivalence of two FSM's	Derivation trees	Conversion of PDA to CFG	Context sensitive grammars and languages	The clique Problem
S-11	SLO-1	Minimization of FSM	Sentential forms and examples	Introduction to DCFL	Linear Bounded Automata(LBA)	Polynomial Time Reduction
	SLO-2	Designing DFA and NFA for Elementary Languages	Relation between Sentential forms and Derivation Trees	Introduction to DPDA	Relation between Recursive and Context Sensitive Languages	NP-Completeness and NP hard problems
S-12	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session

Learning Resources	1. John E Hopcroft, Rajeev Motwani and Jeffrey D Ullman, Introduction to Automata Theory, Languages and Computation, Second Edition, Pearson - Addison wesley, 2001. 2. Michael Sipser, Introduction to the Theory of Computation, Second Edition, Thomson Course Technology, 2006. 3. Kamala Krithivasan, Rama R, Introduction to Formal Languages, Automata Theory and Computation, Pearson Education, 2009.	4. Daniel I.A. Cohen, Introduction to Computer Theory, Second Edition, Wiley Publication, 1996. 5. Peter Linz, An Introduction to Formal Languages and Automata, Fifth Edition, Jones & Bartlett Learning, 2012. 6. Kavi Maheshey, Theory of Computation: A Problem Solving Approach, Wiley Publication, 2011.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)				Final Examination (50% weightage)
		CLA – 1 (10%)	CLA – 2 (10%)	CLA – 3 (20%)	CLA – 4 (10%)#	
		Theory	Theory	Theory	Theory	Theory
Level 1	Remember	40%	30%	30%	30%	30%
	Understand					
Level 2	Apply	40%	40%	40%	40%	40%
	Analyze					
Level 3	Evaluate	20%	30%	30%	30%	30%
	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.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Dr. N. Parvathi, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr. R. Arulprakasam, SRMIST

D6

Course Code	PMA21D06J	Course Name	Introduction to Mathematical Finance	Course Category	D	Discipline Specific Elective Course	L	T	P	C
							3	0	2	4

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

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

		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Provide an introductory on Financial Mathematics.			
CLR-2 :	Understand Asset Pricing and Stochastic Process under Finance			
CLR-3 :	Know the techniques of Black Scholes model, arbitrage, option values, European options, and American option in problem in Financial Engineering			
CLR-4 :	Apply the concept of Stochastic differential equations in problems of Financial Engineering			
CLR-5 :	Gain knowledge of Brownian motion and Binomial Methods in problems involving the Financial Engineering			
CLR-6 :	Develop skills in practical, analytical problem-solving in some parts of Mathematical Finance			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Gain familiarity in the knowledge Stock Market, Investment and securities, Stock return, Risk, Option and futures.	3	85	80	H	H	-	-	-	-	-	-	M	-	-	H	H	H	H
CLO-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	80	M	H	-	M	M	-	-	-	M	-	-	H	H	M	M
CLO-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	80	H	H	-		-	-	-	-	M	-	-	H	H	H	H
CLO-4 :	Gain the knowledge of Black Scholes equation, Arbitrage, European options, and American option in Mathematical Finance	3	85	80	H	H	H	M	-	-	-	-	M	-	-	H	-	-	-
CLO-5 :	Gain the knowledge of Brownian motion, Limit of scaled random walks, and Binomial methods in the problems involving Financial Engineering	3	85	80	M	H	-	-	-	-	-	-	M	-	-	H	-	-	-
CLO-6 :	Acquire the knowledge and developing Mathematical Finance.	3	85	80	M	H	H	M	M	-	-	-	M	-	-	H	H	H	H

Duration (hour)		Module-I (15)	Module-II (15)	Module-III (15)	Module-IV (15)	Module- V (15)
S-1	SLO-1	Introduction to Mathematical Finance	One-period binomial model	Stochastic differential equations Introduction	The Black-Scholes Formula	Definition of Brownian motion
	SLO-2	Stocks	One-period binomial model, Example	Stochastic differential equations	Scaling time and model parameters	Brownian motion
S-2	SLO-1	Bond, Financial market	The Fundamental Theorems of Asset Pricing	Tutorial	Using the Central Limit Theorem to obtain a limit	Tutorial
	SLO-2	Bond, Financial market	The Fundamental Theorems of Asset Pricing	The practical problem of Stochastic differential equations	The role of volatility	Limit of scaled random walks
S-3	SLO-1	Stocks Returns	The Binomial Asset Pricing Model	Ito Calculus	Arbitrage	Quadratic variation of Brownian motion
	SLO-2	Stocks Returns	Pricing by replication in a multiperiod Model	Ito Calculus	Option values	Quadratic variation of Brownian motion
S 4-S-5	SLO-1 SLO-2	Practice Session (Introduction of the financial tools)	Practice Session (Problems of Asset pricing model)	Practice Session (Ito Calculus)	Practice Session (Black-Scholes formula, Calculation of Arbitrage and option value)	Practice Session (Brownian motion)
S-6	SLO-1	Risk	Introduction to Weiner process	Ito Calculus	Payoffs and Strategies	The problem of integration concerning Brownian motion
	SLO-2	Risk	Weiner process	Properties, Example	Put-Call Parity	The problem of integration concerning Brownian motion
S-7	SLO-1	Options	Properties	Tutorial	Tutorial	Binomial methods
	SLO-2	Options	Tutorial	One dimensional diffusion process	Black-Scholes equation	Option valuation
S-8	SLO-1	forward contracts	Introduction to Markov property	One dimensional diffusion process	Similarity solution and Exact formulae for European options	Dividend-paying Stock
	SLO-2	forward contracts	Markov property, Example	One dimensional diffusion process: Numerical problem	American option, Call and Put options	Dividend-paying Stock
S9-S-10	SLO-1 SLO-2	Practice Session (Calculation of general options and forward contract)	Practice Session (Problem of Weiner Process and Morkov Process)	Practice Session (Problem-related to one-dimensional diffusion)	Practice Session	Practice Session (Dividend)

S-11	SLO-1	Pricing by no-arbitrage considerations	Introduction to Martingale Property	Multidimensional diffusion process	Call and Put options	Monte Carlo Simulation: valuation by simulation
	SLO-2	Pricing by no-arbitrage considerations	Martingale Property, Tutorial	Multidimensional diffusion process	Application	Monte Carlo Simulation: valuation by simulation
S-12	SLO-1	Pricing by no-arbitrage considerations	Martingales and European derivative Securities	Multidimensional diffusion process	Binomial Methods:	Grouping by Similarities
	SLO-2	Tutorial	The risk-neutral probability measure	Application & Turorial	Option valuation	Tutorial
S-13	SLO-1	Market Index	The risk-neutral probability measure	Poisson Process	Dividend-paying stock	Stylized Empirical Facts of Asset Returns
	SLO-2	Market Index	Tutorial	Poisson Process	General formulation and implementation	Stylized Empirical Facts of Asset Returns
S-14-S-15	SLO-1 SLO-2	Practice Session (Problem-related Pricing by no-arbitrage and index calculation)	Practice Session (Problem-related to Martingale and The risk-neutral probability	Practice Session (Problem-related to Poisson Process)	Practice Session (Calculation of put and call options)	Practice Session (Monte Carlo Simulation: valuation by simulation, Calculation of Asset return)

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. Christian Fries - Mathematical finance Theory, Modeling, Implementation, Wiley-2007. 5. Jin-Chuan Duan, James E. Gentle, Wolfgang Karl Härdle (auth.), Jin-Chuan Duan, Wolfgang Karl Härdle, James E. Gentle (eds.) - Handbook of Computational Finance, 1 ed., Springer-Verlag Berlin Heidelberg-2012 6. . Nikolai Dokuchaev, Mathematical Finance: core theory, problems and statistical algorithms, Routledge-2007

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Theory	Practice	Theory	Practice	Theory
Level 1	Remember Understand	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	10%	10%	10%	10%	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.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Minimum one expert	Minimum one expert	Minimum one expert
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST, Dr.K. Ganesan, SRMIST,
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr. Pankaj Kumar, SRMIST

S3

Course Code	PMA21S03J	Course Name	Scientific Programming using Python	Course Category	S	Skill Enhancement Course	L	T	P	C
							2	0	2	3

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

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

		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Utilize the basic concepts of PYTHON to manipulate the procedural programming			
CLR-2 :	Utilize the basic concepts of PYTHON to manipulate the data types			
CLR-3 :	Utilize the PYTHON to manipulate the collection data types			
CLR-4 :	Utilize the PYTHON to manipulate the control structure and functions			
CLR-5 :	Construct the PYTHON to manipulate the collection data types programming for modules			
CLR-6 :	Construct the PYTHON code to compute the result for the numerical problems			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Identify the PYTHON codes to find the procedural programming	3	85	80	H	H	-	-	-	-	-	-	M	-	-	H	H	H	H
CLO-2 :	Identify the PYTHON codes for data types in program	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	H	M	M
CLO-3 :	Apply the appropriate coding for collection data types	3	85	80	H	H	-		-	-	-	-	M	-	-	H	H	H	H
CLO-4 :	Apply the appropriate for the control structure and functions	3	85	80	H	H	H	M	-	-	-	-	M	-	-	H	-	-	-
CLO-5 :	Apply PYTHON programming for modules	3	85	80	M	H	-	-	-	-	-	-	M	-	-	H	-	-	-
CLO-6 :	Apply the appropriate PYTHON code to compute the get result for any program.	3	85	80	M	H	H	M	M	-	-	-	M	-	-	H	H	H	H

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Installation	Identifiers and Keywords	Collection Data Types: Sequence Types	Control Structures: Conditional Branching	Modules and Packages
	SLO-2	The Basic elements of Python	Integral Types: Integers	Tuples	Looping	Packages
S-2	SLO-1	Creating and Running Python Programs	Integral Types: Booleans	Named Tuples,	Exception Handling	Custom Modules
	SLO-2	Data Types	Floating-Point Types: Floating-Point Numbers	Lists	Catching and Raising Exceptions	Overview of Python's Standard Library
S-3-4	SLO-1	LAB1: Program using Data types	LAB4: Integral and Floating point types	LAB7: Program on sequence type	LAB10: Program for Control structure	LAB13: Programs using Modules and Packages
	SLO-2					
S5	SLO-1	Object References	Complex Numbers	Set Types	Custom Exceptions	String Handling
	SLO-2	Collection Data Types	Decimal Numbers	Sets, Frozen Sets	Custom Functions	Command-Line Programming
S-6	SLO-1	Logical Operations	Strings: Comparing Strings	Mapping Types	Names and Docstrings	Mathematics and Numbers
	SLO-2	Control Flow Statements	Slicing and Striding Strings	Dictionaries	Argument and Parameter Unpacking	Times and Dates
S-7-8	SLO-1	LAB2: Logical operators and control flow statements	LAB5: Programming on Strings	LAB8: Program on set type	LAB11: Program on Exception Handling	LAB14: Program for Overview of Python's Standard Library
	SLO-2					
S-9	SLO-1	Arithmetic Operators	String Operators and Methods	Default Dictionaries	Accessing Variables in the Global Scope	Algorithms and Collection Data Types
	SLO-2	Input / Output	String Formatting with the str.format() Method	Ordered Dictionaries	Accessing Variables in the Global Scope	File Formats, Encodings, and Data Persistence
S-10	SLO-1	Creating a Functions	Character Encodings	Iterators and Iterable Operations and Functions	Lambda Functions	File, Directory, and Process Handling
	SLO-2	Calling a Functions	Character Encodings	Copying Collections	Assertions	Networking and Internet Programming
S-11-12	**SLO-1**	LAB3: Arithmetic operators, creating and calling function	LAB6: String and character encodings	LAB9: Program on Dictionaries, Iterators and Copying Collections	LAB12: Program on Custom Exceptions	LAB15: Programming for Overview of Python's Standard Library
	SLO-2					

Learning 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

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	10%	10%	20%	20%	20%	20%	20%	20%	20%	20%
Level 2	Apply Analyze	30%	30%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
	Total										

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions	Prof. Y.V.S.S. Sanyasiraju, IIT Madras,	Dr. A. Govindarajan, SRMIST, Dr. N. Parvathi, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur	Dr. M. Suresh , Dr. M. RadhaKrishnan, SRMIST

AE-2

Course Code	PCD21AE2T	Course Name	General Aptitude for Competitive Examinations	Course Category	AE	Ability Enhancement Course	L	T	P	C
							1	0	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Career Development Centre	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1:	Recapitulate fundamental mathematical concepts and skills	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-2:	Provide context - based vocabulary enhancement																		
CLR-3:	Sharpen logical reasoning through skilful conceptualization																		
CLR-4:	Familiarize with basic grammatical and syntactical rules																		
CLR-5:	Enable to solve problems and to crack competitive exams																		
CLR-6:	Develop new strategies to enhance reading comprehension																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1:	Build a strong base in the fundamental mathematical concepts	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	Acquire strategies to build vocabulary	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	Apply the learn conditions towards solving problems analytically	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	Learn grammatical and syntactical rules	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	Grasp the approaches and strategies to solve problems with speed and accuracy	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	Improve reading comprehension strategies	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		Module-I (3)	Module-II (3)	Module-III (3)	Module-IV (3)	Module-V (3)
S-1	SLO-1	Logical Reasoning I	Vocabulary from inference to meaning	Numbers - I	Error Identification - I	Data Sufficiency
	SLO-2	Solving Problems	Vocabulary from inference to meaning	Numbers - I	Error Identification - I	Data sufficiency
S-2	SLO-1	Logical Reasoning - I	Cloze passage	Numbers - II	Error Identification - II	Data Interpretation
	SLO-2	Solving Problems	Cloze passage	Numbers - II	Error Identification - II	Data Interpretation
S-3	SLO-1	Logical Reasoning - I	Sentence Completion	Numbers - III	Sentence Correction - I	Sentence Correction - II
	SLO-2	Solving problems	Sentence Completion	Numbers - III	Sentence Correction - I	Sentence Correction - II

Learning Resources	
1.	Quantitative aptitude – r s agarwal
2.	Quantitative aptitude – ARUN SARMA
3.	ManhattanPrepGMAT Sentence Correction Guide–Avi Gutman
4.	GRE Contextual.Vocabulary–Ken Springer

Learning Assessment

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

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

Course Designers

Experts from Industry	Internal Experts	
1. Mr Nishith Sinha, dueNorth India Academics LLP, Dehradun,nsinha.alexander@gmail.com	1. Dr.P.Madhusoodhanan SRMIST	3. Dr. A Clement, SRMIST
2.Mr Ajay Zenner, Career Launcher, ajay.z@careerlauncher.com	2. Dr.M.Snehalatha SRMIST	4. Dr. J Jayapragash, SRMIST

PC-8

Course Code	PMA21308T	Course Name	Topology	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

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

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

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Know about topological spaces, definitions of sets.																		
CLR-2 :	Learn continuous functions, metric topology and quotient topology.																		
CLR-3 :	Be familiar with connected spaces, components and path components.																		
CLR-4 :	Be familiar with compact spaces, local compactness.																		
CLR-5 :	Exposure to countability.																		
CLR-6:	Be familiar with topological structures and its applications																		

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Understand the topological structure and its properties	3	85	80	H	H	M	-	-	-	-	-	M		-	H	H	-	H
CLO-2 :	Understand the metric topology, quotient topology and product topology	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	H	M	H
CLO-3 :	Understand the concept of connectedness and its properties.	3	85	80	H	H	-		-	-	-	-	M	-	-	H	H	-	M
CLO-4 :	Understand the concept of compactness and its properties.	3	85	80	H	H	H	M	-	-	-	-	M		-	H	H	-	M
CLO-5 :	Understand the concept of countability and separation axioms.	3	85	80	M	H	M	-	-	-	-	-	M	-	-	H	H	-	M
CLO-6 :	Understand the topological structures and its applications	3	85	80	H	H	M	M	M				M			H	H	M	M

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Introduction to point set theory	Closed sets and its properties	Connected spaces	Compact Spaces	Countability axioms
	SLO-2	Fundamental concepts.	Examples	Examples	Examples	Properties of Countability
S-2	SLO-1	Functions and relations	Closure and interior of a set	Properties of connected spaces	Properties of compact spaces	Countability axioms
	SLO-2	Discussion with examples.	Properties based on closure and interior	Applications of connected spaces	Applications of compact spaces	Countability axioms
S-3	SLO-1	Topological Spaces	Limit Points, Hausdorff Space	Connected subspaces of the real line	Properties of compact spaces	Separation axioms
	SLO-2	Examples	Properties of Hausdorff space	Intermediate value theorem	Tube Lemma	Properties of Separation axioms
S-4	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-5	SLO-1	Basis for a topology.	Continuity of a function	Components, Path components Examples	Finite intersection property, Compact subspace of the real line	Normal Spaces
	SLO-2	Examples.	Homeomorphisms and its properties	Properties of path component	Extreme Value theorem	Definition and examples of Normal Spaces
S-6	SLO-1	Basis for a topology and its properties.	Construction of continuous function	Applications of path component	Lebesgue number lemma	Properties of Normal spaces
	SLO-2	Subbasis and its properties	Pasting Lemma	Locally connected	Uniformly continuous	Applications of normal spaces
S-7	SLO-1	Order topology	Product topology	Definition and examples of Locally connected	Properties of uniform continuity	Urysohn's Lemma
	SLO-2	Basis for order topology	Properties based on product topology	Properties of locally connected	Applications of uniform continuity	Proof of Urysohn's Lemma
S-8	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-9	SLO-1	Examples of order topology	Box topology	Properties of locally connected	Limit point compactness	Proof of Urysohn's Lemma
	SLO-2	Examples for Basis.	Properties and applications	Problems on locally connected spaces	Properties of limit point compactness	Applications of Urysohn's Lemma
S-10	SLO-1	Subspace topology	Metric topology	Locally path connected	Applications of limit point in compact space	Urysohn Metrization theorem
	SLO-2	Examples	Properties of metric topology	Definition and examples of Locally path connected	Locally compact	Proof of Urysohn Metrization theorem
S-11	SLO-1	Properties of Subspace topology	Quotient topology	Properties of locally path connected	Properties of locally compact spaces	Proof of Urysohn Metrization theorem

	SLO-2	Basis for Subspace topology.	Properties of quotient topology	Applications of locally path connected spaces.	Applications of locally compact spaces	Applications of Urysohn Metrization theorem
S-12	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session

Learning Resources	1. James R. Munkres, Topology, Second Edition,PHI Learning Private Limited, 2009. 2. M. A. Armstrong, Basic Topology, Springer, 2005. 3. 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.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	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.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Dr. V. Srinivasan, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr.V.Visalakshi, SRMIST

PC9

Course Code	PMA21309T	Course Name	Functional Analysis	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

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

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

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Learn about basics of linear spaces.	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-2 :	Learn about Banach spaces																		
CLR-3 :	Learn about Hilbert spaces																		
CLR-4 :	Learn about operators																		
CLR-5 :	Learn about Spectral theorem																		
CLR-6:	Learn matrix representation of an operator																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Familiar on linear spaces	3	85	80	H	H	M	-	-	-	-	-	M	M	-	M	-	-	-
CLO-2 :	Familiar on Banach space, Hahn-Banach theorem, Open mapping theorem, closed graph theorem and uniform bounded principle.	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	-	-	-
CLO-3 :	Familiar on Hilbert space, Cauchy-Schwartz inequality, Bessel's inequality and Riesz representation theorem	3	85	80	H	H	-		-	-	-	-	M	-	-	H	M	M	M
CLO-4 :	Familiar on operator like adjoint, self adjoint, normal and unitary operators and projection theorem	3	85	80	H	H	H	M	-	-	-	-	M	M	-	H	-	-	-
CLO-5 :	Familiar on matrix representation of an operator, spectrum of normal operator and spectral theorem.	3	85	80	M	H	M	-	-	-	-	-	M	-	-	H	M	M	M
CLO-6 :	Familiar on Banach and Hilbert spaces and operators	3	85	80	M	H	M	M	M	-	-	-	M	M	-	H	M	M	M

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Introduction to Linear space	Norm on quotient space	Introduction to inner product space	Introduction to operators	Representation of operator in matrix form
	SLO-2	Problems on linear space	Continuous linear transformation	Example for inner product space	Properties of operators	Representation of operator in matrix form
S-2	SLO-1	**Linearly independent**	Equivalent conditions for continuous linear transformation	**Cauchy-Schwartz inequality**	Adjoint operator	Properties
	SLO-2	Linearly dependent	Equivalent conditions for continuous linear transformation	Relation between Hilbert space and Banach space	Properties of Adjoint operator	Properties
S-3	SLO-1	Basis for the linear space	Bounded linear transformation	**Hilbert space**	**Properties of Adjoint operator**	Determinant
	SLO-2	Dimension of the linear space	Example for the bounded linear transformations	Example for Hilbert space	Self Adjoint operator	Determinant
S-4	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-5	SLO-1	Introduction to linear transformation	Norm on B(L, L')	Orthogonal complement	Properties of self Adjoint operators	Spectrum of an operator
	SLO-2	Linear transformation	B(L, L') is Banach if L' is Banach	Theorem based on orthogonal complement	Properties of self Adjoint operators	Spectrum of an operator
S-6	SLO-1	Introduction to algebra	Hahn-Banach theorem	Theorem based on orthogonal complement	Normal operators	Spectrum of an operator
	SLO-2	Hom(L, L') is an algebra	Hahn-Banach theorem	Orthonormal basis	Properties of normal operators	Problems on spectrum of an operator
S-7	SLO-1	Introduction to normed linear space	Corollaries of Hahn-Banach theorem	Bessel' s inequality	Properties of normal operators	Problems on spectrum of an operator
	SLO-2	Examples for normed linear space	Problems on Hahn-Banach theorem	Bessel's inequality	Unitary operator	Problems on spectrum of an operator
S-8	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-9	SLO-1	Relation between normed linear space and metric space	Open mapping theorem	Complete orthonormal set	Properties of unitary operator	Spectral theorem on Normal operator
	SLO-2	Complete normed linear space	Problems on Open mapping theorem	Complete orthonormal set	Properties of unitary operator	Spectral theorem on Normal operator
S-10	SLO-1	Introduction to Banach spaces	Closed Graph theorem	Riesz-representation theorem	Projection theorem on Hilbert space	Spectral theorem on Normal operator
	SLO-2	Examples for Banach space	Problems on Closed Graph theorem	Riesz-representation theorem	Projection theorem on Hilbert space	Spectral theorem on Normal operator

S-11	SLO-1	Sequence space	Uniform boundedness theorem	Conjugate space	Problems on projection theorem	Problems on Spectral theorem
	SLO-2	Functional space	Problems on Uniform boundedness theorem	Conjugate space	Problems on projection theorem	Problems on Spectral theorem
S-12	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session

Learning Resources

1. G. F. Simmons, *Introduction to Topology and Modern Analysis*, Tata McGraw-Hill International Ed.2004, Fourteenth reprint 2010.
2. B. V. Limaye, *Functional Analysis*, New Age International, 2nd Ed., 1996.
3. M. T. Nair, *Functional Analysis: A First Course*, PHI-Learning (Formerly: Prentice-Hall of India), New Delhi, 2002.
4. E.Kreyszig,*Introductory Function Analysis with Applications*, John Wiley and Sons, 2010.
5. W. Rudin, *Functional Analysis*, TMH Edition, 2006.
6. John B. Conway, A First course in Functional Analysis, Second edition, Springer-Verlag, 1997.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	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.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Dr. N.Parvathi, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr. E. Nandakumar, SRMIST

PC-10

Course Code	PMA21310T	Course Name	Calculus of Variations and Mechanics	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

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

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

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Learn about fundamentals of functionals.																		
CLR-2 :	Understand about the extremum of functionals and curvature of curve																		
CLR-3 :	Gain knowledge about basic principles of generalised coordinates																		
CLR-4:	Gain knowledge about the relation between Lagrange's, Hamiltonian and Euler dynamical equations																		
CLR-5 :	Learn about rigid body motion and canonical transformation																		
CLR-6:	Gain knowledge about energy equation in conservation fields																		

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Analyse variational problems to deduce key properties of system behaviour	3	85	80	H	H	M	-	-	-	-	-	M	M	-	H	H	M	M
CLO-2 :	Derive equation of extrema of functions of several variables	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	M	M	M
CLO-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	80	H	H	-	-	-	-	-	-	M	-	-	H	-	-	-
CLO-4 :	Deal with the Hamiltonian –Jacobi differential equations for a complete classical solution to dynamical problems	3	85	80	H	H	H	M	-	-	-	-	M	M	-	H	M	M	M
CLO-5 :	Derive and solve problems using change space coordinate systems, Lagrange's equation and invariance Lagrange's equation	3	85	80	M	H	H	M	-	-	-	-	M	-	-	H	H	M	H
CLO:6	Derive solutions of Dynamical systems using Lagrange's and Hamiltonian equations	3	85	80	M	H	H	M	M	-	-	-	M	M	-	H	H	M	M

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Introduction to Differential equations	Introduction to differential calculus	Introduction to coordinate system	Introduction to rotating coordinate systems	Introduction to phase space coordinate system
	SLO-2	Basic problems in Differential equations	Problems in Differential calculus	Introduction to generalized coordinates	Motion of a particle related to rotating earth	Basics of Canonical transformation
S-2	SLO-1	Variation of a functional and its properties	Geodesics	Principles of generalized coordinates	Faucault's pendulum	Equations of Canonical transformation
	SLO-2	Problems in Variation of a functional	Finding the extremum of geodesics	Problems in generalized coordinates systems	Torque free motion of rigid body about a fixed point	Hamilton-Jacobi equation
S-3	SLO-1	Euler –Lagrange equation	Introduction to Isoperimetric curves	Virtual work and D'Alembert's principle	Motion of a symmetrical top and theory of small vibrations	Time dependant Hamilton-Jacobi equation
	SLO-2	Problems using Euler-Lagrange's equation	Condition for finding the extrema of isoperimetric curves	Problems using D'Alembert's principle	Hamilton's variables, Hamilton canonical equation	Derivation of Time dependant Hamilton-Jacobi equation
S-4	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-5	SLO-1	Variational problems with moving boundaries - Introduction and	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
	SLO-2	Variational problems with fixed boundaries	Condition for finding the extrema of isoperimetric curves	Unilateral and bilateral constraints examples Basic problems in Holonomic and non-holonomic systems	Problems using Hamilton's canonical equation	Condition of canonical transformation in Lagrange's brackets
S-6	SLO-1	Difference between variational problems with fixed and moving boundaries	Proper field and family of extremals	Scleronomic and rheonomic systems	Neothers theorem	Character transformation
	SLO-2	moving boundaries	Central field and family of extremals	Problems in scleronomic and rheonomic systems	Introduction to cyclic coordinates	Character transformation in terms of Lagrange's brackets
S-7	SLO-1	Variational problems with moving boundaries	Jacobi condition for extremal in a central field	Lagrange's equations of first kind	Routh's equations and Derivation of Routh's equations	Character transformation in terms of Lagrange's brackets
	SLO-2	Second order variational functional problems	Jacobi's equation	Derive Lagrange's equations of first kind	Hamiltonian principles	Character transformation in terms of Poisson's brackets
S-8	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session

S-9	SLO-1	several dependent variables problems	Weistrass function for extrema	Lagrange's equations of second kind	Problems in Hamiltonian principle	Invariance of Lagrange's brackets
	SLO-2	several dependent variables problems	Weak and Strong extrema	Derivation of Lagrange's equations of second kind	Principle of least action	Derive the Invariance of Lagrange's brackets
S-10	SLO-1	Higher order variational functional problems	Problems in finding weak extrema	Uniqueness of solutions	Poisson bracket and Poisons's identity	Poisson brackets under canonical transformation
	SLO-2	Functionals involving higher order derivatives	Problems in finding weak extrema	Introduction to energy equation for conservative fields	Problems in Poisson bracket and poisons's identity	Derivation of Poisson brackets under canonical transformation
S-11	SLO-1	Extremum of functional using Rayleigh-Ritz method	Problems in finding strong extrema	Euler's dynamical equations	Jocobi-poison theorem	Application of canonical transformation
	SLO-2	Find the maxima and minima of functional using Rayleigh-Ritz method	Problems in finding strong extrema	Problems in Euler's dynamical equations	Problems in Jocobi-Poison theorem	Application of Poisson's brackets
S-12	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session

Learning Resources	1. L. Elsgolts, Differential Equations and the Calculus of Variations, Mir Publishers, 1977. 2.N. C. Rana and P.S. Jog, Classical Mechanics, Tata McGraw-Hill Education Pvt.Ltd., 2015. 3. M. Gelfand and S. V. Fomin, Calculus of Variations, Prentice Hall, Inc., NJ, 1963.	4. H. Goldstein, C. P. Poole, J. L. Safko, Classical Mechanics, 3rd Ed, Addison Wesley, 2001. 5. N. H. Louis and D. F. Janet, Analytical Mechanics, Cambridge University Press, 1998. 6. P. K. Nayak, A text book of Mechanics, Narosa Publishing House, 2016.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	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.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Dr. K. Ganesan, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr. D.K. Sheena Christy, SRMIST

DE-7

Course Code	PMA21D07T	Course Name	Graph Theory and Algorithms	Course Category	D	Discipline Specific Elective Course	L	T	P	C
							3	1	0	4

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

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

CLR-1 :	Learn about basic definition of Graphs.	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	Understand about Euler Graph, Hamiltonian Graph, Hamiltonian Path																		
CLR-3 :	Gain knowledge about Fundamental Circuits and Fundamental Cut Sets																		
CLR-4 :	Gain knowledge about Shortest Path Algorithm																		
CLR-5 :	Gain knowledge about Breadth First Search Algorithm																		
CLR-6 :	Learn the concepts of Graphs and Algorithms																		

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Know the application of Graph	3	85	80	H	H	M	-	-	-	-	-	M	M	-	H	H	H	H
CLO-2 :	Solve problems in Euler Graph, Hamiltonian Graph	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	M	M	M
CLO-3 :	Solve problems in Trees and Fundamental Circuits	3	85	80	H	H	-		-	-	-	-	M	-	-	H	H	H	H
CLO-4 :	Solve Problems using Shortest Path Algorithm	3	85	80	H	H	H	M	-	-	-	-	M	M	-	H	H	H	H
CLO-5 :	Solve problems in Breadth First Search Algorithm	3	85	80	M	H	M	-	-	-	-	-	M	-	-	H	H	H	H
CLO-6 :	Solve problems in Graphs and Algorithms	3	85	80	H	H	M	M	M	-	-	-	M	M	-	H	H	H	H

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Introduction to Graphs	Definition of Euler Graphs	Definition of Trees	Introductions to Algorithms on Graphs	Introduction to Minimum Spanning Tree Algorithm
	SLO-2	Introduction to Graphs	Examples of Euler Graphs	Examples of Trees	Shortest Path Algorithms	Introduction to Kruskal's Algorithm
S-2	SLO-1	Definitions of Graphs	Definition of Hamiltonian Graphs	Some Properties of Trees	Problems on Shortest Path Algorithms	Problems on Kruskal's Algorithm
	SLO-2	Definitions of Graphs	Examples of Hamiltonian Graphs	Some Properties of Trees	Dijkstra's Algorithm	Problems on Kruskal's Algorithm
S-3	SLO-1	Some Applications of Graphs	Theorem on Euler Graphs	Some Properties of Trees	Application on Dijkstra's Algorithm	Introduction to Prims Algorithm
	SLO-2	Some Applications of Graphs	Theorem on Hamiltonian Graphs	Theorem on Trees	Application on Dijkstra's Algorithm	Problems on Prims Algorithm
S-4	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-5	SLO-1	Definition of Incidence and Degree	Introduction to Euler Tour and Euler Graph	Definition of Spanning Tree	Notations on Dijkstra's Algorithm	Introduction to Breadth First Search Algorithm
	SLO-2	Examples on Incidence and Degree	Examples on Euler Tour and Euler Graph	Examples of Spanning Tree	Introduction to Floyd-Warshall's Algorithm	Problems on Breadth First Search Algorithm
S-6	SLO-1	Examples on Incidence and Degree	Examples on Euler Tour and Euler Graph	Examples of Spanning Tree	Problems on Floyd-Warshall's Algorithm	Problems on Breadth First Search Algorithm
	SLO-2	Definition of Isomorphism	Definition of Hamiltonian Path	Definition of Co-Tree	Application on Floyd-Warshall's Algorithm	BFS Algorithm for construction of a Spanning Tree
S-7	SLO-1	Examples of Isomorphism	Examples on Hamiltonian Path	Examples of Co-Tree	Notation on Floyd-Warshall's Algorithm	BFS Algorithm for construction of a Spanning Tree
	SLO-2	Definition of Complete Graph	Theorem on Hamiltonian Path	Examples of Co-Tree	Notation on Floyd-Warshall's Algorithm	BFS Algorithm for construction of a Spanning Tree
S-8	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-9	SLO-1	Definition of Bipartite Graph	Definition of Maximal Non-Hamiltonian Graph	Definition of Fundamental Circuits	Definition of Minimum Spanning Tree	Introduction to Depth First Search Algorithm
	SLO-2	Examples on Bipartite Graph	Examples on Maximal Non-Hamiltonian Graph	Theorem on Fundamental Circuits	Problems on Minimum Spanning Tree	Problems on Depth First Search Algorithm
S-10	SLO-1	Definition of Complete Bipartite Graph	Definition of Complement Graph	Theorems on Fundamental Cut Sets	Problems on Minimum Spanning Tree	Problems on Depth First Search Algorithm
	SLO-2	Examples of Complete Bipartite Graph	Examples of Complement Graph	Properties of Fundamental Cut Sets	Objective of Minimum Spanning Tree Problem	DFS Algorithm for construction of a Spanning Tree
S-11	SLO-1	Definition of Directed Graph	Examples on Complement Graph	Examples on Fundamental Cut Sets	Objective of Minimum Spanning Tree Problem	DFS Algorithm for construction of a Spanning Tree

	SLO-2	Examples of Directed Graph	Definition of Self- Complement Graph	Examples on Fundamental Cut Sets	Objective of Minimum Spanning Tree Problem	DFS Algorithm for construction of a Spanning Tree
S-12	SLO-1	Examples of Directed Graph	Examples on Self- Complement Graph	Problems on Fundamental Cut Sets	Problems Solving using Minimum Spanning Tree	Problem Solving using DFS Algorithm
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session

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

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	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.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Dr. K. Ganesan, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr.S.Vidyanandini, SRMIST

D-8

Course Code	PMA21D08T	Course Name	Fluid Dynamics	Course Category	D	Discipline Specific Elective Course	L	T	P	C
							3	1	0	4

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

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

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Understand the basic concepts in fluid mechanics																		
CLR-2 :	Understand and apply the conservation laws.																		
CLR-3 :	Familiarize with vortex dynamics, velocity potential and stream functions																		
CLR-4 :	Understand the importance of dimensional analysis																		
CLR-5 :	Acquiring linear stability analysis of benchmark problems in fluid mechanics																		
CLR-6	Model and analyse problems on two-dimensional fluid flow problems.																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Derive equation of continuity and to solve problems on steady and unsteady flow.	3	85	80	H	H	M	-	-	-	-	-	M	M	-	H	H	H	H
CLO-2 :	Derive equation of motion of fluid in different forms and to understand the fluid flow in different geometries.	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	H	H	H
CLO-3 :	Solve problems on two dimensional flows with source, sink and doublets	3	85	80	H	H	-		-	-	-	-	M	-	-	H	M	M	M
CLO-4 :	Derive and solve problems on steady, viscous flow.	3	85	80	H	H	H	M	-	-	-	-	M	M	-	H	M	M	M
CLO-5 :	Derive Navier-Stoke's equation and to analyze problems on instability.	3	85	80	M	H	M	-	-	-	-	-	M	-	-	H	H	H	M
CLO-6 :	Analyse and solve practical problems on steady, unsteady and incompressible flows.	3	85	80	H	H	M	M	M	-	-	-	M	M	-	H	H	H	M

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Real and ideal fluids	Pressure at a point in a fluid	Two dimensional flows	Dimensional analysis	Navier-Stokes equations of motion
	SLO-2	Velocity of fluid	Pascal's law for static fluids	Problems on 2D flows	Buckingham's pi theorem	Derivation of Navier-Strokes
S-2	SLO-1	Acceleration of fluid	Pressure at a point in moving fluid	Use of cylindrical polar co-ordinates	Dynamic similarity	Some exact solutions
	SLO-2	Streamlines	Boundary conditions of two inviscid immiscible fluids	Stream function	Dimensionless numbers	Flows at small Reynolds numbers
S-3	SLO-1	Path lines	Problems on fluid pressure	Complex potential for two-dimensional flows	Reynolds number	Boundary layer theory
	SLO-2	Steady and unsteady flows	Euler equation of motion	Irrotational, incompressible flow	Problem on viscous flow	Practice problems
S-4	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-5	SLO-1	SomeVector identities	Problems based on Euler equation	Complex potential for standard two-dimensional flows	Vorticity diffusion	Method of normal modes,
	SLO-2	Results of cartesian tensor analysis	Bernoulli's equation	Uniform stream line source and line sink	Vorticity for 2 dimensional case	Benard problem,
S-6	SLO-1	Problems on velocity potential, streamlines	Other forms of Bernoulli's equation	Line doublets	Practice problems	double-diffusive instability,
	SLO-2	Vorticity vector	Problems based on Bernoulli's equation	Problems on source, sink and doublets	Steady flow between parallel plates	Taylor problem
S-7	SLO-1	Local rate of change	Some potential theorems	Two dimensional image systems	Steady flow between parallel plates	Kelvin-Helmholtz instability
	SLO-2	particle rate of change	Problems on potential theorems	Problems on image systems	Practice problems	Practice problems
S-8	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-9	SLO-1	Equation of continuity	Potential uniqueness theorems	Milne-Thomson circle theorem	Steady flow in a circular pipe	instability of continuously stratified parallel flows,

	SLO-2	Continuity equation for particular cases	Problems based on uniqueness theorems	Application problems	Steady flow in a circular cross section	Squire's theorem.
S-10	SLO-1	Problems on steady flow	Flows involving axial symmetry	Theorem of Blasius	Concentric cylinders	Orr-Sommerfeld equation
	SLO-2	Problems on incompressible flow	Problem on stationary sphere	Mathematical formulation and solution procedures.	Practice problems	Practice problems
S-11	SLO-1	Conditions at a rigid boundary	Problem on sphere moving the constant velocity	Problem on circular cylinder	Steady flow between two co-axial cylinders	Inviscid stability of parallel flows
	SLO-2	Condition for viscous fluid	Problem on accelerating sphere rest at infinity	Practice problems	Practice problems	Practice problems
S-12	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session

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.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate 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.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Dr. N. Parvathi, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr. J. Sasikumar, SRMIST

D9

Course Code	PMA21D09J	Course Name	Mathematical Modelling and Simulation	Course Category	D	Discipline Specific Elective Course	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	Understand the linear models
CLR-2:	Evaluate and learn nonlinear models
CLR-3:	Emphasize the significance of compartmental models
CLR-4:	Gain comprehensive knowledge and sound understanding of phase-plane analysis and linear optimization
CLR-5:	Recognize the nonlinear optimization methods
CLR-6:	Develop skills on practical, analytical problem solving in some parts of mathematical modelling

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Understand and solve problems on linear models	3	80	80	M	H	H	H	H	-	-	-	H	-	H	H	-	-	-
CLO-2 :	Acquire knowledge on nonlinear models	3	85	85	H	H	H	H	H	-	-	-	H	-	H	H	M	M	M
CLO-3 :	Correlate the acquired knowledge and use compartmental models	3	85	80	M	H	H	H	H	-	-	-	H	-	H	H	M	M	M
CLO-4 :	Familiarize themselves with phase-plane analysis and linear optimization	3	85	80	H	H	H	H	H	-	-	-	H	-	H	H	H	M	M
CLO-6 :	Apply the knowledge about nonlinear optimization	3	85	85	H	H	H	H	H	-	-	-	H	-	H	H	M	M	H
CLO-5 :	Learn and apply the knowledge level to Modelling aspects	3	80	80	M	H	H	H	H	-	-	-	H	-	H	H	M	M	M
CLO-6 :	Acquire the knowledge and developing Mathematical Models	3	80	80	M	H	H	H	H	-	-	-	H	-	H	H	M	M	M

Duration (hour)		Module-I (15)	Module-II (15)	Module-III (15)	Module-IV (15)	Module- V (15)
S-1	SLO-1	Basic Principles of Mathematical Modelling	Modelling with linear systems - Some Vector and Matrix Arithmetic	Compartmental models-Introduction	Interacting population models - Model of a battle	Linear Optimization -The Transportation Problem
	SLO-2	Basic Principles of Mathematical Modelling	Modelling with linear systems - Some Vector and Matrix Arithmetic	Compartmental models-Exponential decay	Interacting population models - Case Study: Rise and fall of civilisations	Linear Optimization -The Transportation Problem
S-2	SLO-1	Introduction to Modelling the reality based on the principles of modelling	Modelling with linear systems - Stability and Eigenvalues	Compartmental models- Case Study: Detecting art forgeries	Phase-Plane Analysis-Introduction	Linear Optimization -The Transportation Problem
	SLO-2	Introduction to Modelling the reality based on the principles of modelling	Modelling with linear systems - Stability and Eigenvalues	Compartmental models-Scenario: Pacific rats colonise New Zealand	Phase-Plane Analysis- Phase-plane analysis of epidemic model	Linear Optimization -The Assignment Problem and Binary Constraints
S-3	SLO-1	Basic Principles of Modelling and Analysis	Modelling with linear systems - Stability and Eigenvalues	Compartmental models-Lake pollution models	Phase-Plane Analysis- Phase-plane analysis of epidemic model	Linear Optimization -The Transportation Problem
	SLO-2	Introduction to Discrete dynamical systems	Modelling with linear systems - Stability and Eigenvalues	Compartmental models-Case Study: Lake Burley Griffin	Phase-Plane Analysis- Phase-plane analysis of epidemic model	Linear Optimization -The Transportation Problem
S-4 to S-5	SLO-1	Introduction to programming environments	Simulations using Linear and Nonlinear Models	Simulations on compartmental models	Simulation for the above criteria's	Simulation on the above topics
	SLO-2					
S-6	SLO-1	Linear equations and models – Some linear models	Modelling with linear systems - Stability and Eigenvalues	Compartmental models-Drug assimilation into the blood	Phase-Plane Analysis- Analysis of a battle model	Nonlinear Optimization - Introduction
	SLO-2	Linear equations and models – Some linear models	Modelling with linear systems – Non-homogeneous systems	Compartmental models-Case Study: Dull, dizzy or dead?	Phase-Plane Analysis- Analysis of a battle model	Nonlinear Optimization-Newton's Method
S-7	SLO-1	Linear equations and models – Applications of Homogeneous Equations	Nonlinear Equations and Models - Some Nonlinear Models	Compartmental models-Cascades of compartments	Phase-Plane Analysis- Analysis of a battle model	Nonlinear Optimization-Newton's Method
	SLO-2	Linear equations and models – Applications of Non-Homogeneous Equations	Nonlinear Equations and Models - Some Nonlinear Models	Compartmental models-Case Study: Money makes the world go around	Phase-Plane Analysis- Analysis of a predator-prey model	Nonlinear Optimization-Newton's Method
S-8	SLO-1	Linear equations and models – Applications of Non-Homogeneous Equations	Nonlinear Equations and Models - Some Nonlinear Models	Interacting population models – Introduction	Phase-Plane Analysis- Analysis of competing species models	Nonlinear Optimization-Newton's Method

	SLO-2	Linear equations and models – Dynamics of Linear Equations	Nonlinear Equations and Models - Autonomous Equations and Their Dynamics	Interacting population models- Model for an influenza outbreak	Phase-Plane Analysis- Closed trajectories for the predator-prey	Nonlinear Optimization- Newton's Method
S-9-S10	SLO-1	Simulation of linear models	Simulations using Nonlinear Models	Simulations on the above case studies	Phase-Plane Analysis- Closed trajectories for the predator-prey	Simulation for Nonlinear Optimization
	SLO-2					
S-11	SLO-1	Modelling with linear systems - Some Linear Systems Models	Nonlinear Equations and Models - Autonomous Equations and Their Dynamics	Interacting population models - Case Study: Cholera	Phase-Plane Analysis-Case Study: Bacteria battle in the gut	Nonlinear -The Golden Section
	SLO-2		Modelling with Nonlinear Systems - Nonlinear Systems and Their Dynamics	Interacting population models - Predators and prey	Phase-Plane Analysis-Case Study: Bacteria battle in the gut	Nonlinear Optimization -The One-Dimensional Gradient Method
S-12	SLO-1	Modelling with linear systems- Some Linear Systems Models	Modelling with Nonlinear Systems -Linearization and Local Dynamics	Interacting population models - Scenario: Nile Perch catastrophe	Linear Optimization - Introduction	Nonlinear Optimization-Two-Dimensional Gradient Method
	SLO-2		Modelling with Nonlinear Systems -Linearization and Local Dynamics	Interacting population models - Case Study: It's a dog's life: More on the control of stray dogs	Linear Optimization -Linear Programming	Nonlinear Optimization-Lagrange Multipliers
S-13	SLO-1	Modelling with linear systems - Linear Systems and Their Dynamics	Modelling with Nonlinear Systems -Linearization and Local Dynamics	Interacting population models - Competing species	Linear Optimization -Linear Programming	Nonlinear Optimization-The Traveling Salesman Problem
	SLO-2		Modelling with Nonlinear Systems -Linearization and Local Dynamics	Interacting population models - Scenario: Aggressive protection of lerps and nymphs	Linear Optimization -Linear Programming	Nonlinear Optimization -The Traveling Salesman Problem
S-14 - 15	SLO-1	Simulation of linear systems	Simulations using Nonlinear Models and Basic ODE Solving techniques	Simulations on above case studies	Simulations on Linear optimization	Simulation on Nonlinear optimization
	SLO-2					

Learning Resources	1. Marotto, F. R., "Introduction to Mathematical Modelling using Discrete Dynamical Systems", Thomson Brooks/Cole. (2006) 2. Albright, B., "Mathematical Modelling with Excel", Jones and Bartlett Publishers. (2010) 3. Barnes, B. and Fulford, G. R., "Mathematical Modelling with Case Studies", CRC Press, Taylor and Francis Group. (2009)	4. J. D. Murray, "Mathematical Biology: I. An Introduction, Third Edition" Springer-Verlag Berlin Heidelberg. (2001) 5. Gordon, Steven I.; Guilfoos, Brian "Introduction to Modelling and simulation with MATLAB and Python" Chapman & Hall/CRC (2017) 6. Allen B. Downey, "Modelling and simulation in Python" Green Tea Press (2017)

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand										
Level 2	Apply	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Analyze										
Level 3	Evaluate	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
	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.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions	Prof. Y.V.S.S. Sanyasiraju, IIT Madras	Dr. A. Govindarajan, SRMIST, Dr. N. Parvathi, SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur,	Dr. S. Balamuralitharan, SRMIST Dr. S. ATHITHAN, SRMIST

G-1

Course Code	PPY21G02T	Course Name	Introduction to Nanotechnology	Course Category	G	Generic Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Physics and Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*Comprehend the principles of nanotechnology.*
CLR-2:	*Make the students understand the basic concepts in nanoscience.*
CLR-3:	*Develop understanding on the exotic properties of nanostructured materials.*
CLR-4:	*Introduce various techniques available for the processing of nanostructured materials.*
CLR-5:	*Emphasize the importance and development of nanotechnology in various fields*
CLR-6:	*Enable them to learn applications of nanotechnology in various fields*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1:	*Determine the nanotechnology and actual working areas and applications.*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*Classify different techniques for synthesis of nanomaterials*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*Classify different techniques depending on the application areas*	2	75	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-4:	*Determine the characterization techniques for nanomaterials*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*Discuss and evaluate state-of-the-art characterization methods for nanomaterials*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*Identify the areas of interdisciplinary applications of nanotechnology*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Nanotechnology,	Classification of nanostructures	Top-down approach	Characterization techniques	Application od nanotechnology
	SLO-2	History and importance	zero, one, two and three dimensional nanostructures,	overview	General Introduction	Nanotechnology in food, FDA regulation
S-2	SLO-1	opportunity at the nanoscale,	What is density of states (DOS)? How DOS changes with dimensional nanostructures	bottom-up approach	Scanning electron microscope (SEM), transmission electron microscope (TEM), comparing SEM, TEM and SPM for different classes of nanomaterials.	Nanoemulsions, Methods of producing nanoemulsions
	SLO-2	Examples	Quantum confinement effect	Overview with examples	scanning electron microscope (SEM) Qualitative Overview	Nanotechnology to enhance food safety and quality
S-3	SLO-1	length and time scale in structures,	Confinement effect with different nanostrcture	method of nanomaterials preparation,	transmission electron microscope (TEM),	Intelligent materials for packaging
	SLO-2	Definitions and concepts	size dependency in nanostructures, Examples	Qualitative discussion	Qualitative Overview	Examples
S-4	SLO-1	difference between bulk and nanoscale materials	quantum size	wet chemical routes of synthesis	scanning probe microscope (SPM),	Nanomedicine
	SLO-2	Examples	Concept	physical routes	Qualitative Overview	Interaction of nanoparticles with Biological barriers
S-5	SLO-1	Significance of Nano size	Quantum size effects in nanostructures,	physical vapor deposition (PVD)	comparing SEM, TEM and SPM	Respiratory path, Gastrointestinal absorption and Skin absorption of nanoparticles
	SLO-2	Examples	Examples	What is Plasma? Plasma Components and ionization, DC Plasma	Basic differences	Nanoparticle concentration determination: dose matters
S-6	SLO-1	properties at nanoscale	chemistry of tailored nano shapes	Mean free path of atom/molecule in a chamber	Application of Discussed techniques	Nanostructures for water and wastewater treatment
	SLO-2	optical,	Qualitative discussion	Sputtering, atoms sputter from target	Overview	Construction of membranes and characteristics
S-7	SLO-1	Electronic properties	quantum dots	DC and RF sputtering difference, why need AC plasma?	different classes of nanomaterials	Types of Adsorption, Surface area and pore size
	SLO-2	Magnetic Properties	nanowells	chemical vapor deposition (CVD) and Mass flow controlled regime	Choice of Characterization Technique	Membrane Filtration and reverse osmosis, Membrane configurations
S-8	SLO-1	Chemical Properties	nanoribbons	CVD reaction mechanism, homogenous process and heterogeneous process	SEM, TEM and SPM	Nanotechnology in storage devices
	SLO-2	Overview	nanowires	Growth rate dependence with gas flow rate and temperature	Using for different materials	Batteries and application
S-9	SLO-1	Assignment on Properties	Problem Solving on above given topics	Seminar on Synthesis	Assignment on Characterization	Assignment on applications
	SLO-2					

Learning Resources	1. T. Pradeep, *A Textbook of Nanoscience and Nanotechnology*, Tata McGraw Hill Education, 2012. 2. G. Cao, Y. Wang, *Nanostructures and Nanomaterials: Synthesis, Properties, and Applications*, 2nd Ed., Imperial College Press, 2004.	3. T.K. Sau, A.L. Rogach, *Complex-shaped Metal Nanoparticles: Bottom-Up Syntheses and Applications*, 1st Ed., Wiley-VCH, 2012. 4. Chattopadhyay, Banerjee, Introduction to Nanoscience and Nanotechnology, PHI, 2009.

Learning Assessment

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

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Mr. Navneethakrishanan, CLR Laboratories Pvt Ltd.	Prof. S Balakumar, University of Madras, balakumar@unom.ac.in	Dr. Debabrata Sarkar, SRMIST

G-2

Course Code	PPY21G03T	Course Name	LASER Physics	Course Category	G	Generic Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Physics and Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*Develop theoretical knowledge on lasers*
CLR-2:	*Acquire the knowledge on laser beam characteristics*
CLR-3:	*Acquire knowledge for solving problems in laser physics*
CLR-4:	*Analyze Fabry-Perot cavity to understand laser resonator*
CLR-5:	*Acquire knowledge on Q-switched and mode-locked lasers*
CLR-6:	*Acquire the knowledge on lasers classes and laser safety*

Course Learning Outcomes (CLO):	Course Learning Outcomes (CLO):	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	At the end of this course, Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1:	*Understand the characteristics of a laser*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*Understand the Fabry Perot resonator towards a laser resonator*	2	80	70	H	H	H	H	H	H	H	H	H	M	H	H	H	H	H
CLO-3:	*Understanding the rate equations to apply for lasers*	2	75	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-4:	*Understand the conditions of stable resonators*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*Understand the physics of higher harmonic generation*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*Understand various types of lasers*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	General Introduction to lasers	Cavity life time and Quality factor	Geometrical optics analysis of optical resonators	Introduction to Q-switching	Coherence properties of laser light
	SLO-2	Spontaneous and stimulated emission Stimulated absorption	Ultimate line width of a laser	Condition for stable resonators	Dynamics of the Q-switching process	Temporal coherence
S-2	SLO-1	The laser idea	Einstein's A and B Coefficients	Stability diagram for optical resonators	Electro-optical Q-switching	Spatial coherence
	SLO-2	Gain medium, pumping scheme and optical feedback	Ratio of A and B at thermal equilibrium	Sources of resonator loss	Introduction to mode locking	Young's double slit experiment to understand spatial coherence
S-3	SLO-1	Properties of laser beams: Monochromaticity	Introduction to resonators	Laser rate equations	Mathematical interpretation for mode locking	Specific laser systems
	SLO-2	Directionality, coherence	Fabry-Perot cavity	Introduction to four level laser system	Mathematical interpretation for mode locking	Ruby laser
S-4	SLO-1	Modes of a cavity	Basic apparatus	Mathematical formulation of rate equations for four level laser system	Passive mode locking	He:Ne laser
	SLO-2	Black body radiation	Elementary theory of Fabry-Perot cavity	Mathematical formulation of rate equations for four level laser system	Active mode locking	Carbon dioxide laser
S-5	SLO-1	Black body radiation	Transmission spectrum of a Fabry-Perot cavity	Condition for population inversion	Concept of Gain saturation	Dye lasers, semiconductor lasers
	SLO-2	Calculation of mode density for black body	Coefficient of finesse/Quality factor	Threshold condition for four level system	Hole burning	DBR lasers
S-6	SLO-1	Calculating number of photons per mode for black body	Fundamental Gaussian beam	Calculating threshold for He-Ne laser	Spatial hole burning	Nd:YAG laser
	SLO-2	Comparison of black body radiation with laser radiation	Gaussian beam in homogeneous medium	Integrating cavity rate equation	Longitudinal and transverse mode selection	Higher harmonic generation
S-7	SLO-1	Line shape functions	Gaussian beam focusing	Rate equations under steady state condition	Single mode operation	Physics of harmonic generation
	SLO-2	Line-broadening mechanisms	Higher order Hermite Gauss beams	Variation of laser power around the threshold	Multi-mode lasers	Physics of harmonic generation
S-8	SLO-1	Homogeneous and Inhomogeneous broadening	Analysis of higher order Hermite Gauss beams	Optimum output coupling	Gain competition	Second harmonic generation
	SLO-2	Natural, Doppler and Collison broadening	Analysis of higher order Hermite Gauss beams	Laser spiking	Optical amplifiers	Third harmonic generation
S-9	SLO-1	Problems solving	Problems solving	Problem solving	Problem solving	Classification of lasers
	SLO-2	Problems solving	Problems solving	Problem solving	Problem solving	Laser safety

Learning Resources	1. K. Thyagarajan and A.K. Ghatak, Lasers Theory and Applications, 1st Ed., Macmilan Publishers, 2010. 2. O. Svelto, Principles of lasers, 4th Ed., Springer, 1998.	3. A. Yariv, Quantum Electronics, 3rd Ed., John Wiley, New York, 1989 4. Seigman, Lasers, 3rd Ed., Oxford Univ. Press, 1986. 5. B.E.A. Saleh and M.C. Teich, Fundamentals of Phtonics, 2nd Ed., Wiley, 2012.

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

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

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. N Vijayan, NPL, nvijayan @nplindia.org	Prof. V Subramanian, IIT Madras, manianvs@iitm.ac.in	Dr. K Shadak Alee, SRMIST
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G-3

Course Code	PCY21G02T	Course Name	Chemistry of Biomolecules	Course Category	G	Generic elective course	L	T	P	C
							3	0	0	3

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)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Course Learning Outcomes (CLO):	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-1 :	*Develop a sound knowledge of the fundamental concepts in bio-organic chemistry*																		
CLR-2 :	*Provide basic understanding about the biomolecules like aminoacids, proteins, nucleic acids, lipids and carbohydrates*																		
CLR-3 :	*Appreciate the role of these biomolecules in biology.*																		
CLR-4 :	*Gain knowledge about enzymes and coenzymes*																		
CLR-5 :	*Apply the information gained about enzymes and coenzymes into organic chemistry applications like molecule synthesis*																		
CLR:6	*Gain knowledge about amino acids and proteins and their structural features*																		
CLO-1 :	*Inculcate the organic chemistry knowledge to gain insight into biomolecule systems*	*2*	*75*	*60*	H	H	H	L	H	H	H	H	H	L	H	H	H	H	H
CLO-2 :	*Apply the information gained about enzymes and coenzymes into organic synthesis.*	*2*	*80*	*70*	H	H	L	H	H	H	H	L	L	H	H	L	H	H	H
CLO-3 :	*Understand the importance of nucleic acid in bioorganic chemistry*	*2*	*70*	*65*	H	H	M	M	H	L	H	L	L	H	H	L	H	H	H
CLO-4	*Understand the importance of carbohydrate chemistry*	*2*	*70*	*70*	H	L	H	H	H	L	M	L	L	H	H	L	H	H	H
CLO-5	*Understand the significant role of amino acid, peptides and proteins in bioorganic chemistry*	*2*	*80*	*70*	H	H	H	M	M	H	H	L	L	H	H	L	H	H	H
CLO-6	*Understand interactions between amino acids, peptides, nucleic acids and there role in biomolecule structure*	*2*	*75*	*70*	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		Module-I (9)	Module-II (9)	Module-III (9)	Module-IV (9)	Module-V (9)
S-1	SLO-1	Classification and structure of amino acids	Enzymes, Classification	Nature of genetic material	Fatty acids classification	Classification of carbohydrates
	SLO-2	Continued	Continued	Continued	Continued	Continued
S-2	SLO-1	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-2	Continued	Continued	Continued	Continued	Continued
S-3	SLO-1	Separation of amino acids	Mechanisms of enzyme action	Nucleotides and nucleosides	Properties of fatty acids	Optical isomerism of sugars
	SLO-2	Continued	Continued	Continued	**Continued**	Continued
S-4	SLO-1	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-2	Continued	Continued	Continued	Continued	Continued
S-5	SLO-1	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-2	Continued	Continued	Continued	Continued	Continued
S-6	SLO-1	Structure of polysaccharides	Structure and biological functions of coenzyme-A	Properties of nucleic acids	Spingomyelin	Biological importance of mono, di and polysaccharides
	SLO-2	Structure of proteins	Continued	Tm, denaturation and renaturation	Continued	Continued
S-7	SLO-1	Continued	Thiamine pyrophosphate, pyridoxal phosphate	Hypo and hyperchromicity	Plasmologens	An introduction to mucopolysaccharides
	SLO-2	Determination of the primary structure of a protein, secondary, tertiary and quaternary structures,	Continued	Basic ideas on replication	Continued	Continued
S-8	SLO-1	Continued	NAD+, NADP+	Transcription and translation	Structure and function of glycolipids,	Reactions of carbohydrates due to the presence of hydroxyl, aldehyde and ketone groups.

	SLO-2	Continued	FAD, lipoic acid	Continued	Continued	Continued
S-9	SLO-1	Protein denaturation.	Overview of reactions catalysed by the above cofactors	Determination of the base sequence of DNA	Cholesterol.	Continued
	SLO-2	Continued	Continued	Continued	Continued	Continued

Learning Resources	1.D. L. Nelson, M. M. Cox, Lehninger Principles of Biochemistry, 5thEd., W. H. 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.L. Jain, S. Jain, N. Jain, Fundamentals of Biochemistry, S. Chand & Company. India, 2013. 4. P. Y. Bruice, Organic Chemistry, 5th Ed., Pearson, 2014.

Learning Assessment											
	Bloom's Level of Thinking	**Continuous Learning Assessment (50% weightage)**								**Final Examination (50% weightage)**	
		CLA – 1 (10%)		**CLA – 2 (10%)**		**CLA – 3 (20%)**		**CLA – 4 (10%)#**			
		Theory	**Practice**	**Theory**	**Practice**	**Theory**	**Practice**	**Theory**	**Practice**	**Theory**	**Practice**
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	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.,

Course Designers		
Experts from Industry	**Expert from Higher Technical Institutions**	**Internal Experts**
1. Dr. Sudarshan Mahapatra, Encube Ethicals Pvt. Ltd, Email: sudarshan.m@encubeethicals.com	1. Prof. G. Sekar, Professor, Department of Chemistry, IIT Madras Email: Pgsekar@iitm.ac.in	1. Dr. M. Arthanareeswari , SRMIST
2. Dr. Ravikiran Allada, Head R&D, Analytical, Novugen Pharma, Malaysia Email: ravianalytical@gmail.com	2. Dr. Kanishka Biswas, Associate Professor, New Chemistry Unit, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru. Email: **kanishka@jncasr.ac.in**	2. Dr. Priyadip Das, SRMIST

G-4

Course Code	PMA21G01T	Course Name	Mathematics For Artificial Intelligence	Course Category	G	Generic Elective Course	L	T	P	C
							3	0	0	3

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

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

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Understand the solution methods for solving system of linear equations																		
CLR-2 :	Acquaint knowledge on the concept of Linear transformation																		
CLR-3 :	Understanding the concept of eigenvalues and eigenvectors																		
CLR-4 :	Understand the concept of probability and random variable																		
CLR-5 :	Acquire knowledge in Probability distribution																		
CLR-6 :	Familiarise in applying linear algebra and probability theory																		

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Apply formulation and solution procedure of system of linear equation	3	85	80	H	H	M	-	-	-	-	-	M	-	-	H	H	H	-
CLO-2 :	Gain familiarity with linear transformation	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	H	-	H
CLO-3 :	Gain knowledge in decomposition techniques of matrices	3	85	80	H	H	-		-	-	-	-	M	-	-	H	H	H	-
CLO-4 :	Understand about probability and random variables	3	85	80	H	H	H	M	-	-	-	-	M	-	-	H	H	-	-
CLO-5 :	Solve problems in probability distributions	3	85	80	M	H	M	-	-	-	-	-	M	-	-	H	H	H	-
CLO-6 :	Analyze and solve problems in linear algebra and probability theory	3	85	80	M	H	M	M	M	-	-	-	M	-	-	H	H	H	H

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	System of linear equations	Linear transformation	Determinant and trace	Introduction to probability	Introduction to probability distributions
	SLO-2	System of linear equations	Matrix representation of linear transformation	Testing of matrix invertibility	Addition and multiplication theorems	Binomial distribution
S-2	SLO-1	Introduction to Matrices	Basis change	Eigenvalues and eigenvectors	Conditional probability	Binomial distribution
	SLO-2	Matrix addition and multiplication	Basis change	Properties of eigenvalues and eigenvectors	Theorem of probability	Poisson distribution
S-3	SLO-1	Matrix inverse and transpose	Image of Linear transformation	Geometric multiplicity	Baye's theorem	Poisson distribution
	SLO-2	Representation of system of linear equation	Kernel of linear transformation	Spectral theorem	Baye's theorem	Poisson distribution as limiting form of binomial distribution
S-4	SLO-1	Row reduced echelon form	Rank-nullity theorem	Eigenvalue decomposition	Random variable	Geometric distribtuion
	SLO-2	Inverse of a matrix by Gauss elimination method	Rank-nullity theorem	Eigenvalue decomposition	Discrete random variable	Geometric distribtuion
S-5	SLO-1	Problem solving using tutorial sheet 1	Problem solving using tutorial sheet 2	Problem solving using tutorial sheet 3	Problem solving using tutorial sheet 4	Problem solving using tutorial sheet 5
	SLO-2	Problem solving using tutorial sheet 1	Problem solving using tutorial sheet 2	Problem solving using tutorial sheet 3	Problem solving using tutorial sheet 4	Problem solving using tutorial sheet 5
S-6	SLO-1	Introduction to vector spaces	Affine space	Constrained optimization	Continuous random variable	Normal distribution
	SLO-2	Vector spaces	Affine mapping	Constrained optimization	Expectation	Normal distribution
S-7	SLO-1	Subspaces	Norms	Unconstrained optimization	Covariance	Normal distribution
	SLO-2	Linear dependence	Inner product space	Optimization using Gradient Descent	Variance	Normal distribution
S-8	SLO-1	Linear independence	Symmetric positive definite matrices	Optimization using Gradient Descent	Correlation coefficient	Exponential distribution
	SLO-2	Linear span	Lengths and distances	Optimization using Lagrange's Multiplier	Correlation coefficient	Exponential distribution
S-9	SLO-1	Basis	Angles and orthogonality	Optimization using Lagrange's Multiplier	Regression lines	Functions of several variables
	SLO-2	Rank of a matrix	Orthonormal basis	Convex optimization	Regression lines	Functions of several variables

Learning 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

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	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.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr.S.Mohanaselvi, SRMIST

G-5

Course Code	PMA21G02T	Course Name	Mathematics for Physicists	Course Category	G	Generic Elective Course	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	Develop knowledge in mathematical physics and related theorems
CLR-2:	Develop expertise in mathematical techniques and the mathematics behind it
CLR-3:	Enhance problem solving skills and efficiency with necessary mathematics
CLR-4:	Enable students to formulate, interpret and draw logical conclusions from mathematical solutions.
CLR-5:	*Understand the axiomatic structure of mathematics*
CLR-6:	*Appreciate untraceable connection between mathematics and physics*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1:	*Understand the special functions and its role in solutions of physics' equations*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*Understand the probability and the probability distribution in describing the uncertainty in physics*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*Understand beta and gamma functions as very important special functions*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	*Understand and develop the solution methods for integral equation*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*Understand and apply complex analysis techniques*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*Understand and develop the Dirac delta function as a generalised function*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module- V (12)
S-1	SLO-1	Definition of Probability	Definition of differential equation	Beta Function-Introduction	Analytic function	Integral Equation: definition and examples
	SLO-2	Axioms of Probability Theory	Degree and order	Convergences of Beta function	Differentiation and analyticity	and classifications
S-2	SLO-1	Random Experiment	Formation of differential equation	Trigonometric form of Beta functions	Cauchy-Riemann equation	Volterra equations of first kind
	SLO-2	Elementary events and Sample space	Linear differential equation	Various properties of Beta functions	Proof of Cauchy-Riemann equation	Volterra equations of second kind
S-3	SLO-1	Conditional Probability	Exact differential equation	Gamma function - introduction	Analytic to harmonic function	Fredholm integral equation
	SLO-2	Bayes Theorem	Condition for exactness	Convergence of Gamma	Harmonic function	transformation of a differential equation into an integral equation
S-4	SLO-1	Binomial Distribution	Leibnitz's differential equation	Weierstrass form of Gamma function	Milne Thompsons [MT]equation	transformation of a differential equation into an integral equation (continued)
	SLO-2	Mean and Standard deviation of Binomial Distribution	General method of solution	Legendre's duplication formula	Construction of M-T equation	Neumann series
S-5	SLO-1	Poisson Distribution	Homogeneous Second order Differential equation	factorial notation and applications	Line integration complex function	Separable kernels
	SLO-2	Mean and Standard deviation of Poisson Distribution	Complementary function	Relation between Gamma and Beta function	Line integration in vector calculus	Hilbert-Schmidt theory
S-6	SLO-1	Gaussian Distribution	Particular integral [introduction]	Integral representation of Gamma relevant to Bessel function	Cauchy integral formula	summarization of Kernels
	SLO-2	Mean and Standard deviation of Poisson Distribution	General method to find the Particular integral	Dirac delta function and its first appearance	Proof of integral formula	orthogonal Eigen functions
S-7	SLO-1	Moment Generating Functions	Non-homogeneous differential equation Operator factorization method	Working definition of Delta function	Taylor's Series	non-homogeneous integral equation
	SLO-2	Characteristic Functions	Non-homogenous differential equation variable coefficient	Various properties of delta function	Laurent's Series	non-homogeneous integral equation
S-8	SLO-1	Law of Large Numbers	Introduction to partial differential equation (PDE)	Various integral representation of delta function	Classification of singularities	non-homogeneous integral equation

	SLO-2	Central Limit Theorem	Partial differential equations of theoretical physics	Proof of delta function as a exponential representation	Cauchy residue theorem	Green's function in one dimension as kernel of integral equation
S-9	**SLO-1**	Skewness and Kurtosis	Formation of PDE	Derivative of delta function	Proof of residue theorem	Green's function in one dimension as kernel of integral equation (continued)
	SLO-2	Covariance, Correlation Coefficient	series solutions- Frobenius method	Series representation of delta	*Contour Integration*	Green's function in one dimension as kernel of integral equation (continued)

Learning 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.

Learning Assessment

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

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	*Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in*	Dr. A. Govindarajan, SRMIST Dr.K.Ganesan SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr.Alok Kumar, SRMIST Dr. N. Balaji, SRMIST

G-6

Course Code	PMA21G03T	Course Name	Multivariate Analysis and Non-Parametric Test	Course Category	G	Generic Elective Course	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is:	Learning		
		1	2	3
CLR-1 :	Develop independent and critical thinking skills with respect to multivariate data.	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2:	Understand appropriateness of advanced statistical concepts.			
CLR-3:	Learn how to analyze the multivariate and multi-dimensional data.			
CLR-4:	Do data reduction, dimensionality reduction, data handling, data pre-processing and cantering.			
CLR-5 :	Learn and apply various Nonparametric Tests.			
CLR-6 :	Familiarize students with the fundamental concepts and ideas underlying multivariate statistical data analysis methods.			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1:	Gain experience in analyzing multivariate models, methods and techniques.	3	85	80	M	H	M	-	-	-	-	-	M	M	-	H	H	H	H
CLO-2:	Demonstrate the knowledge and skill of multivariate normal distributions, related probability distributions and their applications.	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	H	H	H
CLO-3:	Analyze high-dimensional data sets with suitable regularization techniques.	3	85	80	H	H	-	-	-	-	-	-	M	-	-	H	-	-	-
CLO-4:	Apply dimension reduction techniques in various fields.	3	85	80	H	H	H	M	-	-	-	-	M	M	-	H	-	-	-
CLO-5:	Make good choices among available nonparametric approaches.	3	85	80	M	H	M		-	-	-	-	M	-	-	H	H	H	H
CLO-6:	Have a general knowledge and understanding of many of the key concepts, theoretical approaches and assumptions needed for dealing with multivariate problems.	3	85	80	M	H	M	M	M	-	-	-	M	M	-	H	H	H	H

Duration (Hour)		Module-I (9)	Module-II (9)	Module-III (9)	Module-IV (9)	Module-V (9)
S-1	SLO-1	Multivariate Data: Introduction	Multivariate Normal distribution and its properties.	Applications of Multivariate Analysis	Discriminant Analysis	Nonparametric Tests: Introduction and Concept
	SLO-2	Multivariate Data: Introduction	Multivariate Normal distribution and its properties.	Applications of Multivariate Analysis	Discriminant Analysis	Nonparametric Tests: Introduction and Concept
S-2	SLO-1	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
	SLO-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
S-3	SLO-1	multiple and partial correlation coefficients	Problems based on Multivariate Normal distribution and its properties.	Analytical approach – Issues relating to PCA.	Problems on DA	Test for randomness based on total number of runs
	SLO-2	multiple and partial correlation coefficients	Problems based on Multivariate Normal distribution and its properties.	Analytical approach – Issues relating to PCA.	Problems on DA	Test for randomness based on total number of runs
S-4	SLO-1	Random Vector: Probability mass/density functions	Multinomial Distribution and its properties.	Factor Analysis: Two Factor Model	Regression approach to DA	Empirical distribution function
	SLO-2	Random Vector: Probability mass/density functions	Multinomial Distribution and its properties.	Factor Analysis: Two Factor Model	Regression approach to DA	Empirical distribution function
S-5	SLO-1	Distribution function	Multinomial Distribution and its properties.	More than TWO Factors	Stepwise DA	One Sample Tests: Kolmogorov- Smirnov
	SLO-2	Distribution function	Multinomial Distribution and its properties.	More than TWO Factors	Stepwise DA	One Sample Tests: Kolmogorov- Smirnov
S-6	SLO-1	mean vector & Dispersion matrix	Problems based on Multinomial Distribution and its properties.	Geometrical view of Factor Analysis (Factor Rotation)	Problems on Stepwise DA	Sign test
	SLO-2	mean vector & Dispersion matrix	Problems based on Multinomial Distribution and its properties.	Geometrical view of Factor Analysis (Factor Rotation)	Problems on Stepwise DA	Sign test
S-7	SLO-1	Marginal & Conditional distributions	Tests for partial correlation coefficients.	Estimation of Communalities problem	External Validation of the Discriminant Function	Signed rank test.
	SLO-2	Marginal & Conditional distributions	Tests for partial correlation coefficients.	Estimation of Communalities problem	External Validation of the Discriminant Function	Signed rank test.
S-8	SLO-1	Multiple and partial correlation coefficient.	Tests for Multiple correlation coefficients.	Comparison of FA and PCA.	Fisher's Linear Discriminant Function.	Wilcoxon-Mann-Whitney test.
	SLO-2	Multiple and partial correlation coefficient.	Tests for Multiple correlation coefficients.	Comparison of FA and PCA.	Fisher's Linear Discriminant Function.	Wilcoxon-Mann-Whitney test.
S-9	SLO-1	More problems based on Multiple and partial correlation coefficient.	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.
	SLO-2	More problems based on Multiple and partial correlation coefficient.	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.

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

Learning Assessment											
	Bloom's Level of Thinking	**Continuous Learning Assessment (50% weightage)**								**Final Examination (50% weightage)**	
		CLA – 1 (10%)		**CLA – 2 (10%)**		**CLA – 3 (20%)**		**CLA – 4 (10%)#**			
		Theory	**Practice**	**Theory**	**Practice**	**Theory**	**Practice**	**Theory**	**Practice**	**Theory**	**Practice**
Level 1	Remember	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
	Analyze										
Level 3	Evaluate	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	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.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.V.Maheshwaran, CTS, Chennai, maheshwaranv@yahoo.com	Dr.Y.V.S.S. Sanyasiraju, IIT, Madras, sryedida@iitm.ac.in	Dr.A.Govindarajan, SRMIST, Dr. N. Parvathi, SRMIST
	Dr.B.V. RatishKumar, IIT, Kanpur, bvrk@iitk.ac.in	Dr. R.Varadharajan, SRMIST

G-7

Course Code	PMA21G04T	Course Name	Research Methodology	Course Category	G	Generic Elective Course	L	T	P	C
							3	0	0	3

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

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

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Provide students the knowledge of why Research is necessary.	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-2 :	Understand what the important things are they should remember in doing Research.																		
CLR-3 :	Gain knowledge about different varieties of Research proposals.																		
CLR-4 :	Gain knowledge about statistical methods through which a Research article is created.																		
CLR-5 :	Gain knowledge about different case studies.																		
CLR-6 :	learn the concepts of Research Methodology in Mathematics																		
CLO-1 :	Learn about the motivation of Research.	2	75	75	H	H	H	H	M	H	M	M	H	M	H	H	H	H	H
CLO-2 :	Have knowledge of important aspects of Research.	2	80	80	H	H	H	H	M	H	M	M	H	H	H	H	H	H	H
CLO-3 :	Write different type of Research Articles.	2	70	70	H	H	H	M	M	H	M	H	H	H	H	H	H	M	M
CLO-4 :	Find some statistical techniques.	2	70	70	H	H	H	H	H	H	M	H	H	H	H	H	H	H	H
CLO-5 :	Find the techniques to collect different samples.	2	80	80	H	H	H	H	M	H	M	H	H	H	H	H	H	H	H
CLO-6 :	Determine the Research importance in modern era.	2	75	75	H	H	H	H	H	H	M	H	H	H	H	H	H	H	H

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:

Duration (hour)		Module-I (9)	Module-II (9)	Module-III (9)	Module-IV (9)	Module-V (9)
S-1	SLO-1	Meaning of Research, Objectives of Research	Citation indices	Organization of proposals Basic knowledge offunding agencies	Basic probability distributions types	Factor analysis
	SLO-2	Motivation in Research	Principles underlying: Literature Review	Research report writing, Precautions for Writing	Applications in Engineering– Statistics types	Cluster Analysis and Discriminant Analysis
S-2	SLO-1	Types of Research	Case studies	Communication skills, Tailoring the presentation to the target audience	Normal distribution	Design of experiments
	SLO-2	Research Approaches	Review articles and Meta-analysis record of research review	Oral presentations, Poster preparations	Exercises problem solving using software tools	Basic experimental designs
S-3	SLO-1	Significance of Research	Role of the librarian	Publication to Reputed journals	Binominal and Poisson distributions	Completely Randomized Design
	SLO-2	Research Methods versus Methodology	Ethical and Moral Issues in Research	Thesis writing	Exercises using software	Randomized Block Design, Latin Square Design, exercises
S-4	SLO-1	Research and Scientific Method	Plagiarism, tools to avoid plagiarism	Research report writing	Weibull and exponential distributions	Full factorial design - 2^2, 2^3 and 2^4 only, exercises
	SLO-2	Importance of knowing How Research is Done	Intellectual Property Rights	Elements of excellent presentation: Preparation	Sampling Types, size of sample, sample designs	Fractional factorial designs, exercises
S-5	SLO-1	Research Process	Copy right laws, Patent rights, Impact Factor	Visual and Delivery	Sampling tests: Student t-test applications in Engineering/ Research	Accuracy, Precision Analysis
	SLO-2	Criteria of Good Research	Accessibility of Journals and other print documents	Oral Communication skills and Oral defence	Exercises using software tools	Error Analysis
S-6	SLO-1	Necessity of Defining the Problem	Needs, ways and means of publication of research findings	Oral Presentation	F-test and its application in research studies	Data Analysis: Data Preparation
	SLO-2	Technique involved in defining a problem	Final paper Presentation	PPT Presentation	Exercises using software	Univariate analysis: Frequency tables,
S-7	SLO-1	Development of a research proposal	Significance of Report writing	Graphing and computation	$\chi 2$ test and its application in research studies	Bar charts, Pie charts
	SLO-2	Theoretical Processes	Difference steps in Writing Report	Graphing and computation	Exercises using software	Percentages
S-8	SLO-1	Experimental Processes	Types of Reports, Layout of the Research Report	Document preparation (LaTeX)	Correlation Analysis	Bivariate analysis
	SLO-2	Sources of information, Literature search	Proposal submission for funding agencies	Document preparation (LaTeX)	Regression Analysis	Cross tabulations
S-9	SLO-1	The computer: Its Role in Research	Result visualization, References	Presentation (Beamer)	Time series analysis	Chi-square test including testing hypothesis of Association
	SLO-2	Online data bases, Search tools	Precautions of Research Reports	Presentation (Beamer)	Forecasting methods	Chi-square test including testing hypothesis of Association

Learning 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.

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
	Analyze										
Level 3	Evaluate	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	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.,

Course Designers		
Experts from Industry	**Expert from Higher Technical Institutions**	**Internal Experts**
Mr.V.Maheshwaran, CTS, Chennai, maheshwaranv@yahoo.com	Dr.Y.V.S.S. Sanyasiraju, IIT, Madras, sryedida@iitm.ac.in	Dr.A.Govindarajan, SRMIST Dr. K. Ganesan, SRMIST
	Dr.B.V. RatishKumar, IIT, Kanpur, bvrk@iitk.ac.in	Dr. Anuradha Yadhav, SRMIST

G-8

Course Code	PMA21G05T	Course Name	Neural Networks, Fuzzy Systems and Evolutionary Mathematics	Course Category	G	Generic Elective Course	L	T	P	C
							3	0	0	3

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

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

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-1 :	Understand the concepts, models of Neural Networks																		
CLR-2 :	Observe and illustrate the BPN, to learn the algorithm of training sets of Neural Network																		
CLR-3 :	Understand the basic mathematical elements of the theory of fuzzy sets.																		
CLR-4 :	Learn evolutionary Mathematics related to fitness function, crossover and Mutations																		
CLR-5 :	Utilize the evolutionary mathematics to calculate the optimal problems																		
CLR-6 :	Recognize the feasibility of applying NN, Fuzzy and GA methodology for a particular real world problems																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	Identify the appropriate models to illustrate the algorithm of training sets.	3	85	80	H	H	H	H	H	-	-	M	M	M	M	H	H	H	H
CLO-2 :	Formalize the problem, to solve it by using a Backpropagation Networks	3	85	80	H	H	H	H	H	M	-	M	M	M	M	H	-	-	-
CLO-3 :	Apply basic fuzzy inference, fuzzy system modelling and approximate reasoning	3	85	80	M	H	H	H	H	M	-	M	M	M	M	H	-	-	-
CLO-4 :	Apply Evolutionary computation methods to find solutions to complex problems	3	85	80	H	H	H	H	H	-	-	M	M	M	M	H	H	H	H
CLO-5 :	Apply Genetic algorithm, Neural networks and Fuzzy to solve the optimization problems.	3	85	80	H	H	H	H	H	M	M	M	M	M	M	H	H	M	-
CLO-6 :	Apply the appropriate methods of an evolutionary mathematics to solve the real world problems	3	85	80	M	H	H	H	H	M	M	M	M	M	M	H	H	H	H

Duration (hour)		Module I (9)	Module II (9)	Module III (9)	Module IV (9)	Module V (9)
S-1	SLO-1	Basic concepts of Neural Networks	Applications of BPN: Design of Journal Bearing	Fuzzy set theory : Fuzzy vs Crisp	Fundamental concepts of Genetic Algorithm	Hybrid Systems : sequential, Auxiliary, Embedded Hybrid Systems
	SLO-2	Model of an Artificial Neuron	Classification of Soil, Hot extrusion of steel	Crisp sets : operations, properties, partition and covering	Working principle of Genetic Algorithm	Neuro-Fuzzy Hybrids, Neuro-Genetic Hybrids, Fuzzy-Genetic Hybrids
S-2	SLO-1	Neural Network Architectures: single, Multilayer Feedforward Network	Effect of Tuning Parameters of the BPN	Fuzzy sets, Membership Function.	Encoding: Binary encoding, Octal Encoding	Genetic Algorithm based Backpropagation Network, Fuzzy-Backpropagation Network
	SLO-2	Recurrent Networks, Characteristics of Neural Networks, Learning Methods	Selection of Various Parameters in BPN: Number of Hidden Nodes, Momentum Coefficient α, Sigmoidal Gain λ, Local Minima, Learning coefficient η	Basic Fuzzy Set Operations ,Properties of Fuzzy sets	Hexadecimal encoding, Permutation encoding, Value Encoding, Tree Encoding	Simplified Fuzzy ARTMAP, Fuzzy Associative Memories, Fuzzy Logic Controlled Genetic Algorithms
S-3	SLO-1	Early Neural Network Architectures	Variations of Standard Backpropagation Algorithms: Detrimental Iteration Procedure	Crisp Relations : Cartesian Product, other crisp relations	Fitness Function	GA based weight determination
	SLO-2	Perception and linearly separable tasks, XOR problem	Adaptive Backpropagation, Genetic Algorithm Based Backpropagation	Fuzzy Relations : Fuzzy Cartesian Product, operations on Fuzzy relations	Computation of fitness function	Weight extraction, Fitness Function, Reproduction, Convergence
S-4	SLO-1	ADALINE Network	Augmented Backpropagation Networks	Fuzzy Systems: Crisp Logic	Reproduction	Application : K- factor Determination
	SLO-2	MADALINE Network, Application Domains	Sequential Learning Approach for single Hidden Layer Neural Networks	Laws of Propositional logic, Inference in Propositional logic	Roulette-wheel Selection, Bolzmann Selection	Application : Electrical Load Forecasting
S-5	SLO-1	Backpropagation Network, Architecture	Associative memory classes of neural networks	Concepts of Predicate Logic	Tournament Selection, Rank Selection, Steady state selection, Elitism	Fuzzy Backpropagation Networks: LR-type Fuzzy Number, Operations
	SLO-2	Perception Model, Single layer Artificial Neural Network	Auto correlators : Recognition of stored patterns, Recognition of noisy patterns	Interpretation of Predicate logic, Inference in Predicate logic	Generation gap and Steady-state Replacement	Fuzzy Neuron, Fuzzy BP Architecture
S-6	SLO-1	Multilayer Neural Network	Heterocorrelators: Kosko's Discrete Bidirectional	Fuzzy logic: Fuzzy propositions, Fuzzy connectives	Genetic Modeling: Inheritance Operators	Learning in Fuzzy BP

			Associative Memory			
	SLO-2	Backpropagation learning: Input, Output Layer Computation, Calculation of Error	Addition and Deletion of Pattern Pairs	Fuzzy Quantifiers, Fuzzy Inference	Cross over: Single-site, 111two-point, Multi-point Cross Over	Inference by Fuzzy BP, Application
S-7	SLO-1	Training of Neural Network	Energy Function for Bidirectional Associative Memory	Fuzzy Rule based System and Defuzzification	Uniform Cross Over	Simplified Fuzzy Adaptive Resonance Theory : Introduction, Input Normalization, output Node Activation
	SLO-2	Method of steepest Descent, Effect of Learning Rate 'η'	Problems of Kosko's BAM	Mamdani Fuzzy models	Matrix Cross Over and Cross Over Rate of Genetic Modeling	Working of Simplified Fuzzy ARTMAP
S-8	SLO-1	Adding a Momentum Term	Concepts of Multiple Training Encoding Strategy	Sugeno Fuzzy Models	Inversion: Linear end inversion, Continuous inversion, Mass inversion	Fuzzy Associative Memories: Introduction, Single Association FAM
	SLO-2	Backpropogation Algorithm	Algorithm, working of multiple training encoding strategy with correlation matrix	Tsukamoto Fuzzy Models	Deletion and Duplication, Deletion and Regeneration, Segregation, Cross over and Inversion	Fuzzy Hebb FAMs
S-9	SLO-1	Algorithm BPN()	Exponential Bidirectional Associative Memory	Input Space Partitioning, Fuzzy Modeling	Mutation : Mutation Rate, Bitwise operators in Genetic Algorithm	Fuzzy Associate Memories involving a rule base
	SLO-2	Illustration of Algorithm with training sets	Associative memory for real-coded pattern pairs, Application - Character Recognition	Application: Fuzzy Cruise Control System, Air Conditioner Controller.	Generation Cycle, Convergence of Genetic Algorithm and Applications	FAM Rules with Multiple Antecedents/Consequents

Learning 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. S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Systems, And Evolutionary Algorithms: Synthesis and Applications, PHI Learning Pvt. Lmt., 2017.
3. 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
4. Hideyuki Takagi, Introduction to Fuzzy Systems, Neural Networks, and Genetic Algorithms, Springer Link,
5. https://towardsdatascience.com/an-illustrated-guide-to-genetic-algorithm-ec5615c9ebe
6. https://www.csd.uwo.ca/~mmorenom/cs2101a_moreno/Class9GATutorial.pdf

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	40%	-	40%	-	40%	-	40%	-	40%	-
Level 2	Apply / Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate / Create	20%	-	20%	-	20%	-	20%	-	20%	-
	Total	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.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Prof. Rajeev Sukumaran,SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr. Radhakrishnan M,SRMIST

G-9

Course Code	PCS21G06T	Course Name	Data Structures and Algorithms	Course Category	G	Generic Elective Course	L	T	P	C
							3	0	0	3

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

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

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-1 :	Utilize the different data types; Utilize searching and sorting algorithms for data search																		
CLR-2 :	Utilize linked list in developing applications																		
CLR-3 :	Utilize stack and queues in processing data for real-time applications																		
CLR-4 :	Utilize tree data storage structure for real-time applications																		
CLR-5 :	Utilize algorithms to find shortest data search in graphs for real-time application development																		
CLR-6 :	Utilize the different types of data structures and its operations for real-time programming applications																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	Identify linear and non-linear data structures. Create algorithms for searching and sorting	3	85	80	H	H	H	H	H	-	-	M	M	M	M	H	H	H	H
CLO-2 :	Create the different types of linked lists and evaluate its operations	3	85	80	H	H	H	H	H	M	-	M	M	M	M	H	-	-	-
CLO-3 :	Construct stack and queue data structures and evaluate its operations	3	85	80	M	H	H	H	H	M	-	M	M	M	M	H	-	-	-
CLO-4 :	Create tree data structures and evaluate its types and operations	3	85	80	H	H	H	H	H	-	-	M	M	M	M	H	H	H	H
CLO-5 :	Create graph data structure, evaluate its operations, implement algorithms to identify shortest path	3	85	80	H	H	H	H	H	M	M	M	M	M	M	H	H	M	-
CLO-6 :	Construct the different data structures and evaluate their types and operations	3	85	80	M	H	H	H	H	M	M	M	M	M	M	H	H	H	H

Duration (hour)		Module I (9)	Module II (9)	Module III (9)	Module IV (9)	Module V (9)
S-1	SLO-1	Introduction-Basic Terminology	Array	Stack ADT	General Trees	Graph Terminology
	SLO-2	Data Structures	Operations on Arrays – Insertion and Deletion	Stack Array Implementation	Tree Terminologies	Graph Traversal
S-2	SLO-1	Data Structure Operations	Applications on Arrays	Stack Linked List Implementation	Tree Representation	Topological sorting
	SLO-2	ADT	Multidimensional Arrays- Sparse Matrix	Applications of Stack- Infix to Postfix Conversion	Tree Traversal	Minimum spanning tree – Prims Algorithm
S-3	SLO-1	Algorithms – Searching techniques	Linked List Implementation - Insertion	Applications of Stack- Postfix Evaluation	Binary Tree Representation	Minimum Spanning Tree - Kruskal"s Algorithm
	SLO-2	Complexity – Time , Space Trade off	Linked List- Deletion and Search	Applications of Stack- Balancing symbol	Expression Trees	Network flow problem
S-4	SLO-1	Algorithms - Sorting	Applications of Linked List	Applications of Stack- Nested Function Calls	Binary Tree Traversal	Shortest Path Algorithm- Introduction
	SLO-2	Complexity – Time , Space Trade off	Polynomial Arithmetic	Recursion concept using stack	Threaded Binary Tree	Shortest Path Algorithm: Dijkstra"s Algorithm
S-5	SLO-1	Mathematical notations	Cursor Based Implementation – Methodology	Applications of Recursion:Tower of Hanoi	Binary Search Tree :Construction, Searching	Hashing: Hash functions - Introduction
	SLO-2	Asymptotic notations-Big O, Omega	Cursor Based Implementation	Queue ADT	Binary Search Tree : Insertion and Deletion	Hashing: Hash functions
S-6	SLO-1	Asymptotic notations - Theta	Circular Linked List	Queue Implementation using array	AVLTrees: Rotations	Hashing : Collision avoidance
	SLO-2	Mathematical functions	Circular Linked List - Implementation	Queue Implementation using Linked List	AVL Tree: Insertions	Hashing : Separate chaining
S-7	SLO-1	Data Structures and its Types	Applications of Circular List - Joseph Problem	Circular Queue	B-Trees Constructions	Open Addressing
	SLO-2	Linear and Non-Linear Data Structures	Doubly Linked List	Implementation of Circular Queue	B-Trees Search	Linear Probing
S-8	SLO-1	1D, 2D Array Initialization using Pointers	Doubly Linked List Insertion	Applications of Queue	B-Trees Deletions	Quadratic probing

	SLO-2	1D, 2D Array Accessing using Pointers	Doubly Linked List Insertion variations	Double ended queue	Splay Trees	Double Hashing
scilab S-9	SLO-1	Declaring Structure and accessing	Doubly Linked List Deletion	Priority Queue	Red Black Trees	Rehashing
	SLO-2	Declaring Arrays of Structures and accessing	Doubly Linked List Search	Priority Queue - Applications	Red Black Trees Insertion	Extensible Hashing

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 6. Thomas H Cormen, Charles E Leiserson, Ronald L Revest, Clifford Stein, Introduction to Algorithms 3rd ed., The MIT Press Cambridge, 2014

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate 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.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. V. Maheshwaran, Cognizant Technology Solutions maheshwaranv@yahoo.com	Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	Dr. A. Govindarajan, SRMIST Prof. Rajeev Sukumaran,SRMIST
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr. Radhakrishnan M,SRMIST

S-4

Course Code	PMA21S04L	Course Name	Machine Learning	Course Category	S	Skill Enhancement Courses	L	T	P	C
							0	0	4	2

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-1 :	Perceive the importance of Preprocessing Techniques in machine learning																		
CLR-2:	Study the various Classification Techniques in Machine learning based on probability																		
CLR-3:	Learn the classification Techniques in Machine learning based Statistical method																		
CLR-4:	Acquire the knowledge of Classification and regression techniques using Supervised Machine learning																		
CLR-5 :	Utilize the method of Support vectors and Reinforcement Learning Algorithm to classify the data																		
CLR-6 :	Learn various types empirical mathematical model based on Machine learning																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1:	Understand the Pre-processing concepts in Machine Learning	3	85	80	M	M	H	H	H	H	-	-	M	-	H	M	M	-	H
CLO-2:	Gain the working knowledge of classification techniques based on probability	3	85	80	M	M	H	H	H	H	-	-	M	-	H	-	M	-	H
CLO-3:	Understanding Classification Techniques in Machine learning based on Statistical method with working knowledge	3	85	80	M	M	H	H	H	H	-	-	M	-	H	-	M	-	H
CLO-4:	Apply the advanced Supervised learning Techniques in real world data	3	85	80	M	M	H	H	H	H	-	-	M	-	H	-	M	-	H
CLO-5:	Model the **Support vector and** Reinforcement Learning Algorithms	3	85	80	M	M	H	H	H	H	-	-	M	-	H	-	M	-	H
CLO-6:	Simulate the properties of various types empirical mathematical model with working knowledge based on Machine learning	3	85	80	M	M	H	H	H	H	-	-	M	-	H	M	M	-	H

Duration (Hour)		Module-I (12)	Module-II (12)	Module-III (12)	Module-IV (12)	Module-V (12)
S-1 to S-4	SLO-1	Python programs related to Machine learning	Bayes' Classification Methods	Logistic regression method	Single layer Feedforward neural networks	Linear classification method using Support vectors method
	SLO-2	Python programs related to Machine learning	Bayes' Classification Methods	Logistic regression method	Single layer Feedforward neural networks	Linear classification method using Support vectors method
S-5 to S-8	SLO-1	Data Normalization	Naïve Bayesian Classification	Cluster Analysis	Multilayer Feedforward neural networks	Support vectors method with kernel function
	SLO-2	Data Normalization	Naïve Bayesian Classification	Cluster Analysis	Multilayer Feedforward neural networks	Support vectors method with kernel function
S-9 to S-12	SLO-1	Data reduction	Random Forests Classification method	K-Means : A Centroid Based Technique	Radial Basis function	Reinforcement Learning Algorithms
	SLO-2	Data reduction	Random Forests Classification method	K-Means : A Centroid Based Technique	Radial Basis function	Reinforcement Learning Algorithms

Learning Resources	
	1. Tom M. Mitchell, Machine Learning, McGraw-Hill Education (India) Private Limited, 2013. 2. Ethem Alpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press 2004. **3.** R Nageswara Rao, Core Python Programming, Dream Tech Press, 2017. 4. Guido van Rossum and Fred L. Drake Jr, An Introduction to Python – Revised and updated for Python 3.2, Network Theory Ltd., 2011. 5. W J Chun, Core Python Programming, Prentice Hall, 2007. 6. John V Guttag, Introduction to computation and programming, MIT Press, 2013.

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	-	40%	-	40%	-	30%	-	40%	-	30%
	Understand										
Level 2	Apply	-	40%	-	40%	-	40%	-	40%	-	40%
	Analyze										
Level 3	Evaluate	-	20%	-	20%	-	30%	-	20%	-	30%
			100%		100%		100%		100%		100%

For the Practice Part of a course or a pure Practice course; Continuous Learning Assessments CLA-1, CLA-2 and CLA-3 are generally conducted at periodic intervals, and for certain courses that need learning verification of oral and skill demonstrative abilities, there would be appropriate oral tests and tests for demonstrations, such as online aptitude tests, classroom activities, case studies, poster presentations, power-point presentations, mini talks, group discussions, mock interviews *etc.*

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

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.V.Maheshwaran, CTS,Chennai, maheshwaranv@yahoo.com	Dr.Y.V.S.S. Sanyasiraju, IIT, Madras, sryedida@iitm.ac.in	**Dr.A.Govindarajan, SRMIST,** Dr. K. Ganesan, SRMIST
	Dr.B.V. RatishKumar, IIT, Kanpur, bvrk@iitk.ac.in	Dr. G.Gajendran, SRMIST

I-1

Course Code	PMA21I01L	Course Name	Massive Open Online Course	Course Category	I	Internship in Industry/higher technical institutions	L	T	P	C
							0	0	0	2

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*Encourage initiative by Govt. of India to achieve the three cardinal principles of access, equity and quality in different learning communities.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:
CLO-1:	*Demonstrate the knowledge and skill gained through learning of professional/elective courses taken on SWAYAM portal*
CLO-2:	*Able to develop the professional skill on the subject areas beyond his curriculum*
CLO-3:	*Experience unique and independent learning opportunity*
CLO-4:	*Expand his/her knowledge of a particular area(s) of interest to enhance employability*

Learning Assessment	
MOOCS	*Student shall be allowed to choose one Swayam course on the recommendation of faculty advisor and appropriate credits will be transferred as per regulations 2021*

I-2

Course Code	PMA21I02L	Course Name	Internship	Course Category	I	Internship in Industry/higher technical institutions	L	T	P	C
							0	0	0	2

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

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

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:
CLO-1:	*Demonstrate the skill gained through work experience with mentors or successful professionals to support the early stages of their career*

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

AE-3

Course Code	PCD21AE3T	Course Name	Employability Skills	Course Category	AE	Ability Enhancement Course	L	T	P	C
							1	0	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Career Development Centre			Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
CLR-1:	Develop contextual approach to acquire new vocabulary	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2:	Establish clear relationship between words			
CLR-3:	Identify problems			
CLR-4:	Learn the fundamental skills to solve problems			
CLR-5:	Acquire experience of attending group discussion and personal interview			
CLR-6:	Equipping students with necessary employability skills			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1:	Determine the accurate meanings of words	2	80	75
CLO-2:	Recognise parallel relationship between words	2	80	70
CLO-3:	Learn to solve problems	2	75	70
CLO-4:	Understand and applies problem solving skills learned.	2	80	75
CLO-5:	Inculcate professional communication through Interviews & Group Discussions	2	80	70
CLO-6:	Acquirenecessary skills for successful career	2	80	75

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO – 1	PSO – 2	PSO – 3
CLO-1:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		Modue- I (3)	Modue- II (3)	Modue- III (3)	Modue- IV (3)	Modue- V (3)
S-1	SLO-1	Time & work	Time, speed, distance	Permutation and combination	Probability	Geometry and Mensuration
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
S-2	SLO-1	Perspective on Issues	Critical Reasoning	Synonyms	Antonyms	Word Analogy
	SLO-2	Perspective on Issues	Critical Reasoning	Synonyms	Antonyms	Word Analogy
S-3	SLO-1	Resume preparation	Group Discussion	Mock GD	Interview Techniques	Mock PI
	SLO-2	Resume preparation	Group Discussion	Mock GD	Interview Techniques	Mock PI

Learning Resources	1.Quantitative aptitude by Dinesh Khattar 2. Ramachandran and Karthik, From Campus to Corporate, India, PEARSON Publication, 2016.	3.Verbal Advantage – Ten Easy Steps to a Powerful Vocabulary – Charles Harrington Elster 4.Barron's GRE

Learning Assessment

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

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

Course Designers		
Experts from Industry	Internal Experts	
1.Mr. Ajay Zenne, Career Launcher,ajay.z@careerlauncher.com	1. Dr.P.Madhusoodhanan, SRMIST	2. Dr. A Clement, SRMIST
	3. Dr.M.Snehalatha, SRMIST	4. Dr.Jayapragash J, SRMIST
2.Mr.Pratap Iyer, Study Abroad Mentors, Mumbai,pratap.iyer30@gmail.com	5. Mr. Harinarayana Rao, SRMIST	6. Mr. P Priyanand, SRMIST
	7. Mrs. Kavitha Srisarann, SRMIST	

P-1

Course Code	PMA21P01L	Course Name	Project Work	Course Category	P	Project Work, Internship In Industry / Higher Technical Institutions	L	T	P	C
							0	0	24	12

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

Course Learning Rationale (CLR):	The purpose of learning this course is:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Scientific Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-1 :	Prepare the student to gain major design and or research experience as applicable to the profession																		
CLR-2:	Apply knowledge and skills acquired through earlier course work in the chosen project																		
CLR-3:	Make conversant with the codes, standards, application software and equipment																		
CLR-4:	Carry out the projects within multiple design constraints																		
CLR-5 :	Incorporate multidisciplinary components																		
CLR-6 :	Acquire the skills of comprehensive report writing																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-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	H	H	H	H	H	H	H	-	M	H	H	M	H	H	H

	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