ACADEMIC CURRICULA

POSTGRADUATE DEGREE PROGRAMME
(Regulations 2021)

MASTER OF SCIENCE

M.Sc. (Physics)

Two Years (Full-Time)

Learning Outcome Based Curriculum Framework
(LOCF)

Academic Year

2021 - 2022

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

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Content

DEPARTMENT OF PHYSICS

1.	Department Vision Statement
Stmt - 1	To be recognized nationally and internationally as an exemplary department of physics
Stmt - 2	To provide core instruction in pure and applied physics to train new generation of leading physicists
Stmt - 3	To emerge as a hub of world class research to disseminate our knowledge through interaction with industry, academia and society at large

2.	Department Mission Statement
Stmt - 1	To provide world class teaching and state of art research environment to highly talented young minds
Stmt - 2	To perform frontier research in pure and applied physics, and to serve the society through technological advances
Stmt - 3	To provide an outstanding educational and research experience for the students, researchers and technologists
Stmt - 4	To enable the students to have wide range of career choices through outstanding learning experience
Stmt - 5	To infuse best scientific methods in teaching theoretical and experimental concepts of physics

3.	Program Education Objectives (PEO)
PEO - 1	To provide students with the strong foundation in core and applied physics, the scientific method and comprehensive education in physical sciences
PEO - 2	To enable the students to employ the essential knowledge base, analytical thinking, technical skills for pursuing higher education in physics and variety of other fields
PEO - 3	To provide the opportunity to experience scientific rigor and joy of discovery in diverse scientific teams through participation in research
PEO - 4	To emphasize the relevance of Physics as the important discipline for sustaining the existing industries and establishing new ones to self-empowering the students to create job opportunities and entrepreneurships
PEO - 5	To develop a national and international perspective in core and applied Physics to enable them for improving knowledge and skill for their career development in the chosen field of Physics

4.	Program Specific Outcomes (PSO)
PSO-1	To develop the critical analysis and problem-solving skills required in the application of principles of Physics.
PSO-2	To prepare the students with a working knowledge of experimental/computational techniques and instrumentation required to work independently in research or industrial environments.
PSO-3	To strengthen students' capability in organizing and presenting the acquired knowledge coherently both in oral and written discourse.

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	M	H	M
PEO - 2	H	M	H	H	H
PEO - 3	M	H	M	H	H
PEO - 4	H	H	H	L	M
PEO - 5	L	H	M	H	H

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.	14.	15.
	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
PEO - 1	H	H	H	H	H	L	M	L	M	M	H	H	M	H	H
PEO - 2	H	H	H	H	H	L	M	L	M	H	M	M	H	H	M
PEO - 3	H	H	H	H	H	M	H	M	M	M	H	H	H	M	M
PEO - 4	H	M	M	H	H	H	M	H	H	H	H	L	M	M	H
PEO - 5	M	M	H	H	M	H	M	H	H	H	M	M	H	M	M

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

7. **PG Programme Structure (Total Credits:80)**

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

Course Code	Course Title	Hours/ Week L	T	P	C
PPY21101T	*Mathematical Physics*	*3*	*1*	*0*	*4*
PPY21102T	*Classical Mechanics*	*3*	*1*	*0*	*4*
PPY21103T	*Electrodynamics*	*3*	*1*	*0*	*4*
PPY21104J	*Electronic Devices and Applications*	*3*	*0*	*2*	*4*
PPY21201T	*Quantum Mechanics – I*	*3*	*1*	*0*	*4*
PPY21202J	*Condensed Matter Physics – I*	*3*	*0*	*2*	*4*
PPY21203T	*Statistical Mechanics and Thermodynamics*	*3*	*1*	*0*	*4*
PPY21204T	*Atomic and Molecular Physics*	*3*	*1*	*0*	*4*
PPY21301T	*Quantum Mechanics – II*	*3*	*1*	*0*	*4*
PPY21302J	*Condensed Matter Physics – II*	*3*	*0*	*2*	*4*
Total Learning Credits					**40**

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

Course Code	Course Title	Hours/ Week L	T	P	C
PPY21D01T	*Structure and Properties of Materials*	*3*	*1*	*0*	*4*
PPY21D02T	*Computational Physics*				
PPY21D03T	*Applied Optics*				
PPY21D04T	*Sensors*				
PPY21D05T	*Nanoscience and Nanomaterials*	*3*	*1*	*0*	*4*
PPY21D06T	*Thin Film Technology*				
PPY21D07T	*Photonics*				
PPY21D08T	*Atmospheric Physics*				
PPY21D09T	*Nuclear and Particle Physics*	*3*	*1*	*0*	*4*
PPY21D10T	*High Energy Physics*				
PPY21D11T	*Quantum Field Theory*				
Total Learning Credits					**12**

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

Course Code	*Course Title*	Hours/ Week L	T	P	C
PCY21G01T	*Research Skills and Learning*	*3*	*0*	*0*	*3*
PCY21G02T	*Chemistry of Biomolecules*	*3*	*0*	*0*	
PMA21G01T	*Mathematics for Artificial Intelligence*	*3*	*0*	*0*	
PMA21G02T	*Mathematics for Physicists*	*3*	*0*	*0*	
Total Learning Credits					**3**

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

Course Code	Course Title	Hours/ Week L	T	P	C
PPY21S01L	*Physics and Electronics Laboratory*	*0*	*0*	*6*	*3*
PPY21S02L	*Scientific Programming in C++*	*0*	*0*	*4*	*2*
PPY21S03L	*Advanced Characterization of Materials and Analysis Laboratory*	*0*	*0*	*6*	*3*
Total Learning Credits					**8**

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

Course Code	Course Title	Hours/ Week L	T	P	C
PPY21I01L	*Massive Open Online Course*	*0*	*0*	*0*	*2*
PPY21I02L	*Internship*	*0*	*0*	*0*	
PPY21P01L	*Project*	*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**

Course Structure								
Semester	Professional Core Courses (PCC)	Discipline Electives Courses (DEC)	Generic Electives Courses (GEC)	Skill Enhancement Courses (SEC)	Project Work, Internship (P)	Ability Enhancement Courses (AE)	Total Credits	Total Hours
Sem I	PCC-1(4) PCC-2 (4) PCC-3 (4) PCC-4 (4)			SEC-1 (2)		AEC-1 (1)	**20**	**24**
Sem II	PCC-5 (4) PCC-6 (4) PCC-7 (4) PCC- 8(4)	DEC-1(4)		SEC-2 (3)		AEC-2 (1)	**23**	**26**
Sem III	PCC- 9(4) PCC- 10(4)	DEC-2(4) DEC-3 (4)	GEC (3)	SEC2 (3)	P-1 (2)	AEC-3 (1)	**25**	**27**
Sem IV					P-2 (12)		**12**	**24**
Total Credits	**40**	**12**	**3**	**8**	**14**	**3**	**80**	**101**

8. **Implementation Plan**

Semester - I

Course Code	Course Title	L	T	P	C
PPY21101T	Mathematical Physics	3	1	0	4
PPY21102T	Classical Mechanics	3	1	0	4
PPY21103T	Electrodynamics	3	1	0	4
PPY21104J	Electronic Devices and Applications	3	0	2	4
PPY21S01L	Physics and Electronics Laboratory	0	0	6	3
PCD21AE1T	Professional Skills and Problem Solving	1	0	0	1
	Total Learning Credits				20

(Hours/ Week: L, T, P)

Semester - II

Course Code	Course Title	L	T	P	C
PPY21201T	Quantum Mechanics – I	3	1	0	4
PPY21202J	Condensed Matter Physics – I	3	0	2	4
PPY21203T	Statistical Mechanics and Thermodynamics	3	1	0	4
PPY21204T	Atomic and Molecular Physics	3	1	0	4
PPY21D01T	Structure and Properties of Materials	3	1	0	4
PPY21D02T	Computational Physics				
PPY21D03T	Applied Optics				
PPY21D04T	Sensors				
PPY21S02L	Scientific Programming in C++	0	0	4	2
PCD21AE2T	General Aptitude for Competitive Examinations	1	0	0	1
	Total Learning Credits				23

Semester – III

Course Code	Course Title	L	T	P	C
PPY21301T	Quantum Mechanics – II	3	1	0	4
PPY21302J	Condensed Matter Physics – II	3	0	2	4
PPY21D05T	Nanoscience and Nanomaterials	3	1	0	4
PPY21D06T	Thin Film Technology				
PPY21D07T	Photonics				
PPY21D08T	Atmospheric Physics				
PPY21D09T	Nuclear and Particle Physics	3	1	0	4
PPY21D10T	High Energy Physics				
PPY21D11T	Quantum Field Theory				
PCY21G01T	Research Skills and Learning	3	0	0	3
PCY21G02T	Chemistry of Biomolecules	3	0	0	
PMA21G01T	Mathematics for Artificial Intelligence	3	0	0	
PMA21G02T	Mathematics for Physicists	3	0	0	
PPY21S03L	Advanced Characterization of Materials and Analysis Laboratory	0	0	6	3
PPY21I01L	Massive Open Online Course	0	0	0	2
PPY21I02L	Internship	0	0	0	
PCD21AE3T	Employability Skills	1	0	0	1
	Total Learning Credits				25

Semester - IV

Course Code	Course Title	L	T	P	C
PPY21P01L	Project Work	0	0	24	12
	Total Learning Credits				12

Total Learning Credits :80

9. Program Articulation Matrix

Course Code	Course Name	Programme Learning Outcomes														
		Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
PPY21101T	*Mathematical Physics*	H	H	H	H	H	H	H	M	H	M	H	L	H	H	H
PPY21102T	*Classical Mechanics*	H	H	H	H	H	H	H	M	H	M	H	L	H	H	H
PPY21103T	*Electrodynamics*	H	H	H	H	H	H	H	H	H	M	H	L	H	M	H
PPY21104J	*Electronic Devices and Applications*	H	H	H	H	H	H	H	M	H	M	H	L	H	H	H
PPY21201T	*Quantum Mechanics – I*	H	H	H	H	H	H	H	M	H	M	H	L	H	H	H
PPY21202J	*Condensed Matter Physics – I*	H	H	H	H	H	H	H	M	H	M	H	L	H	H	H
PPY21203T	*Statistical Mechanics and Thermodynamics*	H	H	H	H	H	H	H	H	H	M	H	L	H	M	H
PPY21204T	*Atomic and Molecular Physics*	H	H	H	H	H	H	H	M	H	M	H	L	H	H	H
PPY21301T	*Quantum Mechanics – II*	H	H	H	H	H	H	H	M	H	M	H	L	H	H	H
PPY21302J	*Condensed Matter Physics – II*	H	H	H	H	H	H	H	H	H	M	H	L	H	M	H
PPY21D01T	*Structure and Properties of Materials*	H	H	H	H	H	H	H	H	H	M	H	L	H	M	H
PPY21D02T	*Computational Physics*	H	H	H	H	H	H	H	H	H	M	H	L	H	M	H
PPY21D03T	*Applied Optics*	H	H	H	H	H	H	H	H	H	M	H	L	H	M	H
PPY21D04T	*Sensors*	H	H	H	H	H	H	H	H	H	M	H	L	H	M	H
PPY21D05T	*Nanoscience and Nanomaterials*	H	H	H	H	H	H	H	H	H	M	H	L	H	M	H
PPY21D06T	*Thin Film Technology*	H	H	H	H	H	H	H	H	H	M	H	L	H	M	H
PPY21D07T	*Photonics*	H	H	H	H	H	H	H	M	H	M	H	M	H	H	H
PPY21D08T	*Atmospheric Physics*	H	H	H	H	H	H	H	M	H	M	H	M	H	H	H
PPY21D09T	*Nuclear and Particle Physics*	H	H	H	H	H	H	H	M	H	M	H	L	H	H	H
PPY21D10T	*High Energy Physics*	H	H	H	H	H	H	H	M	H	M	H	L	H	H	H
PPY21D11T	*Quantum Field Theory*	H	H	H	H	H	H	H	M	H	M	H	L	H	H	H
PCY21G01T	*Research Skills and Learning*	H	H	H	H	H	H	H	M	H	M	H	L	H	H	H
PCY21G02T	*Chemistry of Biomolecules*	H	H	H	H	H	H	H	M	H	M	H	L	H	H	H
PMA21G01T	*Mathematics for Artificial Intelligence*	H	H	H	H	H	H	H	H	H	M	H	L	H	M	H
PMA21G02T	*Mathematics for Physicists*	H	H	H	H	H	H	H	H	H	M	H	L	H	M	H
PPY21S01L	*Physics and Electronics Laboratory*	H	H	H	H	H	H	H	H	H	M	H	L	H	M	H
PPY21S02L	*Scientific Programming in C++*	H	H	H	H	H	H	H	H	H	M	H	L	H	H	H
PPY21S03L	*Advanced Characterization of Materials and Analysis Laboratory*	H	H	H	H	H	H	H	H	H	M	H	L	H	H	H
PPY21I01L	*Massive Open Online Course*	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PPY21I02L	*Internship*	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PPY21P01L	*Project Work*	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
PCD21AE1T	*Professional skills and problem solving*	H	H	M	H	M	H	M	H	H	M	H	L	M	H	H
PCD21AE2T	*General aptitude for competitive examinations*	H	H	M	H	M	H	M	H	H	M	H	L	M	H	H
PCD21AE3T	*Employability skills*	H	H	M	H	M	H	M	H	H	M	H	L	M	H	H
	Program Average	H	H	H	H	H	H	H	H	H	M	H	L	H	H	H

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

SEMESTER I

Course Code	*PPY21101T*	Course Name	*Mathematical Physics*	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	Physics and Nanotechnology	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 its applications.*
CLR-2:	*develop expertise in mathematical techniques required in physics.*
CLR-3:	*enhance problem solving skills*
CLR-4:	*enable students formulate, interpret and draw inferences from mathematical solutions.*
CLR-5:	*reveal the mathematical structure through calculations*
CLR-6:	*direct the mathematical calculation for betterment through mathematical theorems and lemma*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Disciplinary Knowledge	2: Critical Thinking	3: Problem Solving	4: Analytical Reasoning	5: Research Skills	6: Team Work	7: Scientific Reasoning	8: Reflective Thinking	9: Self-Directed Learning	10: Multicultural Competence	11: ICT Skills	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1:	*understand the linear algebra through matrices*	2	80	75	H	H	H	H	H	H	H	H	H	M	M	H	H	H	H
CLO-2:	*understand vector calculus and its application in physical fields*	2	80	70	H	H	H	H	H	H	H	H	H	M	M	H	H	H	H
CLO-3:	*understand and develop the computation methods through complex variable*	2	75	70	H	H	H	H	H	H	H	H	M	M	M	H	H	H	H
CLO-4:	*understand and able to solve differential equation*	2	80	75	H	H	H	H	H	H	H	H	H	M	M	H	H	H	H
CLO-5:	*understand and develop the mathematics structure for periodic functions through integral transform*	2	80	70	H	H	H	H	H	H	H	H	H	M	M	H	H	H	H
CLO-6:	*understand and develop power to solve numerical problems and its use various parts of physics*	2	80	75	H	H	H	H	H	H	H	H	H	M	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Dimensional analysis	Matrix Multiplication	Bessel function of first kind and its series solution	Definition of set and its review	Periodic function
	SLO-2	Vector algebra and vector calculus	Simultaneous linear equations	Bessel function of second kind	Binary operation over a set	Odd and even functions
S-2	SLO-1	Gradient, divergence	Definition of matrix	Bessel's generating function	Definition of Group	Square and triangular wave
	SLO-2	Curl of a Vector Field	Basic Matrix operations	Generating function (continued)	Finite group multiplication table	Euler formula for Fourier series
S-3	SLO-1	Transformation of vectors	Complex conjugation and transposition	Bessel's integral representation and recurrence relations	Conjugate elements and conjugacy classes	Euler coefficient
	SLO-2	Rotation of the coordinate axes	Classification of matrices	Orthogonality for Bessel function	Subgroups	Fourier series with 2l period
S-4	SLO-1	Problem solving	Problem solving	Problem solving	Problem Solving	Problem solving
	SLO-2	Problem solving	Problem solving	Problem solving	Problem Solving	Problem solving
S-5	SLO-1	Invariance of the scalar Product under rotations	Trace of a matrix and its properties	Legendre function and its series solution	Order of a group	Perseval's Identity
	SLO-2	Invariance of the vector Product under rotations	Determinant and its properties	Legendre's generating function	Lagrange' s theorem	Proof of Perseval's Identity
S-6	SLO-1	Vector analysis in curved coordinate	Definition of inverse matrix	Legendre's generating function (continued)	Normal subgroup	Fourier integral theorem
	SLO-2	Special coordinate system	Algorithm to find inverse matrix	Recurrence relations and special properties	Isomorphism and homomorphism	Proof of integral theorem
S-7	SLO-1	Spherical polar coordinates	Symmetric and skew-symmetric matrix	Orthogonality; various Legendre polynomials	Permutation group	Motivation for Fourier transform
	SLO-2	Cylindrical polar coordinates	Hermitian and skew-Hermitian matrix	Associated Legendre functions	Representation of a group	Definition of Fourier transform
S-8	SLO-1	Problem solving	Problem solving	Problem solving	Problem Solving	Problem solving
	SLO-2	Problem solving	Problem solving	Problem solving	Problem Solving	Problem solving
S-9	SLO-1	Introduction to tensor	Orthogonal matrix	Hermite functions and its series solution	Schur's lemma and character table	Properties of Fourier transform
	SLO-2	Einstein's summation notations	Unitary matrix	Generating function	Lie Group: Definition	Linearity and shifting
S-10	SLO-1	Quotient rule	Eigenvalues and eigenvectors	Recurrence relations and special properties	Three-dimensional rotational group	Fourier transforms of derivatives
	SLO-2	Pseudo tensors	Characteristic equation	Orthogonality	Lorentz group	Convolution theorem
S-11	SLO-1	Metric tensor	Cayley –Hamilton theorem	Laguerre function	O(3) and SO(2)	Inverse Fourier transforms
	SLO-2	Non-Cartesian tensors	Diagonalization of matrix	Recurrence relations and orthogonality.	SU(2)	Introduction to Laplace Transform
S-12	SLO-1	Problem solving	Problem solving	Problem solving	Problem Solving	Problem solving
	SLO-2	Problem solving	Problem solving	Problem solving	Problem Solving	Problem solving

Learning Resources	
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. C. Harper, *Introduction to Mathematical Physics*, Prentice Hall of India, New Delhi, 2004. 4. M.R. Spiegel, *Schaum's Outline of Advanced Mathematics for Engineers and Scientists*, 1st Ed., McGraw Hill, 2009. 5. L.A. Pipes, *Applied Mathematics for Engineers and Physicists*, McGraw-Hill, 1958. 6. M.L. Boas, *Mathematical Methods in the Physical Sciences*, 3rd Ed., John Wiley, 2005. 7. M.R. Spiegel, Seymour Lipschutz, John J. Schiller, and Dennis Spellman, *Schaum's outline of Complex Variables*, 2nd Ed., McGraw Hill, 2009. 8. B.D. Gupta, *Mathematical Physics*, 4th Ed., Vikas Publishing House, 2009. 9. S. Hassani, *Mathematical Physics: A Modern Introduction to Its Foundations*, 2nd Ed., Springer, 2013.

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. R Seshadri, Titan Company Limited, seshadri@titan.co.in	*Dr. Ranjit Kumar Nanda, IIT Madras, nandab@iitm.ac.in*	Dr. Alok Kumar, SRMIST
Dr. DK Aswal, NPL, dkaswal@nplindia.org	Prof. C Vijayan, IIT Madras, cvijayan@iitm.ac.in	Dr. SK Mehta, SRMIST

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Course Code	Course Name	Course Category			L	T	P	C
PPY21102T	***Classical Mechanics***		C	Professional Core Course	3	1	0	4

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 :	*emphasize the mathematical formulation of mechanics problems*
CLR-2 :	*understand, explain and derive the various mechanics problems*
CLR-3 :	*learn about the Hamilton's principle and canonical transformation and its significance*
CLR-4 :	*lay the solid background of small oscillations to employ in molecular system*
CLR-5 :	apply the fundamental concepts of classical mechanics to the rigid bodies
CLR-6:	*develop basic understanding of special relativity*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Disciplinary Knowledge	2: Critical Thinking	3: Problem Solving	4: Analytical Reasoning	5: Research Skills	6: Team Work	7: Scientific Reasoning	8: Reflective Thinking	9: Self-Directed Learning	10: Multicultural Competence	11: ICT Skills	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*general concepts of multi particle system, generalised coordinate*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2 :	*learn the reference frames – equations of motion in simple force fields*	2	80	70	H	H	M	H	M	H	H	H	M	H	M	H	M	M	M
CLO-3 :	*carry out advanced tasks within specified area*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*develop problem solving and critical thinking skills*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*develop the skill to combine and use knowledge from several disciplines to enter*	2	80	70	H	H	H	H	H	M	H	H	M	H	M	H	H	H	H
CLO-6:	*learn the basic aspects of relativity*	2	80	75	H	M	M	H	H	H	H	H	H	H	M	H	H	M	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Review of Newtonian mechanics-reference frames, velocity, second law	Hamiltonian formalism, Legendre's dual transformation	DOF of a rigid body, Frames of reference of a rigid body, rotating frames	Periodic motion and types of equilibrium	Introduction of relativity
	SLO-2	Review of Newtonian mechanics-equation of motion for single particle, System of particles	Hamilton's equations of motion from Lagrangian	Body coordinate system and space coordinate system	Understanding potential energy and total energy with equilibrium state	Galilean transformation
S-2	SLO-1	Constraints and it classification	Basic concept of action integral	Centrifugal and Coriolis forces	Study of small oscillations using generalised coordinates	Velocity under Galilean transformation
	SLO-2	Problem solving: work done, conservative force, Constraints	Problem solving: LHO equation of motion of LHO from Hamilton's equations	Effect of Coriolis forces	Phase space dynamics, Condition of stable equilibrium points	Acceleration under Galilean transformation
S-3	SLO-1	Lagrangian Dynamics, Degrees of Freedom	Principle of least action and Hamilton's principle	Euler theorem, Euler angles	Secular equation and eigen value equation	Idea behind Lorentz transformation
	SLO-2	Principle of virtual work	Simple Pendulum equation from Hamilton's equations	Euler equations	Solution of eigen value equation	Length contraction
S-4	SLO-1	Lagrange's equations of first kind	Hamilton's equation for an ideal spring-mass arrangement	Problem solving: coriolis forces	Problem solving: Finding the stable and unstable position	Problem solving: Length contraction
	SLO-2	Problem solving: Principle of virtual work (Atwood machine)	Problem solving: Hamiltonian function and equation of motion of different classical problem	Problem solving: Euler angles	Problem solving: Finding the frequency on stable position	Problem solving: Rocket Length under relativistic velocity
S-5	SLO-1	D'Alembert's principle	Lagrangian of relativistic particles	Angular velocity and angular momentum of a rigid body	Free vibration and Normal coordinates	Simultaneity and Time Dilation

	SLO-2	Lagrange's equations of motion, Generalized Forces	Hamiltonian of relativistic particles	Inertia Tensor, Moment of Inertia matrix	Normal Frequency	Relativity od mass
S-6	SLO-1	Generalised momentum, Cyclic coordinates	Definition of canonical transformations	Product of Inertia, Principal axes	Secular equation for normal frequency	Addition of velocities
	SLO-2	Problem solving: Find out equation of motion of a free particle using Lagrange's equations	Problem solving: Transformation equation is canonical or not	Kinetic energy of a rigid body	Small oscillations in normal coordinates	Postulates of special theory of relativity
S-7	SLO-1	Simple Pendulum- Lagrange's equations	Generating function for canonical transformations	Euler equation of motion	Two coupled pendulum and its characteristic equation	Mass-energy relation
	SLO-2	Motion under Central force- Lagrangian	First and Second form F2 and relation with qj, pj	Euler equation for Torque free motion	Eigen vector of two coupled pendulum system	Energy and momentum relation
S-8	SLO-1	Motion under Central force- Lagrange's equations	Third and fourth form F3, F4 and relation with qj, pj	Problem solving: Calculation of inertia tensor of four point mass	Problem solving: Normal frequency	Problem solving: meson decay
	SLO-2	Problem solving: Lagrangian of charge particle	Problem solving:	Problem solving: Calculation of inertia tensor of parallelopiped	Problem solving: Normal coordinates	Problem solving: cosmic ray
S-9	SLO-1	Linear harmonic oscillator- Lagrange's equations	Poisson brackets and canonical transformations	Symmetric and asymmetric rigid body	Vibration of chain molecules (triatomic)	Minkowski space and Lorentz transformation in four vectors
	SLO-2	Atwood machine Lagrangian	Conditions for canonicality	Force free motion of a symmetrical top	Potential energy matrix of a triatomic molecule	Deduction of Lorentz transformation
S-10	SLO-1	Atwood machine equation of motion from Lagrangian	Poisson brackets, Properties of Poisson brackets	Angular frequency of a symmetrical top	Kinetic energy matrix of a triatomic molecule	Matrix notation of Lorentz transformation
	SLO-2	Problem solving: bead slides on smooth rod	Problem solving: Poisson brackets	Set of equation and establishment of of heavy symmetric top	Secular equation and solution for frequencies for a triatomic molecule	Four-vector notation: velocity
S-11	SLO-1	Projectile Motion from Lagrangian	Poisson's theorem, Jacobi-Poisson theorem	Lagrangian and first integrals of equations of motion of heavy symmetric top	Discuss the eigen vector of three mode of vibration of a triatomic chain molecules	Four-vector notation: momentum
	SLO-2	Definition of Hamiltonian	Hamilton Jacobi equation	Precession without nutation, Figure axis of a of heavy symmetric top	Normal mode and vibration summary of a triatomic chain molecules	energy-momentum four-vector for a particle
S-12	SLO-1	Variational principle	Invariance and Noether's theorem	Problem solving: Principal moments of inertia	Problem solving: small oscillation in two mass and two spring system	Problem solving: rest mass and kinetic energy
	SLO-2	Problem solving: Lagrangian	Problem solving: Poisson brackets	Problem solving: Principal moments of inertia	Problem solving: Calculation of T, V for small oscillation	Problem solving: relativistic kinematics

Learning Resources	1. Classical Mechanics, Dr. J. C. Upadhyaya (Himalaya Publishing House Pvt. Ltd., 2014) 2. Classical Mechanics of Particles and Rigid Bodies, K.C. Gupta (Wiley Eastern, 2006)	3. Classical Mechanics, 3. J.R. Taylor (University Science Books, 2005) 4. Classical Mechanics, H. Goldstein, C. Poole and J. Fafko (Pearson Education Inc., 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 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, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Attendance etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, NPL, dkaswal@nplindia.org	Prof. V Subramanian, IIT Madras, manianvs@iitm.ac.in	Dr. Debabrata Sarkar, SRMIST
Dr. M Sathish, CSIR-CECRI, msathish@cecri.re.in	Prof. C Venkateshwaran, University of Madras, venkateshwaran@unom.ac.in	Dr. Rohit Dhir, SRMIST

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Course Code	*PPY21103T*	Course Name	*Electrodynamics*	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	**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 in electrodynamics.
CLR-2:	develop skills on solving analytical problems in electrodynamics
CLR-3:	bridge the gap between the fundamental principles taught in electromagnetism and its practical application
CLR-4:	acquire advanced knowledge in current understanding of electrodynamics.
CLR-5:	understand the electrodynamics of radiating and relativistic systems.
CLR-6:	give basics of defining the complete electromagnetic response of complex systems.
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:

Learning		
1	2	3
Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)

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:	*be familiar with some elementary phenomena and concepts in electrodynamics*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
CLO-2:	*master the technique of deriving and evaluating formulae for the electromagnetic fields from very general charge and current distributions*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
CLO-3:	*apply mathematical tools to explain electromagnetic interactions.*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*
CLO-4:	*solve problems in electromagnetism that require analytical and numerical approach*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
CLO-5:	*calculate the electromagnetic radiation from radiating systems*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
CLO-6:	*formulate and solve electrodynamic problems in covariant form in four-dimensional space-time*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*

Duration (hour)		**12**	**12**	**12**	**12**	**12**
S-1	**SLO-1**	Electrodynamics before Maxwell	Poynting's theorem	Scalar and vector potentials	Electric dipole radiation	Special Theory of relativity
	SLO-2	Gauss law, Integral Differential Form	Poynting vector	Maxwell equations for V and A	Power radiated	General Concepts
S-2	**SLO-1**	Electric scalar potential	Electromagnetic waves in vacuum,	Gauge transformations	Magnetic dipole radiation	Lorentz transformations
	SLO-2	Generalization of concept	Transverse nature of electromagnetic waves	Non-unique A and V	Far field approximation and comparison with Electric dipole power	Lorentz transformation matrix
S-3	**SLO-1**	Laplace's equation	Energy and momentum in electromagnetic fields	Coulomb gauge	Radiation from an arbitrary source	covariant and contravariant vectors
	SLO-2	Poisson's equation	Radiation Pressure	Lorentz gauge	Total Power radiated and Larmor Formula as special case	Einstein's notation
S-4	**SLO-1**	Problem solving on Gauss Law, Vector calculus	Problem solving on Poynting Vectors	Problem solving on Potentials	Problem solving on Dipole radiations	Problem solving on relativity
	SLO-2	Problem solving on Laplace Equation etc.	Problem solving on Energy and Momentum	Problem solving on Gauge Conditions	Problem solving on Power Radiated	Problem solving on Lorentz transformations
S-5	**SLO-1**	Biot-Savart's law	Electromagnetic waves in matter,	Retarded potentials	Power radiated by a point charge:	Magnetism as a relativistic phenomenon
	SLO-2	Applications	Reflection and transmission at normal incidence	Derivation	Larmor formula	relativistic case of linear charge density
S-6	**SLO-1**	divergence and curl of magnetic field	Reflection and transmission at oblique incidence	Jefimenko's equations	Lienard's relativistic generalization	Electromagnetic field transformation
	SLO-2	Physical Significance	Fresnel's Equations	Physical Significance and meaning	Bremsstrahlung and Cyclotron Radiation (Qualitatively)	Various equations involved
S-7	**SLO-1**	magnetic vector potential,	Absorption and Dispersion	Lienard-Wiechert potentials	Radiation reaction	Field tensor
	SLO-2	Ampere's law	electromagnetic waves in conductor	Relation between V and A	Abraham-Lorentz formula	Asymmetry and components
S-8	**SLO-1**	Problem solving on Biot-Savart's law	Problem solving on Reflection, refraction	Problem solving on retarded potentials	Problem solving on relativistic charges in potentials	Problem solving on EM fields in Lorentz transformations
	SLO-2	Problem solving: Vector Potential and Ampere's Law	Problem solving on Brewster's angle, Absorption and Dispersion	Problem solving on LW potentials	Problem solving on radiation reaction	Problem solving on Filed tensor Asymmetry
S-9	**SLO-1**	Faraday's law.	Propagation in conductors	Fields of moving point charge:	Acausal Pre-acceleration	Current density four-vector,
	SLO-2	Lorentz force,	Skin depth, Conductors and Dielectrics	Electric and Magnetic fields at retarded point	Modern Physics explanation based on Uncertainty principle	Continuity Equation in four vector
S-10	**SLO-1**	Electrodynamics after Maxwell:	Reflection at a conducting surface	Generalization of Coulomb field	Radiation Damping of a Charged Particle	Lorentz force law using tensor notation
	SLO-2	Maxwell's modification to Ampere's law	Boundary conditions	Velocity and acceleration Terms of Lorentz force	Damping factor and Frequency	Relativistic potentials.
S-11	**SLO-1**	Maxwell's equations in matter	Frequency dependence of permittivity	Fields of a moving charge	Physical basis of radiation reaction.	Maxwell's equations
	SLO-2	boundary conditions and continuity equation.	Cauchy's Formula	Constant Velocity case	Force of the charge on itself	In-homogenous and Homogenous four notations
S-12	**SLO-1**	Problem solving on Maxwell Equations	Problem solving on conducting surface and dielectrics	Problem solving on retarded fields of moving charges	Problem solving on Damping	Problem solving on Maxwell Equations and field tensors
	SLO-2	Problem solving on Boundary Conditions	Problem solving on Skin Depth, Wave Propagation	Problem solving on velocity and acceleration radiation force components	Problem solving on Radiation Reaction	Problem solving on relativistic Lagrangian for ED

Learning Resources	1. D.J. Griffiths, Introduction to Electrodynamics, 4th Ed., Prentice-Hall India, 2013. 2. J.D. Jackson, Classical Electrodynamics, 3rd Ed., Wiley 1998. 3. E.C. Jordan, and K. G. Balmain, Electromagnetic Waves and Radiating Systems, Prentice Hall, 1995.	4. Schwinger et. al., Classical Electrodynamics, Perseus Books, 1998. 5. G.S. Smith, Classical Electromagnetic Radiation, Cambridge, 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 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
Dr. M Sathish , CSIR-CECRI, msathish@cecri.re.in	Prof. C Vijayan, IIT Madras, cvijayan@iitm.ac.in	Dr. Rohit Dhir, SRMIST
Dr. DK Aswal , NPL, dkaswal@nplindia.org	Prof. V Subramanian, IIT Madras, manianvs@iitm.ac.in	Dr. K. Shadak Alee, SRMIST

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Course Code	*PPY21104J*	Course Name	*Electronic Devices and Applications*	Course Category	C	Professional Core Course	L	T	P	C
							3	0	2	4

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:	*enhance comprehension capabilities of students through understanding of electronic devices*
CLR-2:	*give clear understanding of operational amplifier and its importance*
CLR-3:	*provide a clear picture of importance of operational amplifier applications*
CLR-4:	*understand the physical construction, working and operational characteristics of semiconductor devices*
CLR-5:	*introduce the basic building blocks of linear integrated circuits & digital converters*
CLR-6:	*introduce the basics of microprocessors*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Disciplinary Knowledge	2: Critical Thinking	3: Problem Solving	4: Analytical Reasoning	5: Research Skills	6: Team Work	7: Scientific Reasoning	8: Reflective Thinking	9: Self-Directed Learning	10: Multicultural Competence	11: ICT Skills	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1:	*understand characteristic of materials from band gap point of view*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*know about the concept of op-amp, amplifier, differentiator and integrator*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*explore various types of filters, comparators and waveform generators*	2	75	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-4:	*understand the basics of logic gates, flip flops and d/a converter and vice versa*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*solve various problems using integrator and differentiator*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*understand the microprocessor, 8085 architecture, data transfer, and logic and branch instructions*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		15	15	15	15	15
S-1	SLO-1	Fundamentals of insulator, conductors and semiconductors	Op-amp parameters	Active filters	Basic introduction to logic gates	Registers
	SLO-2	Classification based on band gap: insulator, conductors and semiconductors	Ideal op-amp	Low-pass filters	Flip-flops	Details of Registers
S-2	SLO-1	n-type and p-type semiconductors, understanding the p-n junction, forming a p-n junction	Open loop op-amp configuration	High-pass filters	Digital clock	Bus organization in computers
	SLO-2	Diffusion- “built-in” electric field, forward bias, reverse bias, I-V characteristics, breakdown voltage	Differential amplifier	Band-passfilter	Different types of registers	Microprocessor
S-3	SLO-1	Zener diode	Inverting amplifier	Band-reject filters	Serial In Serial Out	8085 architecture
	SLO-2	Schottky barrier diode, varactor diode	Non-inverting amplifier	All-pass filters	Serial In Parallel Out	Details of 8085 architecture
S-4 to S-5	SLO-1 SLO-2	Obtain V-I characteristics of a Zener diode and find its breakdown potential.	Design of of differential amplifier, inverting amplifier and non-inverting amplifier using IC741	Design of active filters using operational amplifiers.	Design of SISO and SIPO shift registers using Flip-Flops.	Assembly Language Programs to perform the Arithmetic operations (addition and Subtraction) using microprocessor 8085.
S-6	SLO-1	Light Emitting Diode (LED)	Equivalent circuit of an op-amp	Waveform generators	Parallel In Serial Out	Qualitative overview of memory interfacing.
	SLO-2	Surface Emitting LED and Edge Emitting LED	Ideal voltage transfer curve	Square wave generator	Parallel In Parallel Out and applications	Interfacing i/o devices
S-7	SLO-1	Seven segment display	Op-amp linear application-DC amplifier	Triangular wave generator	Asynchronous counters	Assembly language programming
	SLO-2	Details of seven segment display	ac amplifier	Sawtooth wave generator	Synchronous counters	Instruction classification
S-8	SLO-1	Solar cells, photodiodes	Summing amplifier	Comparators: basic comparator types	Decade counters	Addressing modes
	SLO-2	Photo-conductive cells, photo transistors	Scaling amplifier	Characteristics, applications	Sample and hold circuits	Timing diagram
S-9 to S-10	SLO-1 SLO-2	Study the V-I characteristics of Light Emitting Diode.	Design of Summing amplifier and Scaling amplifier using IC 741	Design of square wave generator using IC 741	Design of UP and Down Counters using Flip-flops	Assembly Language Programs to perform the Arithmetic operations (multiplication and division) using microprocessor 8085.
S-11	SLO-1	Tunnel diode	Averaging amplifier	Zero crossing detector	Types of D/A converter,	Data transfer instructions
	SLO-2	Working principle of tunnel diode	Instrumentation amplifier	Schmitt trigger	Binary weighted resistors	Details of data transfer instructions
S-12	SLO-1	Unijunction transistor	Integrator	log-amplifiers	A/D converter,	Logical and branch instructions
	SLO-2	p-n-p-n devices and characteristics	Differentiator	Antilog amplifiers	Flash converter, successive approximation register	Details of logical and branch instructions
S-13	SLO-1	Thyristor	solving problems using integrator	Astable multivibrators using op-amp	Astable multivibrators using 555 timer.	Simple programs
	SLO-2	Silicon controlled switch (SCS)	solving problems using differentiator	Monostable multivibrators using op-amp	Monostable multivibrators using 555 timer	Simple programs

S-14 to S-15	SLO-1	UJT characteristics and design of sawtooth wave oscillator.	Design and set up an integrator and differentiator circuit using IC 741	Design of Monostable multivibrator and Astable multivibrator using IC 741	Design of Monostable multivibrator and Astable multivibrator using IC 555	Assembly Language Program to perform Binary Code to Gray code conversion using microprocessor 8085
	SLO-2					

Learning Resources	1. R.L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory, 9th Ed., Pearson Education, 2009. 2. T.L. Floyd, Electronic devices, 9th Ed., Pearson Education. Ltd., 2013. 3. A.R. Gayakwad, Op-amps and linear integrated circuits, 3rd Ed., Prentice-Hall, Inc., 2000. 4. D.P. Leach, A.PMalvino and G. Saha, Digital Principles and Applications, 7th Ed., 2011. 5. R.S. Gaonkar, Microprocessor Architecture, Programming & Applications with 8085, Prentice Hall, 2002.	6. W.D. Stanley, Operational amplifiers with linear integrated circuits, 4th Ed., Pearson Education India, 2002. 7. D.D. Givone, Digital Principles and Design, Tata McGraw-Hill, 2002. 8. K. Udaya Kumar, The 8085 Microprocessor: Architecture, Programming and Interfacing, Pearson Education India, 2008. 9. A. Sproul, Understanding the pn Junction Solar Cells, Resources for the Secondary Science Teacher (2003): 13-24.

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 %	30 %	30 %	30 %	30 %	30 %
Level 2	Apply Analyze	40 %	40 %	40 %	40 %	40 %	40 %	40 %	40 %	40 %	40 %
Level 3	Evaluate Create	30 %	30 %	30 %	30 %	30 %	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
Dr. M Satish, CSIR-CECRI, msathish@cecri.re.in	Prof. C Venkateshwaran, University of Madras, venkateshwaran@unom.ac.in	Dr. Naga Rajesh A, SRMIST
Dr. V. Jayaraman, IGCAR, Kalpakkam, vjram@igcar.gov.in	Dr. V. Gunasekaran, Central University TN, gunasekaran@cutn.ac.in	Dr. Bhaskar C. Behera, SRMIST

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Course Code	*PPY21S01L*	Course Name	*Physics and Electronics Laboratory*	Course Category	S	Skill Enhancement Course	L	T	P	C
							0	0	6	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:	*make the students familiarize with the basics of experimental physics*
CLR-2:	*gain knowledge in the use of sophisticated experimental set up*
CLR-3:	*demonstrate skills to use mathematical methods for experimental data analysis*
CLR-4:	*learn to estimate the errors in the experimental measurements*
CLR-5:	*impart hands-on experience on verification of network theorems*
CLR-6:	*study experimentally the characteristics of Diodes, BJTs and FETs*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Disciplinary Knowledge	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1:	*understand the basic physics behind measurements of physical quantities*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*experimentally verify physical phenomena in physics*	2	80	70	H	M	M	H	M	H	H	H	M	H	M	H	M	M	M
CLO-3:	*apply error analysis in physical measurements*	2	75	70	H	M	H	H	H	H	H	M	H	H	M	H	H	H	H
CLO-4:	*understand the need of network theorems to simplify the circuits*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLR-5:	*ability to use the diode for various applications*	2	80	70	H	H	H	H	H	M	H	H	M	H	M	H	H	H	H
CLR-6:	*gaining knowledge on the design and operations of BJT and FET*	2	80	75	H	H	H	M	H	M	H	H	M	H	M	H	H	M	H

DURATION (HOURS)		12	12	12	12	12
S1 to S4	SLO-1	Introduction to error analysis and least-squares analysis (straight line fitting)	Study of Fresnel's diffraction	Virtual experiment at https://www.vlab.co.in/	Comparative study on V-I Characteristics of P-N Junction Diode and Zener Diode	Study the frequency response characteristics of BJT in CE configuration.
	SLO-2					
S5 to S8	SLO-1	Determination of paramagnetic susceptibility of given liquid using Quincke's tube method	To study the characteristics of a GM counter	Verification of Thevenin's theorem	Design and study Full Wave Bridge Rectifier with filter and without filter.	Obtain the Drain and Transfer Characteristics of FET and also calculate the transconductance of the given FET.

	SLO-2					
S9 to S12	SLO-1	Measurement of diameter of a thin paper strip using air wedge between two glass plates	Bandgap determination of a semiconductor using post office box method	Verification of Maximum Power Transfer Theorem.	Design various Clipper circuits using diode and observe the input and output waveforms	Design and analyze the operation of BJT and FET as a switch
	SLO-2					

Learning Resources	1. An Advanced Course in Practical Physics, D. Chattopadhyay et al., 6th Edition, New Central Book Agency Ltd, 2002. 2. Semiconductor Devices: Basic principles, J. Singh, John Wiley, 2001.	3. R.L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory, 9th Ed., Pearson Education, 2009. 4. T.L. Floyd, Electronic devices, 9th Ed., Pearson Education. Ltd., 2013.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)							
		CLA-1 (20%)		CLA-2 (20%)		CLA-3 (40%)		CLA-4 (20%)#	
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	30 %	-	30 %	-	30 %	-	30 %
Level 2	Apply Analyze	-	40 %	-	40 %	-	40 %	-	40 %
Level 3	Evaluate Create	-	30 %	-	30 %	-	30 %	-	30 %
	Total	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. DK Aswal, National Physical Laboratory (NPL), dkaswal@nplindia.org	Prof. C Venkateshwaran, University of Madras, venkateshwaran@unom.ac.in	Dr. P. Sivakumar, SRMIST
Dr. V. Jayaraman, IGCAR, Kalpakkam, vjram@igcar.gov.in	Dr. V. Gunasekaran, Central University TN, gunasekaran@cutn.ac.in	Dr. A. Naga Rajesh, SRMIST

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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*	Data Book / Codes/Standards	*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:	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
		Learning 1	2	3	PLO 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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)		3	3	3	3	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
Mr Ajay Zenne, Career Launcher, **ajay.z@careerlauncher.com**	Mr. P Priyanand, SRMIST *Mrs. Kavitha Srisarann, SRMIST*
Mr.Pratap Iyer, Study Abroad Mentors, Mumbai, pratap.iyer30@gmail.com	*Mr. Harinarayana Rao, SRMIST* *Dr. A Clement, SRMIST*

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SEMESTER II

Course Code	*PPY21201T*	Course Name	*Quantum Mechanics – I*	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	Physics and Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	understand the inadequacy of classical physics and the need for quantum theory
CLR-2:	learn the general formalism of quantum mechanics
CLR-3:	learn the mathematical background of Schrodinger quantum mechanics
CLR-4:	obtain analytical solutions for simple model systems in 1D
CLR-5:	obtain analytical solutions for simple atomic systems such as hydrogen atom
CLR-6:	develop problem solving skills

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:	understand the principle of duality	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	the fundamental postulates of quantum mechanics	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	the operators' formalism in quantum mechanics	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	the quantum mechanics of fully solvable model systems	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	the angular momentum algebra	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	the consequences of symmetries in quantum mechanics	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Particle-like properties of waves	Infinite square well potential in 1D	Spherical polar coordinate system	Angular momentum operators	Symmetries – discrete vs continuous
	SLO-2	Wave-like properties of particles	Eigenfunctions of particle in a 1D box	Schrodinger's equation in spherical polar coordinates	Commutation relations of angular momentum operators	Translation operator
S-2	SLO-1	Free particle wave function	Finite square well potential in 1D	Separation of radial and angular equations	Ladder operators and their commutation relations	Transformation of operators
	SLO-2	Difficulty with normalization of free particle wave function	Energy eigenvalues of a particle in a finite square well potential	Separation of theta and phi equations	Properties of ladder operators	Translation symmetry
S-3	SLO-1	Wave packets - group velocity vs wave velocity	Quantum mechanical tunneling in 1D	Solution of phi equation – quantization of *m*	Eigenvalues of L^2 operator	Discrete translation symmetry – Bloch theorem
	SLO-2	Postulates of quantum mechanics – Born's interpretation and operators	Expression for tunneling probability	Solution of theta equation – quantization of *l*	Quantization of orbital angular momentum	Continuous translation symmetry – momentum conservation
S-4	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-5	SLO-1	Postulates of quantum mechanics – Eigenvalue equations and expectation values	Simple harmonic oscillator in 1D using algebraic method	Polar plots of angular wave functions	Eigenvalues of L_z operator – Space quantization	Parity operator – eigenvalues of the parity operator
	SLO-2	Dirac notation	Raising and lowering operators and their commutation relation	Spherical harmonic functions and their orthogonality relations	Angular momentum operators in derivative forms	Inversion symmetry and its consequences
S-6	SLO-1	Hermitian operator - definition	Expression for energy eigenvalues and eigenfunctions using algebraic method	Radial equation for infinite square well potential	Spherical harmonics are eigenfunctions of L^2 and L_z operators - Proof	Pseudovectors and pseudoscalars
	SLO-2	Properties of Hermitian operator	Simple harmonic oscillator in 1D using analytic method	Ground state energy and wave function for infinite spherical well	Schrodinger equation of hydrogen atom in terms of L^2 operator	Laporte's rule
S-7	SLO-1	Schrodinger's time-dependent equation	Hermite polynomials	Radial equation for hydrogen atom	Spin angular momentum – Stern Gerlach experiment	Rotational symmetry – generator of rotations
	SLO-2	Schrodinger's time-independent equation	Expression for simple harmonic oscillator energy quantization	Solutions for radial equation of hydrogen atom	Commutation relations of spin operators	Rotations in 3D
S-8	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-9	SLO-1	Stationary states	Schrodinger picture: Time-evolution operator	Laguerre polynomial	Pauli spin matrices- eigenvalues	Continuous rotational symmetry – conservation of L
	SLO-2	Orthonormality and completeness properties of eigenfunctions	Equation of motion for Schrodinger picture	Energy quantization of hydrogen atom	Pauli spin matrices - eigenvectors	Symmetry, conservation laws , degeneracy
S-10	SLO-1	Commutation relations	Rate of change of expectation values	Orthogonality of hydrogen atom wave functions	Total angular momentum	Irreducible tensor operators (rank 0 and 1)
	SLO-2	Position-momentum commutation relation	Ehrenfest theorem and its verification	Expectation values of position operators (x, y, z, r) for ground state of hydrogen atom	Addition of angular momenta: C-G coefficients	Wigner-Eckart theorem (only statement) and it's applications
S-11	SLO-1	Generalized uncertainty relation	Heisenberg picture of time evolution	Hydrogen atom spectrum	Singlet and triplet states of system of two electrons	Time translations
	SLO-2	Probability current and continuity equation	Equation of motion for Heisenberg picture	Expression for energy of hydrogen-like atoms	Singlet & triplet spin states - Coupled and uncoupled representations	Time-translation invariance

S-12	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving

Learning Resources	1. Introduction to Quantum Mechanics, D J Griffiths, D F Schroeter (Cambridge University Press, 3 edition, 2018) 2. Introductory Quantum Mechanics, R L Liboff (Pearson Education; 4 edition, 2003) 3. A Text Book of Quantum Mechanics, P M Mathews, K. Venkatesan, (McGraw Hill, 2nd Edition, 2010)	4. Quantum Mechanics, V K Thankappan, (New Academic Science, 4th Edition, 2005). 5. Principles of Quantum Mechanics, R. Shankar (Plenum Press, 2nd Edition, 1994).

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. R Seshadri, Titan Company Limited, seshadri@titan.co.in	Dr. Ranjit Kumar Nanda, IIT Madras, nandab@iitm.ac.in	Dr. P. Sivakumar, SRMIST
Dr. M Satish, CSIR-CECRI, msathish@cecri.re.in	Prof. C Vijayan, IIT Madras, cvijayan@iitm.ac.in	Dr. Rohit Dhir, SRMIST

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Course Code	*PPY21202J*	Course Name	*Condensed Matter Physics – I*	Course Category	C	Professional Core Course	L	T	P	C
							3	0	2	4

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:	understand the basic building block in condensed matter system
CLR-2:	obtain fundamental understanding of material properties
CLR-3:	learn the mechanism of thermal and electrical transport in various material
CLR-4:	learn different assumption in band structure calculation
CLR-5:	develop skills on solving analytical problems in solid state physics
CLR-6:	understand the basic building block in condensed matter system

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1:	*apply fundamental knowledge of condensed matter system*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	solve analytical problems in solid state physics	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	apply conceptual understanding to explain various material properties	2	75	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-4:	address the difference between the mechanism of thermal conductivity of various solid system	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	explain the mechanism of electrical transport	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	analyze the band structure of different type of materials	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		15	15	15	15	15
S-1	SLO-1	Introduction to condensed matter physics	Crystal of inert gases	Vibrations of crystals with monatomic basis	Energy levels in 1D	Nearly free electron model
	SLO-2	Amorphous, polycrystalline and single crystalline solid	Mechanism of interaction between inter gas atoms	Derivation of expression for vibration of crystals for monoatomic basis	Derivation of expression for energy levels in 1D	Derivation of nearly free electron model
S-2	SLO-1	Basis, Primitive cell	Bonding	Vibrations of crystals with two atoms per primitive basis	Fermi-Dirac distribution	Bloch function
	SLO-2	Wigner-Sitz cell, Symmetry	Covalent bond, Ionic bond	Derivation of expression for vibration of crystals with two atoms per primitive basis	Effect of temperature on the Fermi- Dirac distribution	Periodic potential
S-3	SLO-1	Bravais Lattice in 2D and 3D	Metallic bond, Hydrogen bond	Quantization of elastic waves	Free electron theory	Kronig-Penny model
	SLO-2	Miller indices	Charge density distribution in different bond	Understanding of Phonon	Free electron gas in three dimension	Derivation of Kronig-Penny model

S-4 to S-5	SLO-1	Overview of different experiments	Introduction to Transmission Electron Microscope	Calculation of elastic constants for various material	Calculation of Fermi energy for various material	Description of experimental set up used for photo-current measurement
	SLO-2	Calculations of Miller indices	Experimental set up description of High Resolution Transmission Electron Microscope	Analysis of Poisson's ratio for different solids	Estimation of Fermi temperature	Analysis of photo-current as a function of irradiance at a constant voltage
S-6	SLO-1	Reciprocal lattice	Atomic radii	Phonon momentum	Density of states in 3D, 2D and 1D	Origin of band gap
	SLO-2	Reciprocal lattice of bcc lattice	Estimation of atomic radii	Inelastic scattering by phonons	Heat capacity of the electron gas	Wave equation of electron in a periodic potential
S-7	SLO-1	Reciprocal lattice of fcc lattice	Lennard-Jones potential	Phonon heat capacity	Derivation of heat capacity of the electron gas	Derivation of wave equation of electron in a periodic potential
	SLO-2	Brillouin zone	Explanation of various terms in Lennard-Jones potential	Assumption in Debye's model of specific heat	Introduction to Electrical conductivity	Number of orbitals in a band
S-8	SLO-1	X-ray diffraction	Derivation of equilibrium condition from Lennard-Jones potential	Derivation of Debye's model of specific heat in low temperature limit	Classical theory of electrical conductivity	Concept of number of orbitals in a band
	SLO-2	X-ray diffraction condition in reciprocal space	Madelung constant	Debye's model of specific heat in high temperature limit	Mechanism of electrical conductivity	Understanding of orbitals in a band
S-9 to S-10	SLO-1	X-ray diffraction experimental set up description	Calculation of interplanar spacing from lattice fringes study using TEM	Experimental set up description for Lee's disc method for estimating Thermal conductivity	Introduction to Stefan-Boltzmann's constant	Experimental set up description for studying temperature characteristics of a thermistor
	SLO-2	Analysis of XRD results from single crystal	Analysis of Selected Area Diffraction Pattern of polycrystalline and single crystalline materials	Interpretation of experimental result obtained for bad conductor	Experimental set up description used for estimating Stefan-Boltzmann's constant	Interpretation of temperature characteristics of a thermistor using Wheatstone network
S-11	SLO-1	Laue condition for diffraction	Concept of elastic strains and stress	Assumptions in Einstein's model of specific heat	Drude's model	Tight binding approximation
	SLO-2	Ewald sphere	Analysis of elastic stiffness	Einstein's model of specific heat	Quantum theory of electrical conductivity	Assumption involved in tight binding approximation
S-12	SLO-1	Structure factor	Understanding elastic compliance	Comparison between Einstein model and Debye model	Discussion of Ohm's law	Orthogonal Plane Wave (OPW) method
	SLO-2	Form factor	Relation between elastic compliance and stiffness constant	Anharmonic crystal interactions	Thermal conductivity of metals	Application of OPW method
S-13	SLO-1	Application of structure factor and form factor	Elastic waves in cubic crystals	Thermal conductivity	Ratio of electrical and thermal conductivity	Pseudo potential method
	SLO-2	Electron diffraction	Propagation along [100], [110] and [111] direction	Mechanism of Thermal conductivity	Wideman-Frenz law	Application of pseudo potential method
S-14 to S-15	SLO-1	Analysis of X-ray diffraction from thin film	Estimation of Young's modulus of a material of a beam by uniform bending using single optic lever	Discussion of Thermal conductivity in various material	Analysis of resistivity versus temperature behavior for metals and insulators	Discussion of experimental set up used for the determination of band gap
	SLO-2	Calculation of interplanar spacing, peak width and peak intensity	Analysis of Young's modulus for different materials	Calculation of Thermal conductivity	Interpretation of Current-Voltage characteristics of a photo-resistor	Determination of the band gap of the material of the thermistor

Learning Resources	1. C.Kittel, Introduction to Solid State Physics, 8th Ed., J. Wiley and Sons, 2005. 2. A.Wahab, Solid state Physics, 2nd Ed., Narosa Publishing House, 2006. 3. G.D. Mahan, Condensed Matter in a Nutshell, 1st Ed., Princeton University Press, 2010.	4. N.W. Ashcroft and D.M. Mermin, Solid State Physics, Holt, Rinehart and Winston, 1976. 5. A.J. Dekker, Solid State Physics, Macmillan, 2009. 6. H. Ibach and H. Lueth, Solid State Physics, An introduction to theory and experiment, Narosa Publishing House, 1991.

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 %	30 %	30 %	30 %	30 %	30 %
Level 2	Apply Analyze	40 %	40 %	40 %	40 %	40 %	40 %	40 %	40 %	40 %	40 %
Level 3	Evaluate Create	30 %	30 %	30 %	30 %	30 %	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
Dr. N Vijayan, NPL, nvijayan @nplindia.org	Prof. C Venkateshwaran, University of Madras, venkateshwaran@unom.ac.in	Dr. Jaivardhan Sinha, SRMIST
Dr. V Subramanian, CLRI, subbu@clri.res.in	Prof. S Balakumar, University of Madras, balakumar@unom.ac.in	Dr. Rohit Dhir, SRMIST

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Course Code	PPY21203T	Course Name	Statistical Mechanics and Thermodynamics	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	Physics and Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	understand the basic principles of thermodynamics
CLR-2:	develop an understanding of the statistical mechanics
CLR-3:	acquire the knowledge of various statistical distributions and its application
CLR-4:	understand the applications of statistical mechanics in broad areas of modern physics and classical physics
CLR-5:	*appreciate the role of entropy as connector between statistical world to thermodynamic world*
CLR-6:	*recognize the partition function a very practical tool to compute thermodynamical variables*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Disciplinary Knowledge	2: Critical Thinking	3: Problem Solving	4: Analytical Reasoning	5: Research Skills	6: Team Work	7: Scientific Reasoning	8: Reflective Thinking	9: Self-Directed Learning	10: Multicultural Competence	11: ICT Skills	12: Disciplinary Knowledge	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1:	understand the mathematical structure of thermodynamics	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	understand the Boltzmann Planck relation and its importance	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	understand and develop the concepts of entropy and Carnot's cycle profoundly	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	understand and develop the computational quantity -partition function vis ensemble theory	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	understand and develop the concepts of phase transition	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	understand and develop the indistinguishability criteria and the distributions related to it	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Introduction to heat and work	Clausius Theorem	Phase space	Distinguishable particles	Phase transition -Introduction
	SLO-2	Reversible process and quasi-static process	Clausius Inequality	trajectories and density of states	Maxwell-Boltzmann distribution	Classification of phase transitions
S-2	SLO-1	Zeroth law of thermodynamics	Second law of thermodynamics in terms of Entropy	Liouville's theorem	Maxwell-Boltzmann distribution (Continued)	Phase diagram
	SLO-2	Existence of Absolute temperature with thermometer	Third law of thermodynamics	Condition for statistical equilibrium	indistinguishable particles	Clausisus-Clapeyron equation
S-3	SLO-1	Joule Peddle experiment	Change in entropy in a reversible process	Micro-canonical ensemble	Fermi Dirac Distribution	Second order phase transition
	SLO-2	First Law of thermodynamics	Change in entropy in an irreversible process	Canonical ensemble	Fermi Dirac Distribution (continued)	Landau theory of phase transition
S-4	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-5	SLO-1	First law of thermodynamics its differential form-Internal Energy	Entropy of perfect gas	Canonical distribution	Mean energy of Fermions at T=0 K	Landau free energy
	SLO-2	Limitations and significance of first law	Thermodynamic Potentials: Internal Energy	Mean and fluctuations	Fermi gas in a metal	Ferromagnetic materials phase transitions
S-6	SLO-1	Application of first law	Enthalpy	Grand-canonical distribution	Pauli Para magnetism	Liquid Helium
	SLO-2	isothermal and adiabatic process	Helmholtz Free Energy	Entropy and its relation to partition function	Fermi energy at finite temp	Chemical equilibrium
S-7	SLO-1	Work done calculation for isothermal and adiabatic process	Gibbs free energy	grand partition function	Bose-Einstein Distribution	Law of mass action
	SLO-2	Mayer's relations	Maxwell's thermodynamical relations	Number density fluctuation in grand canonical ensemble	Bose-Einstein Distribution (continued)	Saha Ionization formula
S-8	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-9	SLO-1	Second law of thermodynamics – Kelvin -Planck statement	Maxwell's thermodynamical relations -continued	Partition function of classical ideal gas	Photon gas	Ising Model one dimension
	SLO-2	Second law of thermodynamics –Clausius statement	Maxwell's thermodynamical relations-Significance and applications	Gibbs' Paradox	Derivation of Planck's law	Ising model in one dimension (continued)
S-10	SLO-1	Conversion of Work into Heat and Heat into Work	thermodynamic limit	entropy of mixing	Bose-Einstein condensation	Thermodynamic fluctuation
	SLO-2	Carnot's cycle Heat Engines	contact between statistics and thermodynamics	Sackur -Tetrode equation.	Specific heat from lattice vibration	Random walk
S-11	SLO-1	Efficiency of heat engine	Derivation of Boltzmann -Planck relation	Equipartition theorem	Deybe Model of solid	Brownian motion
	SLO-2	Entropy from Carnot cycle	Postulates of Statistical Mechanics	Statistics of Para magnetism	Phonon gas	Diffusion equation
S-12	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving

Learning Resources		
Learning Resources	1. *M. Zemansky, and R. Dittman, Heat and Thermodynamics, 8th Ed., McGraw-Hill Education, 2011.* 2. *R.K. Pathria, P.D. Beale, Statistical Mechanics, 3rd Ed., Elsevier, 2011.* 3. *BB Laud, Fundamentals of Statistical Mechanics.,New Edge International , 2009.* 4. *K. Huang, Statistical Mechanics, 2nd Ed., Wiley, 2008.*	5. *L.D. Landau and E.M. Lifshitz, Statistical Physics, 3rd Ed., Pergamon Press, 1980.* 6. *R.E. Sonntag, G.J. Van Wylen, Introduction to Thermodynamics, Classical and Statistical, 3rd Ed., Wiley, 1991.* 7. *J.M. Seddon and D. Julian, Thermodynamics and Statistical Mechanics, 3rd Ed., RSC publication, 2001.*

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
Dr. V Subramanian, CLRI, subbu@clri.res.in	Dr. Ranjit Kumar Nanda, IIT Madras, nandab@iitm.ac.in	Dr. Alok Kumar, SRMIST
Dr. M Satish, CSIR-CECRI, msathish@cecri.re.in	Dr.G.Kalpana, Anna University, g_kalpa@annauniv.edu	Dr. Jaivardhan Sinha, SRMIST

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Course Code	Course Name	Course Category			L	T	P	C
PPY21204T	*Atomic and Molecular Physics*	C	Professional Core Course		3	1	0	4

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 the skills to solve real physical problems using quantum mechanics.
CLR-2:	provide the accomplishments necessary for advanced courses such as optics, astrophysics, condensed matter physics and nuclear physics.
CLR-3:	emphasize the modern developments in experimental techniques especially spectroscopy
CLR-4:	realize the role and practical application of physics of atoms and molecules in the modern world.
CLR-5:	develop the skills to solve real physical problems using molecular spectroscopy
CLR-6:	explore the concept of Laser

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

		Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Disciplinary Knowledge	2: Critical Thinking	3: Problem Solving	4: Analytical Reasoning	5: Research Skills	6: Team Work	7: Scientific Reasoning	8: Reflective Thinking	9: Self-Directed Learning	10: Multicultural Competence	11: ICT Skills	12: Disciplinary Knowledge	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1:	understand the concept of fine structure of hydrogen like atoms	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	know about the concept of ls-coupling and jj-coupling schemes	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	understand the idea of Hartree-Fock equations and Thomas-Reiche-Kuhn sum rule	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	understand the basic concepts the rotation and vibration of diatomic molecules	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	know about the concept of Frank-Condon principle	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	understand the concepts of laser technology	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Fine structure of hydrogen like atoms	The idea of Hartree-Fock equations	Born-Oppenheimer separation for diatomic molecules	Rotation spectra (microwave) for diatomic molecules	Equation and saturation in 3-level system
	SLO-2	Mass correction	Properties of the Hartree-Fock potential and spin orbitals	The rotation and vibration of diatomic molecules	Vibration spectra (infrared) for diatomic molecules	Equation and saturation in 4-level system
S-2	SLO-1	Spin-orbit term	Helium spectra	Electronic structure of diatomic molecules	Vibration-rotation spectra for diatomic molecules	Significance of Rabi frequency
	SLO-2	Darwin term	Difference between hydrogen and helium spectra	Symmetry properties of H_2, O_2 and N_2	Electronic spectra (UV-Vis) for diatomic molecules	Physical interpretation of Rabi Frequency
S-3	SLO-1	Intensity of fine structure lines	Two-electron atoms	Molecular orbital and valence bond methods for H_2^+	Pure Rotational Raman spectra for diatomic molecules	Laser pumping
	SLO-2	Fine structure splitting	Alkaline metal spectra	Molecular orbital and valence bond methods for H_2	Vibrational Raman spectra for diatomic molecules	Population inversion
S-4	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-5	SLO-1	The Zeeman effect	Thomas-Fermi model of atom	Centrifugal distortion	Principle of X-ray spectroscopy	He-Ne Laser
	SLO-2	Strong fields	Hartree-Fock equation	Morse potential	Application of X-ray spectroscopy	Solid state Laser

S-6	SLO-1	Weak fields	Many-electron atoms	Homonuclear diatomic molecules	Electronic Spin	Free-electron Laser
	SLO-2	The ground state of two-electron atoms	Alkaline earth-metal spectra	Pairing and valency	Electron Spin Resonance Spectroscopy	Non-linear phenomenon
S-7	SLO-1	Perturbation theory	Auger effect	Correlation diagrams for heteronuclear molecules	Nuclear Spin	Non-linear Lasers
	SLO-2	Harmonic oscillator	Stark effect	Lithium hydride	Nuclear Magnetic Resonance	Modes and harmonic generation
S-8	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-9	SLO-1	variation method	selection rules for electric multipole radiation	Hydrogen chloride (HCL)	Frank-Condon principle	Laser accelerator
	SLO-2	*LS*-coupling schemes	selection rules for magnetic multipole radiation	Sodium chloride (NaCl)	Hund's cases and selection rules	Liquid Laser
S-10	SLO-1	*jj*-coupling schemes	Absorption spectra	The structure of polyatomic molecules	Idea of symmetry for diatomic molecules	Gas Laser
	SLO-2	Hund's rules	Emission Spectra	Electronic structure	Idea of symmetry for polyatomic molecules	Semiconductor Laser
S-11	SLO-1	Many-electron atoms	Oscillator strengths	The water molecule (H_2O)	Principle of Mossbauer Spectroscopy	Diode Laser
	SLO-2	Lande interval rule	Thomas-Reiche-Kuhn sum rule	The methane, ethylene and acetylene molecules	Applications of Mossbauer Spectroscopy	Applications of different lasers
S-12	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving

Learning Resources		
	1. B.H. Bransden and C. J. Jochain, *Physics of Atoms and Molecules*, 2nd Ed., Pearson Education, 2003. 2. E.U. Condon and G. H. Shortley, *The Theory of Atomic Spectra*, Cambridge University Press, 1989. 3. C.J. Foot, *Atomic Physics*, Oxford Univ. Press, 2005.	4. C.N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, Tata McGraw-Hill, 2008. 5. W. Demtroder, *Atoms, Molecules and Photons*, Springer, 2006.

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. R Seshadri, Titan Company Limited, seshadri@titan.co.in	Dr. Ranjit Kumar Nanda, IIT Madras, nandab@iitm.ac.in	Dr. Junaid M. Laskar, SRMIST
Dr. M Satish, CSIR-CECRI, msathish@cecri.re.in	Prof. C Vijayan, IIT Madras, cvijayan@iitm.ac.in	Dr. K Shadak Alee, SRMIST

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Course Code	*PPY21D01T*	Course Name	***Structure and Properties of Materials***	Course Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

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:	understand basics of structure and properties of solids
CLR-2:	have basic knowledge on bonding in solid and their properties
CLR-3:	realize an importance of types of imperfections in the materials.
CLR-4:	explore the diffusion and its mechanisms in solids
CLR-5:	understand the phase transition through phase diagram
CLR-6:	explore the advanced high-strength composite materials

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Disciplinary Knowledge	2: Critical Thinking	3: Problem Solving	4: Analytical Reasoning	5: Research Skills	6: Team Work	7: Scientific Reasoning	8: Reflective Thinking	9: Self-Directed Learning	10: Multicultural Competence	11: ICT Skills	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1:	*know the importance of structures in materials*	2	80	75	H	H	H	H	H	H	M	M	M	H	M	H	H	H	H
CLO-2:	*realize the role of bonding in solids and its functional properties*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*explore the type of imperfections in materials*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	*understand the types of diffusion processes*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

CLO-5:	*distinguish the phase transitions via phase diagram*	2	80	70	H	H	H	H	M	H	M	H	H	H	M	H	H	H	H
CLO-6:	*understand the significance of composite materials and their properties*	2	80	75	H	M	H	H	M	H	M	H	H	M	M	M	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Properties of Materials	Introduction to Point defect	Introduction to diffusion	Introduction to phase diagrams	Introduction to composites
	SLO-2	Structure of atoms	Defect Thermodynamics	Introduction to diffusion (Solid/Gas/Liguid)	Importance of phase diagrams	Introduction to composites
S-2	SLO-1	Quantum states	Schottky defect	Laws of Diffusion	Gibbs Phase rule	Types of composites materials
	SLO-2	Calculation of radius of atom,	Frenkel defect	Fick's First laws of Diffusion	Gibbs Phase rule	Concepts of load transfer
S-3	SLO-1	energy of electrons	Kroger-Vink Notation (for NaCl)	Fick's second law of diffusion	Phase equilibria	Matrix materials
	SLO-2	Atomic bonding in solids	Kroger-Vink Notation (for NaCl)	Solution to Fick's second law	Phase equilibria (Single and multi component systems)	Matrix materials
S-4	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-5	SLO-1	Binding energy	Defect Interaction	Application of Fick's second law	Solid solutions	Polymers
	SLO-2	Cohesive energy	Dislocations	Kirkendall Effect	Alloys With examples	Classification of polymers
S-6	SLO-1	Chemical bonding:	Burgers Vector	Atomic mechanism of diffusion	Phase diagrams	co-polymers
	SLO-2	Primary Bonding	Burgers Vector	Interstitial diffusion	Phase diagrams (single component systems)	Metals and ceramics
S-7	SLO-1	Ionic bonds	Types of Dislocation	Steady state diffusion	Eutectic Phase diagram	Tacticity
	SLO-2	Energy of Ionic bonds	Dislocation movement	Unsteady state diffusion	Level rule	geometric isomerism
S-8	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-9	SLO-1	Properties of ionic bonds	Slip Systems	Substitutional diffusion	Iron carbide phase diagram	Crystallization of polymers
	SLO-2	Metallic bonding	Energies of Dislocations and their interactions	Self-diffusion	Study of properties of phase diagrams	Fibers: Glass, boron, carbon
S-10	SLO-1	Secondary bonding	Planner Defects: Stacking fault	Self-diffusion with examples	Nucleation kinetics and growth	Organic and metallic fibers,
	SLO-2	Hydrogen bonds	Grain boundaries (low angle and high angle)	Vacancy diffusion	Kinetics of transformation	Fiber packing arrangements
S-11	SLO-1	Van der Waals bonds	Antiphase boundaries and Twinning surface defects	Vacancy diffusion with examples	Homogeneous and Heterogeneous nucleation	Particle reinforced composites
	SLO-2	Variation in bonding and Properties	Non-equilibrium Structures	Diffusion in alloys	Differential scanning calorimetry	Structural composites
S-12	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving

Learning Resources	1. V. Raghavan, Materials Science & Engineering, Hall of India New Delhi 2001. 2. W.D. Callister, Jr. Materials Science & Engineering, 7th Ed., John Wiley & Sons 2007.	3. B.S Mitchell, An introduction to materials Engineering and science for Chemical and Materials Engineers, 1Ed, Wiley, 2003, 4. W. Smith, J. Hashemi, Foundation of materials science and engineering, 5th McGraw - Hill Education, 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
Dr. M Satish, CSIR-CECRI, msathish@cecri.re.in	*Prof. C Venkateshwaran, University of Madras, venkateshwaran@unom.ac.in*	Dr. Suresh Perumal, SRM IST
Dr. Ajay Singh, BARC, Mumbai, ajay@barc.gov.in	Prof. S Balakumar, University of Madras, balakumar@unom.ac.in	Dr. S. Ravikirana, SRM IST

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Course Code	PPY21D02T	Course Name	*Computational Physics*	Course Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

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 basic understanding of scientific programming*
CLR-2:	*develop skill to write algorithm of a problem and convert the algorithm to code*
CLR-3:	*bridge the gap between the theory and computational applications*
CLR-4:	*acquire advanced knowledge in current computational standards*
CLR-5:	*acquire knowledge of advanced techniques like oop and parallel programming*
CLR-6:	*motivate students to solve complex problems numerically*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Disciplinary Knowledge	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1:	*be familiar with some elementary concepts of computer language and scientific computation*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*understand the basics of computational physics.*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*study numerical algorithms and their implementation to solve problems*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	employ and develop concepts and methods for small scale simulations	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*solve linear systems*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*calculate root, derivative and integration of functions*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Introduction to computer, language and Fortran	User defined functions and subroutines	Allocatable array: idea of dynamic memory allocation	Basics of object oriented programming	Sorting Methods Quick Sort
	SLO-2	Binary numbers, Two's complement	User defined functions and subroutines	Allocatable array	Basics of object oriented programming	Quick Sort
S-2	SLO-1	Structure of a program; Fortran Hello World	Modules	pointers and target: memory reference	Class, Fields and Methods	Heap Sort
	SLO-2	Compilers, basic compiler options	Modules	pointers and target	Class, Fields and Methods	Heap Sort
S-3	SLO-1	Constants and variable data type, User defined data type;	sharing data between procedures	pointers and target	Finalizer. Polymorphism and Inheritance	Numerical derivatives
	SLO-2	Assignment and basic arithmetic; intrinsic functions and subroutines	sharing data between procedure, INTENT Statement	Pointers association	Finalizer. Polymorphism and Inheritance	Numerical derivatives
S-4	SLO-1	Use of pseudocode and flowchart	Using external routines like LAPACK, BLAS	Introduction to numerical methods	Finalizer. Polymorphism and Inheritance	Numerical Integration: Simpsons 1/3 rule
	SLO-2	Use of pseudocode and flowchart	Using external routines like LAPACK, BLAS	Introduction to linear algebra	Finalizer. Polymorphism and Inheritance	Numerical Integration: Simpsons 3/8 rule
S-5	SLO-1	Use of pseudocode and flowchart	Using external routines like LAPACK, BLAS	Matrix operations and arithmetic	Interoperability with C	Numerical Integration: Trapezoidal method
	SLO-2	Use of pseudocode and flowchart	Using external routines like LAPACK, BLAS	Determinant and transpose	Interoperability with C	Numerical Integration: Trapezoidal method
S-6	SLO-1	Basic IO concept	Reading and writing to a file	Solving linear equations	Basics of parallel processing	ODE Euler method
	SLO-2	Format specifications	read, write statement, iomsg,iostat statement	Solving linear equations	Basics of parallel processing	ODE Euler method
S-7	SLO-1	Logical constants, variables and operators	Namelist I/O	Newton-Raphson method	SIMD, MIMD, SPMD & MPMD concept	ODE Backword Euler method
	SLO-2	Branching, assignments and relation calculator	Namelist I/O	Newton-Raphson method	SIMD, MIMD, SPMD & MPMD concept	ODE Backword Euler method
S-8	SLO-1	If construct, If-else-if construct, Case construct	Stream Access	Newton-Raphson method	Coarray & Images	ODE: rk4
	SLO-2	Do loop, While loop, Do while loop, Cycle and exit statement	Stream Access	Newton-Raphson method	Coarray & Images	ODE:rk4
S-9	SLO-1	Elementary parallel programming with openmp do	Direct access	Linear Regression	Synchronization between images	ODE adaptive step size
	SLO-2	Elementary parallel programming with openmp do	Direct access	Linear Regression	Synchronization between images	ODE adaptive step size
S-10	SLO-1	Elementary ploting: gnuplot	Arrays in fortran, array operations	Linear Regression	Critical section	Discrete Fourier Transformation
	SLO-2	Gnuplot and basic statistics	Whole array operation	Linear Regression	Critical section	Discrete Fourier Transformation
S-11	SLO-1	Review problems like Fibonacci series without array	Fibonacci Series with array	RNG and pseudo RNG	Parallel Matrix algebra example and comparison with serial method	Fast Fourier transformation
	SLO-2	Review problems like Fibonacci series without array	Fibonacci Series with array	Linear congruential generator	Parallel Matrix algebra example and comparison with serial method	Fast Fourier transformation
S-12	SLO-1	Error, round off error,Error analysis	Basic debugging	Bifurcation Method	Parallel Matrix algebra example and comparison with serial method	Spectrum analysis

	SLO-2	Error, round off error, Error analysis	Compiler's Inbuilt debugging options	Bifurcation Method	Parallel Matrix algebra example and comparison with serial method	Spectrum analysis

Learning Resources	1. Michael Metcalf, John Reid, and Malcolm Cohen, Modern Fortran Explained 4th Ed., Oxford University Press, 2011. 2. W.S. Brainerd, Guide to Fortran 2008 Programming, Springer-Verlag London, 2015. 3. T. Pang, An Introduction to computational Physics, Cambridge University Press, 2010	4. Joe Thijssen, Computational Physics, 2nd Ed, Cambridge University Press, 2012. 5. Michael P. Allen and Dominic J. Tildesley, Computer Simulation of Liquids: 2nd Ed., Oxford University, 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 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
Dr.V Subramanian- CLRI, subbu@clri.res.in	Prof. K. Sethupathi, IIT Madras, ksethu@iitm.ac.in	Dr. Rudra Banerjee, SRMIST
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							L	T	P	C
Course Code	***PPY21D03T***	**Course Name**	***Applied Optics***	**Course Category**	**D**	**Discipline Elective Course**	**3**	**1**	**0**	**4**

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:	**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:	develop theoretical and practical knowledge in Applied Optics.																		
CLR-2:	acquire the knowledge Interference, diffraction																		
CLR-3:	familiarize with the latest developments in optics and its applications.																		
CLR-4:	*acquire the knowledge on different microscopes*																		
CLR-5:	*acquire the knowledge on different Interferometers*																		
CLR-6:	*acquire the knowledge on some basic optical elements*																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	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	Disciplinary Knowledge	PSO - 1	PSO - 2	PSO - 3
CLO-1:	understand the concepts of interference, diffraction and coherence	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	understand light propagation in photonic crystals and disordered media	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	understand image formation and aberrations	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	understand the concepts of basic optical elements like prisms, mirrors, stops and apertures	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	understanding the concepts of afm, optical tweezers and their applications	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	understand the working principle and applications of different microscopes	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		**12**	**12**	**12**	**12**	**12**
S-1	**SLO-1**	Wave motion	Photonics crystals general Introduction	Image formation	Introduction to scattering types	Introduction of Optical microscope
	SLO-2	Superposition of waves	Applications of photonic crystals	First-order optics	Mie scattering technique	Principle of microscope
S-2	**SLO-1**	Interference	2D photonic crystals	Aberrations	static light scattering technique	Introduction of Bright field microscope
	SLO-2	A few examples on Interference and Mathematical formulation	3D photonic crystals	Different types of aberrations	static light scattering technique: principles and applications	Working Principle and applications of bright filed microscopy
S-3	**SLO-1**	Diffraction	Light propagation through ordered media	Prisms and mirrors	Dynamic light scattering technique	Introduction to Dark filed microscopy
	SLO-2	Single slit and multi slit Diffraction	Light propagation through disordered media	Application of prisms and mirrors	Dynamic light scattering technique: principles and applications	Working Principle and applications of Dark filed microscopy
S-4	**SLO-1**	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-5	**SLO-1**	Basic Coherence Theory	Localization of light	Stops and apertures	Optical tweezers	Introduction and applications of polarizing microscopy
	SLO-2	Coherence time and coherence length	Photonic glass	Basic optical devices	Applications of optical tweezers	Introduction to phase contrast microscopy

S-6	SLO-1	Temporal Coherence	Random lasing	Design of optical systems	AFM microscopy	Working principle and applications of phase contrast microscopy
	SLO-2	Spatial Coherence	Difference between conventional and random lasing	Application of optical systems in various fields	AFM colloidal probe technique	Introduction of fluorescence microscopy
S-7	SLO-1	Michelson Interferometer	Optical metamaterials	Aplanatic points	Magnetic chaining technique	Working principle and applications of fluorescence microscopy
	SLO-2	Applications of Michelson Interferometer	Optical properties of metal dielectric composites	Spherical aberration	Potential applications of magnetic chaining technique	fluorescence confocal microscopy
S-8	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-9	SLO-1	Fabry-Perot interferometer	Electric metamaterials	Solid immersion lens	Various laser beam profiles	Introduction to light sheet fluorescence microscopy
	SLO-2	Principle and application of Fabry-Perot interferometer	Magnetic metamaterials	Application of solid immersion lens	Introduction to knife edge scanning	Working principle and applications of light sheet fluorescence microscopy
S-10	SLO-1	Statistical properties of laser speckle patterns	Positive index metamaterials	Numerical aperture introduction	Knife edge scanning to measure laser beam profile	Introduction to nonlinear optical microscopy
	SLO-2	First-Order Statistics of a Polarized Speckle Pattern	Negative index metamaterials	Far field imaging techniques	Principle, working and application of Refractometer	Applications of nonlinear optical microscopy
S-11	SLO-1	Information processing using speckle patterns	Nonlinear optics introduction	Numerical aperture based lens	Liquid refractometer	Introduction to two photon fluorescence microscopy
	SLO-2	Laser speckle contrast imaging	Nonlinear optics with metamaterials	Numerical aperture increasing lens microscopy (NAIL)	Knife edge scanning based liquid refractometer	Applications of two photon fluorescence microscopy
S-12	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving

Learning Resources	1. M. Bornand, E. Wolf, Principles of Optics, 7th Ed., Cambridge University Press, 1999. 2. J.D. Joannopoulos, R. D. Meade, J. N. Winn, Photonic Crystals: Molding the Flow of Light, 2nd Ed., Princeton University Press, 2008. 3. V. Shalaevand W. Cai, Optical Metamaterials: Fundamentals & Applications, 2nd Ed., Springer, 2010.	4. W.J. Smith, Modern Optical Engineering, 3rd Ed., McGraw-Hill, 2000. 5. C.F. Bohren and D. R. Huffman, Absorption and scattering of light by small particles, Professional paperback Ed., Wiley-VCH, 1998. 6. J. Mertz, Introduction to Optical Microscopy, 1st Ed., Roberts & Company publishers, 2010.

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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Course Code	PPY21D04T	Course Name	Sensors	Course Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

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:	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 the principle, and working of sensors*																		
CLR-2:	*understand the types of sensors and the corresponding physical effects*																		
CLR-3:	*comprehend the knowledge on physical sensors*																		
CLR-4:	*realize the importance of chemical sensors*																		
CLR-5:	*figure out the basics and significance of biosensors*																		
CLR-6:	*recognize the applications of sensors in day-to-day life*																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	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:	*understand the principles of sensors*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*distinguish different types of sensors*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*elaborate about the physical sensors*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	*recognize the importance of chemical sensors*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*realize the significant role of biosensors*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*appreciate the applications of sensors in and around us*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Introduction to Sensors	Introduction to physical sensors	Introduction to chemical sensors	Introduction to biosensors	On-board automobile sensors-Flow-rate sensors-Pressure sensors-Temperature sensors
	SLO-2	Active and passive sensors	temperature sensors	Thermal sensors – principle, working	Principle and working	Oxygen sensors-Torque and position sensors
S-2	SLO-1	Static characteristics	Sensors for aerospace and defense	Types of thermochemical sensors	Biomolecules used in biosensors	Home appliance sensors-mechanical category
	SLO-2	Accuracy and precision	Accelerometer	Mass sensors- principle, working	Immobilization methods-Physisorption	Chemical, temperature and radiation sensors in home appliances
S-3	SLO-1	Offset and linearity	Pressure sensor	SAW and quartz crystal microbalance	Immobilization methods-Chemisorption	Aerospace sensors- Static pressure sensors
	SLO-2	Dynamic characteristics	Types of pressure sensors and application	Electrochemical sensors-principle, working	Types of biosensors	Temperature sensing
S-4	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-5	SLO-1	Zeroth order sensors	Strain sensors	Types of electrochemical sensors	Properties of biosensors	Fluid velocity sensors
	SLO-2	First order sensors	Flow rate sensors,	Potentiometric sensors- principle, working	Characteristics of biosensors	Monitoring strain, force, thrust and acceleration
S-6	SLO-1	Second order sensors	Speed sensors	Amperometric sensors- principle, working	Performance factors	Medical diagnostic sensors – raditation, biomechanics, temperature
	SLO-2	Physical effects involved in signal transduction	Optical sensors	Conductometric sensors-principle, working	Enzymatic biosensors- principle, working	Electromagnetic variables
S-7	SLO-1	Photoelectric effect	Mechanical sensors	Optical chemical sensors-principle, working	Immuno biosensors- principle, working	Chemical and electrochemical sensors
	SLO-2	Photoluminescence effect	Anisotropic Magneto-Resistive (AMR) sensors	Types of optical chemical sensors	Types of immuno biosensors	Variables related to blood flow-Kinematic and geometric
S-8	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-9	SLO-1	Electroluminescence effect	Giant magneto resistance effect	Fiber optic chemical sensors-principle, working	DNA biosensors- principle, working	Sensors for food monitoring-introduction
	SLO-2	Hall effect	Colossal magneto resistance effect	Types of Fiber optic chemical sensors	Cell based biosensors- principle, working	Types of sensors for food monitoring
S-10	SLO-1	Thermoelectric effect	Extraordinary magneto resistance effect	Sensitivity	Electrochemical biosensor-principle, working	Sensors for environmental monitoring
	SLO-2	Piezoresistive effect	Tunneling magneto resistance effect	Selectivity	Types of electrochemical biosensors	Pollution hazards
S-11	SLO-1	Piezoelectric effect	GMR, TMR based sensors	Sensor arrays -Electronic nose	Optical biosensors- principle, working	Sensing environment pollution
	SLO-2	Magneto resistive effect	Magnetic tunneling junctions	Electronic tongue	Types of optical biosensors	Ecological studies of air
S-12	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving

Learning Resources	1. J. Vetelino and A. Reghu, Introduction to Sensors, 1st Ed., CRC Press, 2011. 2. J. Fraden, Handbook of Modern Sensors: Physics, Designs, and Applications, 4th Ed., Springer, 2010. 3. J. Cooper, and T. Cass, Biosensors, 2nd Ed., Oxford University Press, USA, 2004. 4. J. Janata, Principles of Chemical Sensors, 2nd Ed., Springer US, 2009	5. A.Mulchandani, K. R. Rogers, Enzyme and Microbial Biosensors-Techniques and Protocols, Humana Press, Totowa, New Jersey, 1998. 6. F.-G. Bănică, Chemical Sensors and Biosensors: Fundamentals and Applications, John Wiley & Sons Ltd., 2012. 7. P. Gründler, Chemical Sensors, Springer-Verlag Berlin Heidelberg, 2007. 8. G. Meijer, Smart Sensor Systems, Wiley, 2008.

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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Course Code	PPY21S02L	Course Name	Scientific Programming in C++	Course Category	S	Skill Enhancement Course	L	T	P	C
							0	0	4	2

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:	*familiarize with C++ for scientific problem solving*
CLR-2:	*use built-in functions and define variables and functions in C++*
CLR-3:	*gain skills to write and develop simple programs in C++*
CLR-4:	*demonstrate skills to use mathematical methods for modelling physical systems*
CLR-5:	*estimate the errors in the use of numerical methods*
CLR-6:	*describe the results of a simulation in lab reports*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	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
		Learning: 1	2	3	PLO: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLO-1:	*exhibit skills in developing C++ functions and define variables, construct programs and functions*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*visualize and simulate computations and data sets by self-explaining graphics*	2	80	70	H	M	M	H	M	H	H	H	M	H	M	H	M	M	M
CLO-3:	*gain basic programming skills in C++*	2	75	70	H	M	H	H	H	H	H	M	H	H	M	H	H	H	H
CLO-4:	*demonstrate basic knowledge of physics in using numerical methods to solve various problems.*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*exhibit an understanding of the applicability of mathematical methods for modelling physical systems.*	2	80	70	H	H	H	H	H	M	H	H	M	H	M	H	H	H	H
CLO-6:	*assert the ability to critically examine and evaluate a model of a physical system.*	2	80	75	H	H	H	M	H	M	H	H	M	H	M	H	H	M	H

DURATION (HOURS)		12	12	12	12	12
S1 to S4	SLO-1 / SLO-2	Introduction to C++, I/O statements, control statements, loops, arrays and pointers, GNU plots	Radioactive decay program using Euler method	Fourier analysis of square, saw-tooth and triangular waves	Numerical integration on 1D function using Rectangular and Simpson rules	To demonstrate frequency and amplitude modulation
S5 to S8	SLO-1 / SLO-2	Finding the roots of a quadratic equation using complex data type	Motion of a 1D simple harmonic oscillator using Euler-Cromer method	Construction of a wave packet and verification of uncertainty principle	Determination of eigenvalues and eigenvectors of a given symmetric matrix	To study motion of electron in cathode ray tube
S9 to S12	SLO-1 / SLO-2	Finding the least square fitted curve for a given set of data points	Simulation of Earth's orbit around Sun	Finding first-order derivatives at given x for a set of data points using Lagrange interpolation	Solution of n simultaneous linear equations using Gauss elimination method	Monte Carlo simulation of p

Learning Resources

1. Numerical Recipes in C++: The Art of Scientific Computing, W H Press et al., 2nd Edition, Cambridge University Press, 2002.
2. Object Oriented Programming with C++, E. Balagurusamy, 2nd Edition, Tata McGraw Hill, 2002.
3. Computational Physics, Nicholas J. Giordano, Hisao Nakanishi, 2nd Edition, Pearson, 2005.
4. Computer Applications in Physics, S. Chandra, 2nd Edition, Narosa Publishing House, 2008.
5. Computational Physics, R. C. Verma, P. K. Ahluwalia, K. C. Sharma, 1st Edition, New Age, 2005.

Learning Assessment

	Bloom's Level of Thinking	CLA-1 (20%) Theory	CLA-1 (20%) Practice	CLA-2 (20%) Theory	CLA-2 (20%) Practice	CLA-3 (40%) Theory	CLA-3 (40%) Practice	CLA-4 (20%)# Theory	CLA-4 (20%)# Practice
		Continuous Learning Assessment (100% weightage)							
Level 1	Remember / Understand	-	30 %	-	30 %	-	30 %	-	30 %
Level 2	Apply / Analyze	-	40 %	-	40 %	-	40 %	-	40 %
Level 3	Evaluate / Create	-	30 %	-	30 %	-	30 %	-	30 %
	Total	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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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:
CLR-1:	recapitulate fundamental mathematical concepts and skills
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:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
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)		3	3	3	3	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 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	
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2.Mr Ajay Zenner, Career Launcher, **ajay.z@careerlauncher.com**	2. Dr.M.Snehalatha SRMIST	4. Dr. J Jayapragash, SRMIST

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SEMESTER III

Course Code	PPY21301T	Course Name	Quantum Mechanics – II	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	Physics and Nanotechnology	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 approximation methods used in quantum mechanics																		
CLR-2:	understand the quantum mechanics of spectroscopic transitions																		
CLR-3:	learn to describe multi-particle systems in quantum mechanics																		
CLR-4:	learn quantum mechanical scattering theory																		
CLR-5:	learn elements of relativistic quantum mechanics																		
CLR-6:	understand the Dirac theory of electron																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	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:	understand the time-independent perturbation theory	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	understand the time-dependent perturbation theory	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	apply variation theorem to calculate energy of two-electron systems	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	write wave functions for a bosonic and fermionic systems	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	understand scattering theory	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	understand quantum mechanics of particles at relativistic speeds	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Time-independent perturbation theory – nondegenerate case – general formulation	Time-dependent perturbation theory – two-level system	Two-particle systems	Classical scattering theory – scattering angle and impact parameter	Postulates of special theory of relativity
	SLO-2	Time-independent perturbation theory – nondegenerate case - first-order energy correction	Expression for probability amplitude – Exact method	Schrodinger's equation for a two-particle system	Differential and total cross section	Four vectors
S-2	SLO-1	Time-independent perturbation theory – nondegenerate case - first-order wave function correction	Expression for probability amplitude – zeroth-order correction and first-order correction	Bosons and Fermions	Rutherford scattering theory (only results)	Lorentz transformation
	SLO-2	Time-independent perturbation theory – nondegenerate case - second-order energy correction	Constant perturbation and its connection with energy-time uncertainty relation	Symmetric	Quantum scattering theory – scattering amplitude	Difficulty with Schrodinger equation under Lorentz transformation
S-3	SLO-1	Time-independent perturbation theory – degenerate case – two-fold degeneracy	Sinusoidal perturbation	Anti-symmetric wave functions	Relation between differential cross section and scattering amplitude	Klein-Gordon (K-G) equation
	SLO-2	Removal of degeneracy	Expression for transition probability	Exchange operator and its eigenvalues	Collisions between identical particles	Expressions for charge and current density
S-4	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-5	SLO-1	Stark effect - Hamiltonian	Fermi's golden rule	Slater determinants	Schrodinger equation in integral form	K-G equation for a particle in electromagnetic field
	SLO-2	Stark effect in ground and first excited state of hydrogen atom	Fermi's golden rule for incoherent perturbation	Pauli exclusion principle	Green's function for Laplacian operator	Nonrelativistic limit of the K-G equation
S-6	SLO-1	Normal Zeeman effect – Hamiltonian	Einstein's coefficients	Excited states of helium atom	Green's function for Helmholtz operator	Difficulty with K-G equation
	SLO-2	Normal Zeeman effect – splitting of energy levels	Spontaneous emission, lifetime of excited states	Coulomb integral	Born's approximation	Dirac equation
S-7	SLO-1	Anomalous Zeeman effect – Hamiltonian	Selection rule for *m*	Exchange integral	Born's approximation for spherically symmetric potential (Yukawa scattering)	Dirac matrices and their properties
	SLO-2	Anomalous Zeeman effect – splitting of energy levels	Selection rule for *l*	Orthohelium and parahelium	Born's approximation for spherically symmetric potential (Rutherford scattering)	Expressions for probability density and probability current
S-8	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-9	SLO-1	Relativistic correction - Hamiltonian	Variation theorem – statement and proof	Exchange force between bosons	Partial wave analysis - formalism	Plane wave solutions to Dirac equation
	SLO-2	Relativistic correction – expression for energy correction	Variation theorem – verification for 1D systems	Exchange force between fermions	Partial wave amplitude	Relation between plane wave solutions and electron spin

S-10	SLO-1	Spin-orbit coupling Hamiltonian	Ground state energy of helium atom	Occupation number representation for fermions	Rayleigh's formula	Negative energy states and Positrons
	SLO-2	Expectation value of $\boldsymbol{L} \cdot \boldsymbol{S}$	Estimation of helium atom energy using effective nuclear charge	Occupation number representation for fermions – anti-commutator relations	Phase shifts in 1D	Dirac equation of a particle in electromagnetic field
S-11	SLO-1	Expression for energy correction due to fine structure	WKB approximation	Occupation number representation for bosons	Relation between phase shifts and partial wave amplitudes	Nonrelativistic limit of the Dirac equation of a particle in electromagnetic field
	SLO-2	Energy level splitting due to fine structure	Applications to tunnelling problems	Occupation number representation for bosons – commutator relations	Optical theorem	Prediction of electron magnetic moment
S-12	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving

Learning Resources	1. Introduction to Quantum Mechanics, D J Griffiths, D F Schroeter (Cambridge University Press, 3 edition, 2018) 2. Introductory Quantum Mechanics, R L Liboff (Pearson Education; 4 edition, 2003) 3. A Text Book of Quantum Mechanics, P M Mathews, K. Venkatesan, (McGraw Hill, 2nd Edition, 2010)	4. Quantum Mechanics, V K Thankappan, (New Academic Science, 4th Edition, 2005). 5. Principles of Quantum Mechanics, R. Shankar (Plenum Press, 2nd Edition, 1994).

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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Course Code	Course Name	Course Category			L	T	P	C
PPY21302J	***Condensed Matter Physics – II***	C	**Professional Core Course**		3	0	2	4

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 in band structure of semiconductors
CLR-2:	understand the advanced topics in solid state physics
CLR-3:	understand the mechanism of ferroelectrics and dielectrics
CLR-4:	gain fundamental knowledge of magnetism and superconductivity
CLR-5:	obtain in-depth insight into the mechanism of magnetism and superconductivity
CLR-6:	gain knowledge of liquid crystals

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

Learning: 1 Level of Thinking (Bloom), 2 Expected Proficiency (%), 3 Expected Attainment (%). Program Learning Outcomes (PLO): 1 Disciplinary Knowledge, 2 Critical Thinking, 3 Problem Solving, 4 Analytical Reasoning, 5 Research Skills, 6 Team Work, 7 Scientific Reasoning, 8 Reflective Thinking, 9 Self-Directed Learning, 10 Multicultural Competence, 11 ICT Skills, 12 Life Long Learning, 13 PSO - 1, 14 PSO - 2, 15 PSO - 3

		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:	identify application potential of semiconductors	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	solve relevant problems in advance condensed matter system	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	envision the application potential of superconductors	2	75	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-4:	appreciate the role of magnetic materials in useful application	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	identify the distinction of liquid crystal from conventional crystal	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	take up contemporary topics in experimental condensed matter physics research	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		15	15	15	15	15
S-1	SLO-1	Introduction to Condensed Matter Physics-II	Introduction to Dielectrics	General discussion of magnetism, type of magnetism	Introduction to superconductivity	Discussion of Lattice vacancies
	SLO-2	Semiconductors	Discussion of Macroscopic electric field	Spin configuration	Meissner effect	Schottky and Frenkel defects
S-2	SLO-1	Classical description of band gap	Microscopic electric field	Langevin diamagnetism equation	Type I superconductors	Diffusion, Fick's law
	SLO-2	Quantum Mechanical description of origin of band gap,	Lorentz field	Quantum theory of diamagnetism of mononuclear systems	Type II superconductors	Color centers

S-3	SLO-1	Concept of metals	Analysis of local electric field at an atom	Quantum theory of Paramagnetism	Thermodynamics of superconducting transitions	Dislocations
	SLO-2	Concept of semiconductors and insulators	Dielectric constant and its significance	Paramagnetic susceptibility	Derivation of free energy of superconducting state	Edge dislocations and Screw Dislocations
S-4 to S-5	SLO-1	Overview of different experiments	Experimental set up description for 4 probe resistance measurement	Determination of paramagnetic susceptibility of given liquid using Quincke's tube method	Magnetic domain imaging using magnetic force microscopy	Calculation of defect density
	SLO-2	Numerical estimate of band gap	Calculation of resistivity of metallic sheet	Calculation of paramagnetic susceptibility for powder sample using Gouy's balance	Calculation of domain wall energy	Estimate of wavelength of from the color center
S-6	SLO-1	Direct bandgap	Concept of Polarizability	Ferromagnetic order	Origin of energy gap	Introduction of quasi crystals
	SLO-2	Indirect bandgap	Various mechanisms of polarizability	Curie-Weiss law	Isotope effect	Diffraction pattern of quasi crystals
S-7	SLO-1	Introduction to impurity conductivity	Clausius-Mossotti relation	Magnetic susceptibility	London equations	Concept of liquid crystals
	SLO-2	Intrinsic carrier concentration	Derivation of Clausius-Mossotti relation	Quantum mechanical origin of Ferromagnetism	Derivation of London Penetration depth	Types of liquid crystals
S-8	SLO-1	Hall effect	Piezoelectricity	Spin waves, Magnon	Coherence length	Order parameter
	SLO-2	Derivation of Hall effect	Paraelectricity and Pyroelectricity	Magnon dispersion relation of magnon	Significance of Coherence length	Classification of liquid crystals
S-9 to S-10	SLO-1	Discussion of experimental technique to determine the direct/indirect nature of band gap	Experimental set up description for the measurement attenuation characteristics of optical fiber	Description of Vibrating sample magnetometer (VSM)	Calculation of critical temperature of superconductor	Description of experimental set up used for the determination of compressibility of a liquid
	SLO-2	Analysis and interpretation of band gap nature	Measurement of numerical aperture and attenuation characteristics of optical fiber	Magnetic parameter measurement and calculation	Estimation of critical field for the superconductor	Calculation of compressibility of liquid
S-11	SLO-1	Quantum Hall effect	In-depth understanding of Structural Phase Transition	Ferrimagnetic order	Elements of BCS theory	Thermotropic liquid crystals
	SLO-2	Fractional quantum Hall effect	Derivation of condition for 1st order phase transition	Antiferromagnetic order	Flux quantization	Examples of thermotropic liquid crystals
S-12	SLO-1	Central Equation of motion	Derivation of condition for 2nd order phase transition	Magnon dispersion relation for Antiferromagnet	Tunneling, Josephson effect	Calamitic liquid crystals
	SLO-2	Quantum mechanical description of Central equation of motion	Examples of 1st order and 2nd order phase transition	Magnetic Anisotropy	AC Josephson effect	Examples of Calamitic liquid crystals
S-13	SLO-1	Discussion on Thermoelectric effects	Mechanism of ferroelectricity	Ferromagnetic domains	High Tc superconductors	Lyotropic liquid crystals
	SLO-2	Semimetals	Displacive transition	Investigating Ferromagnetic domains	Superfluidity	Examples of Lyotropic liquid crystals
S-14 to S-15	SLO-1	Description of Hall effect experimental set up	Experimental set up description for polarization versus electric field (PE) measurement	Magnetization versus field (MH) response using VSM in ferromagnetic single crystal	Description of superconducting quantum interference device (SQUID)	Calculation of velocity of ultrasonic wave
	SLO-2	Calculation of carrier concentration and Hall coefficient	Analysis of PE response of a ferroelectric	MH response from thin film	Calculation of sensitivity of SQUID	Analysis of velocity of ultrasonic wave in different medium

Learning Resources	1. C. Kittel, Introduction to Solid State Physics, 8th Ed., J. Wiley and Sons, 2005. 2. M.A. Wahab, Solid state Physics, 2nd Ed., Narosa Publishing House, 2006. 3. G.D. Mahan, Condensed Matter in a Nutshell, 1st Ed., Princeton University Press, 2010.	4. N.W. Ashcroft and D.M. Mermin, Solid State Physics, Holt, Rinehart and Winston, 1976. 5. S. Singh, Liquid Crystals Fundamentals, World Scientific Publishing Co. Pvt. Ltd., 2002. 6. H. Ibach and H. Lueth, Solid State Physics, An introduction to theory and experiment, Narosa Publishing House, 1991.

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 %	30 %	30 %	30 %	30 %	30 %
Level 2	Apply Analyze	40 %	40 %	40 %	40 %	40 %	40 %	40 %	40 %	40 %	40 %
Level 3	Evaluate Create	30 %	30 %	30 %	30 %	30 %	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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Course Code	PPY21D05T	Course Name	Nanoscience and Nanomaterials	Course Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

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:	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 :	*acquire knowledge on dimensionality and size dependent properties*																		
CLR-2 :	*gain knowledge on different types of nanomaterials*																		
CLR-3 :	*understand the techniques and their requirements for preparing nanomaterials.*																		
CLR-4 :	*gain knowledge on nanomaterial characterization techniques*																		
CLR-5 :	*acquire knowledge on the applications of nanomaterials*																		
CLR-6:	*understand the suitable preparation method required for different applications*																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	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 :	*explain the size dependent behavior of nanomaterials*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2 :	*analyze the given nanomaterial and its properties*	2	80	70	H	M	M	H	M	H	H	H	M	H	M	H	M	M	M
CLO-3 :	*utilize the suitable material for a particular application*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*implement a suitable technique to study the nanomaterial*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*explain the methods involved for the preparation of nanomaterials*	2	80	70	H	H	H	H	H	M	H	H	M	H	M	H	H	H	H
CLO-6:	*describe nanomaterial characterization techniques, advantageous and limitations*	2	80	75	H	M	M	H	H	H	H	H	H	H	M	H	H	M	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Definition of nanoscale materials	Change in properties-important principle factors	Fabrication of Nanomaterials Classification: Top-down approach	UV –Vis Spectrometer (UV-vis)	Applications: nanoparticle-based drug delivery
	SLO-2	Bulk and nanoscale materials and their significance	Quantum confinement, Quantum confinement an Bohr exciton radius	Bottom-up approach	Optical absorption an spectroscopy	advantages of using nanoparticles as a drug delivery system
S-2	SLO-1	Where from the difference coming between bulk and nanoscale materials	Effect of confinement	Lithography – Basic Concept	Beer's law and Lambert law	storage devices and nanomaterial
	SLO-2	Dimensionality	Quantization effect on electronic state	Types of Lithography	Interaction of EMR with matter	Battery and electrical energy storage
S-3	SLO-1	Classification based on dimensionality	Electronic state transition from bulk metal/semiconductor to small cluster	Photolithography Roots and conditions	Electron transitions (bonding, antibonding)	Lithium-ion battery, Working principal of Li-ion battery
	SLO-2	Zero dimensional, one-dimensional nanostructure, Two dimensional nanostructures	Dimensionality and Optical Properties, Asymmetry plays a large role on optical properties	Steps Used in Photolithography, Types of Photoresist	Primary Photophysical process, Absorption and emission pathways	Discovery of Photocatalysis
S-4	SLO-1	Seminar on basic nanoscience	Seminar on nanomaterial and quantization	Seminar on Photolithography	Seminar on Electron transitions	Seminar on Nanoscience Research for Energy Needs
	SLO-2	Seminar on basic nanoscience	Seminar on nanomaterial and quantization	Seminar on Photolithography: Exposure steps during Photolithography	Seminar on application of UV-Visible Spectroscopy	Seminar on Nanoscience Research for Energy Needs
S-5	SLO-1	Quantum dots (QDs) and its properties, Example of QDs	Nanoparticles change its color with size	Contact, proximity and projection	Photoluminescence (PL)	Definition of Photocatalysis
	SLO-2	Why quantum dots shows different color	Optical Properties of Semiconductor	Resolution and depth of focus in Photolithography	Luminescent and phosphor	Photocatalytic Mechanism
S-6	SLO-1	Nanoribbons and its application	Dimension effect on electronic structure (DOS and band position)	Problem solving: calculation of resolution and depth of focus	Decay processes and Jablonski energy diagram	Photocatalysis and semiconducting nanomaterials
	SLO-2	Graphene nanoribbons properties	Semiconductor size and red-shift in absorption	Photoresist cleaning and device fabrication	Properties of Luminescence spectrum	Oxidation mechanism and valence band position
S-7	SLO-1	Nanowires and its applications	Brus Equation	electron-beam lithography	Application of PL	Reduction Mechanism
	SLO-2	Density of states (DOS) and Volume in k-space	electron-hole spatial correlation effect and Brus equation modification	Procedures of EBL	Raman spectroscopy and basic principles	Application of Photocatalysis: self-cleaning
S-8	SLO-1	Problem: Calculation of DOS for 1 dimensions nanomaterial	Problem solving: Band gap calculation of a semiconductor nanomaterial with size	Seminar relate to Bottom-up approach	Seminar on Classical picture of Raman	Seminar on Photocatalysis: treatment of water
	SLO-2	Problem: calculation of DOS for 2 dimensions nanomaterial	Problem solving: Size calculation of a semiconductor nanomaterial using Brus equation	Problem solving: Resolution calculation on lithography	Seminar on Classical picture of Raman	Seminar on spintronic devices
S-9	SLO-1	Calculation of DOS for 3 dimensions nanomaterial	Optical Properties of Metal nanomaterial	Sol-Gel methods, Definition of sol and gel	X-ray Diffraction (XRD), Peak Broadening method for crystallite size estimation	Spin degree of freedom, spin field effect transistors (SPINFET)
	SLO-2	Carbon nanotubes, (n,m) notation	Advantages of different color of metal nanoparticles	Colloidal gel and polymer gel, Sol stabilization	Use of XRD pattern	Advantages of Spin and GMR
S-10	SLO-1	Atomic structure of CNT, primitive unit cell	Surface plasmon resonance (SPR)	Step by step Sol-Gel process	Phase identification, Scherrer formula and grain size determination	Tunneling magnetoresistance (TMR)
	SLO-2	Types and Structure of carbon nanotubes	Delocalized electron and oscillation of conduction electrons	Hydrolysis and condensation reaction	scanning electron microscope (SEM)	magnetic tunnel junction (MTJ)
S-11	SLO-1	chiral vector and chiral angle	Understanding of polarization	Network formation and ageing during sol-gel process	transmission electron microscope (TEM),	magnetic tunnel junction (MTJ) and spin

	SLO-2	Buckyballs (C60), Properties of Buckyballs	Surface area to volume ratio of bulk materials and nanomaterials	Hydrothermal synthesis, Solvothermal Synthesis	atomic force microscope (AFM)	Magnetic tunnel junction based devices
S-12	SLO-1	Seminar on CNT	Seminar on Chemical reaction and surface area	Seminar on sol-gel	Seminar on Working modes of AFM	Seminar on Basic Phenomena in (Magnetic Tunnel Junction)MTJs
	SLO-2	Problem solving: Diameter calculation of CNT	Seminar on Chemical properties of nanomaterials	Seminar related to different factors during crystal growth in solvothermal	Seminar on Scanning tunneling microscopy (STM)	Seminar on MTJs working principal

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. D. Bucknall, Nanolithography and Patterning Techniques in Microelectronics, CRC Press, 2005.	4. T.K. Sau, A.L. Rogach, Complex-shaped Metal Nanoparticles: Bottom-Up Syntheses and Applications, 1st Ed., Wiley-VCH, 2012. 5. Hari Singh Nalwa, Nanostructured Materials and Nanotechnology, Academic Press, 2002. 6. Charles P. Poole & Frank J. Owens, Introduction to Nanotechnology, John Wiley & Sons, Inc. 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 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, Tech Talks, Mini-Projects, Case-Studies, Self-Study, Attendance 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. A. Karthigeyan, SRMIST

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Course Code	PPY21D06T	Course Name	Thin Film Technology	Course Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

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:	impart a sound basis for an understanding of vacuum technology.
CLR-2:	provide a fundamental knowledge on various principles and methods used in the synthesis of materials in thin film form.
CLR-3:	introduce nucleation and growth mechanisms of thin films based on thermodynamics and molecular theory.
CLR-4:	introduce nucleation and growth mechanisms of thin films based on thermodynamics and molecular theory.
CLR-5:	provide understanding of optical techniques for thickness measurements
CLR-6:	familiarize with physics and techniques involved in the measurement and characterization of thin films

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	2: Critical Thinking	3: Problem Solving	4: Analytical Reasoning	5: Research Skills	6: Team Work	7: Scientific Reasoning	8: Reflective Thinking	9: Self-Directed Learning	10: Multicultural Competence	11: ICT Skills	12: Disciplinary Knowledge	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1:	*understand the concept of vacuum technique*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*explore evaporation and sputtering systems for fabrication of films*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*know about the concept of various CVD techniques and their applications*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	*understand the possible growth modes and techniques to measure thickness of films*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*explore various advanced experimental techniques to search for crystal structures, morphology, elemental and surface analysis*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*solve various problems for understanding about vacuum techniques, nucleation and growth aspects, and characterization techniques*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Fundamentals of vacuum	Thermal evaporation	Electrodeposition	Introduction: nucleation	X-ray diffraction (XRD)
	SLO-2	Basic definition and pressure regions of vacuum	resistive heating	electrolytic deposition	early stages of film growth	Experimental investigation of X-ray diffraction (XRD
S-2	SLO-1	kinetic theory of gases, mean free path	flash evaporation	electro less deposition	thermodynamic aspects of nucleation	scanning electron microscopy
	SLO-2	types of flow	laser evaporation	anodic oxidation	capillary theory	Morphology analysis using scanning electron microscopy…

S-3	SLO-1	Conductance	rf-heating	spray pyrolysis	thin film growth modes	Transmission electron microscopy
	SLO-2	vacuum pumps	co-evaporation	spin coating	Volmert, Weber (VW) growth	Investigation of nanostructures using transmission electron microscopy…
S-4	SLO-1	Problem Solving on mean free path from kinetic theory of gases	Problem Solving on rf and resistive heating	Problem Solving on electro-deposition	Problem Solving on nucleation	Problem Solving on crystallite size, strain analysis using XRD
	SLO-2	Problem Solving on vacuum	Problem Solving on different evaporation systems	Problem Solving on electrolytic and electro less deposition	Problem Solving on growth modes	Problem Solving on morphology study from SEM and TEM data
S-5	SLO-1	vacuum pumps and systems	electron bombardment heating	dip coating	Frank-van der Merwe (FM) growth	Energy dispersive analysis
	SLO-2	rotary mechanical pump	sputtering plasma	chemical vapor deposition (CVD)	Stranski-Krastanov growth	Elemental analysis using energy dispersive analysis
S-6	SLO-1	roots pump	discharges and arc	homogenous process	thickness measurement	Auger electron spectroscopy
	SLO-2	diffusion pump	sputtering yield low pressure sputtering	heterogeneous process,	electrical methods	Study of surface using Auger electron spectroscopy
S-7	SLO-1	turbo molecular pump	rf-sputtering	CVD reactions	microbalance monitors	Basic principle of X-ray photoelectron spectroscopy
	SLO-2	sputter ion pump	reactive sputtering	Pyrolysis	quartz crystal monitor	Experimental details of X-ray photoelectron spectroscopy
S-8	SLO-1	Problem Solving on turbomolecular pump	Problem Solving on generation of plasma	Problem Solving on CVD	Problem Solving on thickness analysis	Problem Solving on elemental analysis
	SLO-2	Problem Solving on diffusion pump	Problem Solving on rf-sputtering	Problem Solving on CVD reactions	Problem Solving on quartz crystal monitor	Problem Solving on surface analysis
S-9	SLO-1	measurement of vacuum	Basic principle of magnetron sputtering	hydrogen reduction, halide disproportionation,	Basic of mechanical method (stylus)	Identify elements within materials from X-ray photoelectron spectroscopy study
	SLO-2	concept of different gauges	Details study of magnetron sputtering	transfer reactions	Mechanical method (stylus)	Introduction of Rutherford backscattering spectroscopy
S-10	SLO-1	capacitance gauges	magnetron configurations	CVD processes and systems	Basic of optical interference methods	Use of Rutherford backscattering spectroscopy
	SLO-2	Pirani gauge	bias sputtering	low pressure CVD	Details of optical interference methods	Introduction of secondary ion mass spectrometry
S-11	SLO-1	ionization gauge and penning gauge	evaporation versus sputtering	laser enhanced CVD	Ellipsometry	Experimental study of secondary ion mass spectrometry
	SLO-2	vacuum system components	evaporation versus sputtering	metal organic CVD (MOCVD)	Interference fringes	Use of Secondary ion mass spectrometry
S-12	SLO-1	Problem Solving on different gauges	Problem Solving on magnetron sputtering	Problem Solving on MOCVD	Problem Solving on optical interference methods	Problem Solving on compositional analysis
	SLO-2	Problem Solving on vacuum operation	Problem Solving on evaporation versus sputtering	Problem Solving on low pressure CVD	Problem Solving on Interference fringes	Problem Solving on secondary ion mass spectrometry

Learning Resources

1. D.M. Hoffman, B. Singh and J.H. Thomas, Handbook of Vacuum Science & Technology, Academic Press, 1998.
2. M. Ohring, Materials Science of Thin Films: Deposition and Structure, 2nd Ed., Academic Press (An Imprint of Elsevier), 2002.
3. S. Campbell, The Science and Engineering of Microelectronic Fabrication, 2nd Ed., OUP, 1996.
4. Kaufmann, Characterization of Materials, 2nd Ed., Wiley, 2003.
5. K.L. Chopra, Thin Film Phenomena, Robert E. Krieger Publishing Company, 1979.
6. Z.L. Wang, Characterization of Nanophase Materials, Wiley, 2000.
7. St J.N. Braithwaite, "Introduction to gas discharges." Plasma sources science and technology 9.4 (2000): 517.
8. N. Yoshimura, Vacuum Technology: Practice for Scientific Instruments, Springer Publications, 2007.
9. The Vacuum Technology Book Volume II, Pfeiffer Vacuum [Online Book]
10. E. Ahmed, et al. "Significance of substrate temperature on the properties of flash evaporated CuIn 0.75 Ga 0.25 Se 2 thin films." Thin Solid Films 335.1 (1998): 54-58.
11. L.B. Jonsson, et al. "Frequency response in pulsed DC reactive sputtering processes." Thin Solid Films 365.1 (2000): 43-48.
12. J.B. Mooney, and S.B. Radding. "Spray pyrolysis processing." Annual Review of Materials Science 12.1 (1982): 81-101.
13. R.F. Bunshah, Handbook of Deposition Technologies for Films and Coatings, Science, Technology and Applications, Noyes Publications, 1994.

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
Dr. S. Saravanan, RenewSys India Pvt. Ltd, Telangana, India, shrisharavanan@yahoo.co.uk	Prof. S. Balakumar, University of Madras, balakumar@unom.ac.in	Dr. Bhaskar Behera, SRMIST
Dr. N. VIJAYAN, CSIR-NPL, nvijayan@nplindia.org Experts from Higher Technical Institutions	Prof. V. Subramanian, IIT Madras, manianvs@iitm.ac.in	Dr. Kovendhan, SRMIST

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Course Code	PPY21D07T	Course Name	*Photonics*	Course Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

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

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Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
CLR-1:	develop theoretical and practical knowledge in photonics.			
CLR-2:	understand basic concepts of photonics at nanoscale.			
CLR-3:	familiarize with the latest developments in photonics and its applications.			
CLR-4:	*provide understanding of nonlinear optical phenomenon*			
CLR-5:	*familiarizes with the physics of plasmonics and semiconductors*			
CLR-6:	*acquire knowledge on the optical properties of graphene and topological insulators*			

Program Learning Outcomes (PLO)

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1:	understand the light propagation in linear, nonlinear and plasmonic media	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	explore the light scattering by small particles and optical properties of semiconductors	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	know about the concepts of near-fields and their application in microscopy	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	understand the generation of sum and difference frequencies	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	understand the concepts of plasmon waveguides and Kramers-Kronig relations	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	solve problems on anharmonic oscillator, Mie scattering, particle in periodic potential, Drude model	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		**12**	**12**	**12**	**12**	**12**
S-1	**SLO-1**	Linear optics: Brief Introduction	Extinction, Scattering, and absorption cross sections	Angular spectrum representation of optical fields	Dielectric response of metals	Complex dielectric function and refractive index
	SLO-2	Homogeneous and isotropic media	Extinction, Scattering, and absorption coefficients	Polarized electric and polarized magnetic fields	Lorentz model	Relation between ε' and ε''
S-2	**SLO-1**	Wave propagation in linear media	Optical Theorem	Far-field	frequency dependence of permittivity	optical properties of metals
	SLO-2	Wave propagation in anisotropic media	Asymmetry parameter and radiation pressure	Near-field	Kramer-Kronig relation	Normal and anomalous dispersion
S-3	**SLO-1**	Tensors Description	Internal and scattered fields	Evanescent field	dispersion relationship, plasmons	permittivity of metals, damping constant
	SLO-2	Tensor nature of anisotropy	Light Scattering from small objects	Evanescent wave application	Bulk and surface plasmon	High and low frequency behaviour
S-4	**SLO-1**	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-5	**SLO-1**	Harmonic oscillator	Historical introduction: The colour and the polarization of skylight	Evanescent wave coupling	surface plasmons and localized surface plasmons	optical properties of semiconductors
	SLO-2	Linear susceptibility	General theory of scattering by sphere	The role of Evanescent field in optical fiber sensing	classical free electron theory of metals	Size dependent absorption spectra. Inhomogeneous broadening
S-6	**SLO-1**	Nonlinear Susceptibility	Bessel functions and Legendre functions	angular spectrum representation of dipole field	Particle in periodic potential	optical properties of semiconductor nanocrystals
	SLO-2	Properties of the Nonlinear Susceptibility	General theory of scattering by sphere	Higher order laser beam	Drude model permittivity	Homogenous line widths
S-7	**SLO-1**	Nonlinear Susceptibility of a classical Anharmonic oscillator	Forward and backward scattering	scanning near-field optical microscopy	conductivity, excitation of surface plasmons	Selective emission spectroscopy
	SLO-2	Susceptibility tensor	Mie scattering	Application of scanning near-field optical microscopy	Application of SPR in bio sensing	quantum dots, excitons
S-8	**SLO-1**	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-9	**SLO-1**	Wave propagation in Nonlinear media	Mie scattering and phase angles in non-absorbing spheres	Biological application of scanning near-field optical microscopy	Otto configuration	Size dependent radiative decay of excitons
	SLO-2	Wave propagation in linear media	Resonance effects in Mie theory	Abbe diffraction limit	Total internal reflection	optical properties of graphene
S-10	**SLO-1**	Second Harmonic Generation	Mie scattering theory formulation for cylinder	Overcoming diffraction limit	Kretschmann configuration	Raman spectroscopy of graphene
	SLO-2	Sum and Difference-Frequency Generation	Rayleigh Scattering	Diffraction barrier in optical microscopy	application of surface plasmons	Absorption spectrum of graphene
S-11	**SLO-1**	Sum-Frequency Generation	Importance of scattering in optical experiments	Applications of optical near-field	plasmons in semiconductors and other novel plasmonic materials	optical properties of topological insulators
	SLO-2	Difference- Frequency Generation	Importance of extinction in optical experiments	Principle and application of Near field scanning microscopy (NSOM)	Plasmon waveguide	2-d topological insulators
S-12	**SLO-1**	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving

Learning Resources	1. R. Boyd, Nonlinear Optics, 3rd Ed., Academic Press, 2008 2. C.F. Bohren, D. R. Huffman, Absorption and Scattering of Light by Small Particles, Wiley-VCH, 2008 3. S.V. Gaponenko, Optical Properties of Semiconductor Nanocrystals, Cambridge University Press, 1998	4. J.D. Jackson, Classical Electrodynamics, 3rd Ed., John Wiley & Sons, 2005. 5. S.A Maier, Plasmonics: Fundamentals and Applications, Springer, 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	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
Dr. N Vijayan, NPL, nvijayan @nplindia.org	Prof. V Subramanian, IIT Madras, manianvs@iitm.ac.in	Dr. Junaid M. Laskar, SRM IST
Mr. R Seshadri, Titan Company Limited, seshadri@titan.co.in	Prof. C Vijayan, IIT Madras, cvijayan@iitm.ac.in	Dr. K Shadak Alee, SRM IST

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Course Code	PPY21D08T	Course Name	Atmospheric Physics	Course Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

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:	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 basics of structure and properties of earth's atmosphere																		
CLR-2:	interpret the various atmospheric processes																		
CLR-3:	realize the fundamental science behind the weather events																		
CLR-4:	explore the physics of extreme weather events																		
CLR-5:	understand the clouds and their role in atmosphere																		
CLR-6:	explore the role of weather systems																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	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:	*know the basics of earth's atmosphere*	2	80	75	H	H	H	H	H	H	M	M	M	H	M	H	H	H	H
CLO-2:	*analyze the general weather phenomena*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*interpret the various extreme weather events*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	*develop ideas of climate systems and their influence*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*distinguish the weather and climate issues*	2	80	70	H	H	H	H	M	H	M	H	H	H	M	H	H	H	H
CLO-6:	*understand the significance of atmospheric processes and the laws governing them*	2	80	75	H	M	H	H	M	H	M	H	H	M	M	M	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	A Brief Survey of the Atmosphere: Chemical Composition	Gas Laws	Water Vapor in Air	Nucleation of Water Vapor Condensation, Theory	The Effect of Friction
	SLO-2	Vertical structure	Virtual Temperature	Moisture Parameters	Cloud Condensation Nuclei	The Gradient Wind & The Thermal Wind
S-2	SLO-1	Components of the Earth System: The Oceans	The Hydrostatic Equation	Latent Heats	Cloud Classification	The Atmospheric General Circulation
	SLO-2	The Cryosphere	Geopotential	Saturated Adiabatic and Pseudoadiabatic Processes	terminal velocity	The Kinetic Energy Cycle
S-3	SLO-1	The Terrestrial Biosphere	Scale Height and the Hypsometric Equation	The Saturated Adiabatic Lapse Rate	Microstructures of Warm Clouds	Atmospheric Boundary Layer and its structure
	SLO-2	Roles of Various Components of the Earth System in Climate	Thickness and Heights of Constant Pressure Surfaces	Equivalent Potential Temperature and Wet-Bulb Potential Temperature	Cloud Liquid Water Content and Entrainment	Estimation of Atmospheric Boundary Layer
S-4	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-5	SLO-1	The Hydrologic Cycle	The First Law of Thermodynamics	Normand's Rule	Growth of Cloud Droplets in Warm Clouds : Growth by Condensation	Numerical Weather Prediction
	SLO-2	Its components	Joule's Law	Net Effects of Ascent Followed by Descent	Bridging the Gap between Droplet Growth by Condensation and Collision–Coalescence	Numerical Weather Prediction
S-6	SLO-1	Carbon Cycle	Specific Heats	Static Stability	Formation of Precipitation in Cold Clouds	Extratropical Cyclones : An Overview
	SLO-2	Carbon in the Atmosphere	Enthalpy	Unsaturated Air	Classification of Solid Precipitation	Fronts and Surface Weather
S-7	SLO-1	Carbon in the Biosphere	Adiabatic Processes	Saturated Air	Kinematics of the Large-Scale Horizontal Flow	Vertical Structure

	SLO-2	Carbon in the Oceans	Concept of an Air Parcel	Conditional and Convective Instability	Elementary Kinematic Properties of the Flow	Air Trajectories
S-8	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
S-9	SLO-1	Solar Constant	The Dry Adiabatic Lapse Rate	Physics of Scattering and Absorption and Emission	Vorticity and Divergence	Orographic Effects : Rossby Wave Propagation along Sloping Terrain
	SLO-2	Incoming and outgoing radiation of earth	Derivation of Dry Adiabatic Lapse Rate	Scattering by Air Molecules and Particles	Deformation	Deep Convection : Structure and Evolution of Convective Storms
S-10	SLO-1	Radiation Budget	Potential Temperature	Absorption by Particles	Dynamics of Horizontal Flow : Apparent Forces	Mesoscale Convective Systems
	SLO-2	Radiation Budget	Its derivation	Absorption and Emission by Gas Molecules	Real Forces	Mesoscale Convective Systems
S-11	SLO-1	Radiative Equilibrium	Thermodynamic Diagrams	Absorption and Emission of Infrared Radiation in Cloud-Free Air	The Horizontal Equation of Motion	Tropical Cyclones
	SLO-2	Temperature of planet Earth	Applications	Vertical Profiles of Radiative Heating Rate	The Geostrophic Wind	Structure, Thermodynamics, and Dynamics
S-12	SLO-1	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving
	SLO-2	Problem Solving	Problem Solving	Problem Solving	Problem Solving	Problem Solving

Learning Resources	1. John M Wallace and Peter V Hobbs, Atmospheric Science – An introductory Survey, International Geophysics Series, 2006 2. Murry L Salby, Fundamentals of Atmospheric Physics, International Geophysics Series, 1996	3. Kshudiram Saha,The Earth's Atmosphere, Its Physics and Dynamics, Springer, 2008 4. C. Donald Ahrens, Essentials of Meteorology : An invitation to the atmosphere, Cengage Learning, 2010

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
Dr. D. Sivaprakasam, Scientist F, ARCI, Chennai. sprakash@arci.res.in	Prof. B.S. Murthy, Director, IIT Hyderabad, *bsm@iith.ac.in*	Dr. T.V. Lakshmi Kumar, SRM IST
Dr. Ajay Singh, BARC, Mumbai, ajay@barc.gov.in	Prof. S Balakumar, University of Madras, balakumar@unom.ac.in	Dr. A. Naga Rajesh, SRM IST

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Course Code	*PPY21D09T*	Course Name	***Nuclear and Particle Physics***	Course Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

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:	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:	*introduce students to the fundamental principles and concepts governing nuclear and particle physics.*																		
CLR-2:	*know about nuclear physics' scientific and technological applications*																		
CLR-3:	*understand the nuclear shell structure and complexities of nuclear deformation*																		
CLR-4:	*give in-depth knowledge of nuclear decay processes and dynamics*																		
CLR-5:	*understand the basic concepts of elementary particles and their properties*																		
CLR-6:	*give basic introduction to fundamental interactions and the standard model*																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	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:	*pursue the phenomenological aspects of nuclear physics*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
CLO-2:	*master the technique of deriving and evaluating formulae for the electromagnetic fields from very general charge and current distributions*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
CLO-3:	*apply mathematical tools to explain electromagnetic interactions.*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*
CLO-4:	*solve problems in electromagnetism that require analytical and numerical approach*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
CLO-5:	*master relativistic kinematics for computations of the outcome of various reactions and decay processes*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
CLO-6:	*classify elementary particles according to their quantum numbers and fundamental interactions*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*

Duration (hour)		12	12	12	12	12
S-1	SLO-1	The nuclear radius	The deuteron Problem	The Shell model	Interaction of radiation with matter	Relativistic kinematics
	SLO-2	nuclear size determination experiments and evidences	Square well Potential	Evidences and Contributing terms	Qualitative recapitulation	Basic Definitions and notations
S-2	SLO-1	Nuclear form-factors	Spin and Parity of deuteron	Shell Model Potential	Interaction of Charged particles with matter (Qualitative)	Spin and parity determination of pions,
	SLO-2	Charge Distribution	Dipole and Quadrupole moments	Shell Structure	Bethe-Block Formula	strange particles
S-3	SLO-1	mass and abundance of nuclides	central and tensor forces	Nilsson mode	Interaction of neutral particles with matter	Gell-Mann Nishijima scheme,
	SLO-2	Separated Isotopes	evidence for saturation property	Nuclear deformation and harmonic oscillator potential	Energy loss	Elementary particles: Quarks
S-4	SLO-1	Problem solving on radius	Problem solving on Deuteron	Problem solving on magic numbers from harmonic oscillator	Problem solving on Energy Loss in EM interaction	Problem solving on relativistic kinematics
	SLO-2	Problem solving on mass and energy	Problem solving on Magnetic moments, potential and radius	Problem solving on nuclear spectroscopic notations	Problem solving on Energy Loss in charged and neutral particles	Problem solving on Gell-Mann Nishijima formula
S-5	SLO-1	Nuclear binding energy	Nucleon-Nucleon scattering	Physical concepts of the unified model	Ge and Si solid state detectors,	Classification and
	SLO-2	Binding Energy Curve	Partial Wave analysis and Phase Shifts	Salient features of Collective behaviour	Construction and Working	properties of quarks
S-6	SLO-1	Liquid Drop Model	Spin dependence	electromagnetic decays	Scintillation counters	Elementary ideas of SU(2) and SU(3) symmetry groups
	SLO-2	Contributions to Semiempirical mass formula	Scattering cross-sections for ortho- and para-hydrogen	Types and selection rules	Construction and Working	hadron classification,
S-7	SLO-1	Nuclear angular momentum	Scattering length	electron capture and beta decays	Calorimeters	quark spin and color,
	SLO-2	Parity	S-wave effective range theory	energy relations and q-values in beta decays,	and their use for measuring jet energies;	quark-antiquark combination;
S-8	SLO-1	Problem solving on Nuclear binding energy	Problem solving on Nucleon magnetic moments	Problem solving EM decays	Assignment on Solid state detectors	Problem solving on quantum numbers of reactions/processes
	SLO-2	Problem solving on liquid drop model	Problem solving on singlet triplet cross-sections	Problem solving on Selection Rules	Assignment on Scintillators	Assignment on quark model
S-9	SLO-1	nuclear electromagnetic moments	Proton - proton and neutron - neutron Interactions	Fermi theory of beta decay	Bremsstrahlung	meson octet,
	SLO-2	Magnetic moments of nucleons	evidence for hardcore potential	Curie plots	Cerenkov Radiation	the baryon decuplet, baryon octet,
S-10	SLO-1	Quadrupole moments	Properties of nuclear Forces	Fermi and Gamow-Teller transitions, classification of beta transitions,	Cerenkov counters	Introduction to the standard model
	SLO-2	Their significance	general form of the nucleon-nucleon force	selection rules for allowed and forbidden transitions,	One Example: Water Cerenkov detector	Four fundamental forces
S-11	SLO-1	Nuclear excited states	Exchange force model	parity violation in beta-decay: Wu-Ambler experiment	Qualitative Idea of Hybrid Detectors	qualitative idea of electroweak interaction
	SLO-2	Early evidences of shell structure	Yukawa theory	helicity of electron and of neutrino	Overview of applications	W & Z bosons.
S-12	SLO-1	Problem solving on nuclear electromagnetic moments	Problem solving on spin-spin interaction	Problem solving on Beta decays, Gamow-Teller Transitions	Assignment on Cerenkov Counters	Problem solving on Hadron decays
	SLO-2	Problem solving on Excited States Energies	Problem solving on exchange force model	Problem solving on parity violation	Assignment of Hybrid detectors	Problem solving on range and strength of fundamental forces

Learning Resources	1. K.S. Krane, *Introducing Nuclear Physics*, Wiley India, 2008. 2. R.R. Roy and B.P. Nigam, Nuclear Physics: Theory & Experiments, New Age International, 2005. 3. S.S.M. Wong, Introductory Nuclear Physics, 2nd Ed., Wiley VCH, 2004. 4. C.A. Bertulani, Nuclear Physics in a Nutshell, 1st Ed., Princeton University Press, 2007.	5. D. Griffiths, Introduction to Elementary Particles, 2nd Ed., Academic Press, 2008. 6. B.L. Cohen, *Concept of Nuclear Physics*, McGraw-Hill, 2003. 7. B. Martin, *Nuclear & Particle Physics: An Introduction*, Willey, 2006. 8. I. Kaplan, *Nuclear Physics*, Addison Wesley, (Indian Ed., from Narosa Publishing House, New Delhi), 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 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
Dr. M Krishna Surendra, Saint Gobain Research, krishana.muvvala@saint-gobain.com	Dr. M Krishna Surendra, Saint Gobain Research, krishana.muvvala@saint-gobain.com	Dr. Rohit Dhir, SRMIST
Mr. Navneethakrishanan, CLR Laboratories Pvt Ltd.	Mr. Navneethakrishanan, CLR Laboratories Pvt Ltd.	Dr. Alok Kumar, SRMIST

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Course Code	PPY21D10T	Course Name	High Energy Physics	Course Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

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:	have a thorough understanding of particle physics
CLR-2:	understand the various interactions involving elementary particle
CLR-3:	learn basic concepts of high energy physics and its application in various fields
CLR-4:	learn particle physics at a level sufficient for graduate studies.
CLR-5:	understand the standard model of physics
CLR-6:	be able to work in high energy physics phenomenology

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Disciplinary Knowledge	2: Critical Thinking	3: Problem Solving	4: Analytical Reasoning	5: Research Skills	6: Team Work	7: Scientific Reasoning	8: Reflective Thinking	9: Self-Directed Learning	10: Multicultural Competence	11: ICT Skills	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1:	understand the role of symmetries and conservation laws in high energy physics	2	80	75	H	H	H	H	H	H	H	H	H	H	H	M	H	H	H
CLO-2:	learn and apply the basic concepts of quark model of hadrons and understand their properties	2	80	70	H	H	H	H	H	H	H	H	H	H	H	M	H	H	H
CLO-3:	apply mathematical tools to explain electromagnetic interactions.	2	75	70	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
CLO-4:	have in depth understanding of electromagnetic, strong and weak interactions	2	80	75	H	H	H	H	H	H	H	H	H	H	H	M	H	H	H
CLO-5:	understand the idea and outcome of electroweak unification and the Standard model	2	80	70	H	H	H	H	H	H	H	H	H	H	H	M	H	H	H
CLO-6:	familiarize with advances in high energy physics	2	80	75	H	H	H	H	H	H	H	H	H	H	H	M	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Review of concepts of spin, parity, isospin in particle physics	Introduction to constituent quark model	Low energy electron nucleon scattering	Evidence for Color	Global symmetry breaking
	SLO-2	Example of Pion	Hadron: Mesons and Baryons	Importance and applications	Gauge Principle	Goldstone theorem
S-2	SLO-1	charge conjugation invariance	Quantum number of quarks	Form factors	Extension to Relativistic Quantum Mechanics	Goldstone Boson
	SLO-2	Intrinsic Parity, G-parity	Conservation laws	Probability distributions and scattering cross-sections	Non-abelian gauge field Yang-Mills theory	Mass Term
S-3	SLO-1	Time reversal	valence quark contents of hardrons	Electromagnetic form factors	Elements of QCD	Spontaneous symmetry breaking
	SLO-2	CP Symmetry	Quark flavor content	evaluation for nucleons	Feynman Diagrams	Higgs mechanism
S-4	SLO-1	Problem Solving on Parity, Conjugation	Problem solving on Quark Model	Problem solving on formfactors	Assignment on Gauge theories	Assignment on Symmetry breaking
	SLO-2	Problem solving Spin, Isospin	Problem solving on Quantum Numbers and conservation laws	Problem solving on scattering	Problem solving on Feynman Diagrams	Problem solving on Higgs mechanism
S-5	SLO-1	CP violation	Introduction to quarkonia	Deep inelastic scattering	Introduction to four fermion Fermi theory	Higgs Boson Properties
	SLO-2	CPT theorem	charm and bottom systems	Basic introduction and dynamics	Basic Lagrangian and overview	Discovery of Higgs Boson
S-6	SLO-1	Introduction to symmetries:	Simple applications	structure functions	Fermi transitions	Renormalizability
	SLO-2	discrete and continuous symmetries with examples	hadron phenomenology	Nucleons and evidence of partons	Gamow-Teller transitions	Experimental evidences of electroweak unification
S-7	SLO-1	Young's tables	Unitary spin	Introduction to Parton model	development of V-A theory	Glashow-Weinberg-Salam model
	SLO-2	their relation to group theory	Space, spin and flavor wave functions	Parton distribution functions	V-A currents	Introduction
S-8	SLO-1	Problem solving on CP Examples	Problem solving on quarkonia	Problem solving on elastic and inelastic scattering	Problem solving on fermi theory	Assignments on Electroweak theory
	SLO-2	Problem solving: Young Tableau	Problem solving on spin wavefunctions	Problem solving on partons	Problem solving on V-A currents	Assignment on Glashow-Weinberg-Salam model
S-9	SLO-1	Groups	meson mixing	Gauge invariance	Weak neutral current	The Standard Model
	SLO-2	O(3) and SU(2)	mass formulae	Revisiting the concepts	Glashow-Iliopoulos-Maiani (GIM) mechanism	Introduction
S-10	SLO-1	Symmetry groups	spin hadron wave functions	Local gauge invariance	Neutrino-nucleon scattering	SM Lagrangian
	SLO-2	SU(3) and SU(6)	mesons and baryons	Global gauge invariance	Form factors	New Physics
S-11	SLO-1	Applications of symmetry groups	baryon masses	Symmetries and conservations	Electroweak unification	Current Experiments
	SLO-2	Hadron spectroscopy	Magnetic moments	Noether's theorem	Qualitative overview	Overview
S-12	SLO-1	Problem solving on Groups	Problem solving on mixing	Problem solving on Gauge invariance	Problem solving on GIM	Assignment on basic interactions
	SLO-2	Problem solving on Special Groups	Problem solving on masses and moments	Assignment on Symmetries and conservation laws	Assignment on Electroweak Unification	Assignment on GUT

Learning Resources		
	1. D. Griffiths, Introduction to Elementary Particles, 2nd Ed., Wiley VCH, 2008. 2. W.N. Cottingham, D. A. Greenwood, An Introduction to the Standard Model of Particle Physics, 2nd Ed., Cambridge University Press, 2007. 3. D.H. Perkins, An Introduction to High Energy Physics, 4th Ed., Cambridge University Press, 2000.	4. I.S. Hughes, Elementary Particles, 3rd Ed., Cambridge University Press, 1996. 5. F.E. Close, Introduction to Quarks and Partons, Academic Press, London, 1981. 6. M.P. Khanna, Introduction to Particle Physics, 3rd Ed., Prentice-Hall of India, 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 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
-	Dr. AC Sharma, GGSIP UNIVERSITY, Delhi, acsharma@gmail.com	Dr. Rohit Dhir, SRMIST
-	Dr. Alka Upadhayay, Thapar University, Patiala, alka.iisc@gmail.com	Dr. Alok Kumar, SRMIST

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Course Code	PPY21D11T	Course Name	*Quantum Field Theory*	Course Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

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:	*apply the fundamental concepts of classical field theory*
CLR-2:	*emphasize the mathematical formulation of second quantization*
CLR-3:	*lay the solid background of mathematical methods to use in field theories*
CLR-4:	*develop problem solving and critical thinking for filed theoretical approaches*
CLR-5:	*understand the second quantization problems and to physically interpret the solutions.*
CLR-6:	*enable them to pursue research in theoretical physics*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1:	*use and apply four vector formulation for classical field theory*	2	80	75	H	H	H	H	H	H	H	H	H	H	H	M	H	H	H
CLO-2:	*understand failure of relativistic quantum mechanics and the need for quantum field theory*	2	80	70	H	H	H	H	H	H	H	H	H	H	H	M	H	H	H
CLO-3:	*apply Feynman rules to calculate probabilities for basic processes in various interactions*	2	75	70	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
CLO-4:	*demonstrate an understanding of field quantisation upto Dirac Field*	2	80	75	H	H	H	H	H	H	H	H	H	H	H	M	H	H	H
CLO-5:	*use effective field theory techniques to develop models for various high energy physics domains*	2	80	70	H	H	H	H	H	H	H	H	H	H	H	M	H	H	H
CLO-6:	*analyse a problem by applying fundamental laws in a sophisticated context*	2	80	75	H	H	H	H	H	H	H	H	H	H	H	M	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Relativistic formulation	*The Klein-Gordon equation*	*Interacting fields*	The Lorentz group	the spin-statistics theorem
	SLO-2	notations	*Scalar Fields*	*Types of interaction*	Representations	Review
S-2	SLO-1	Field theory	*Field Quantization of Scalar Fields*	*the interaction picture*	Clifford Algebras	The Dirac Hamiltonian
	SLO-2	Introduction to Lagrangian field theory	*the simple harmonic oscillator*	*Dyson's Formula*	Spinor representation	Energy Relations
S-3	SLO-1	Lagrangian Field Density	*Second quantization of Scalar Fields*	*Scattering Example*	Dirac Equation	Quantization
	SLO-2	Action	*Commutation relations*	*Meson Decay*	Slash Notation	Commutators
S-4	SLO-1	Problem solving on Relativistic formulation	*Problem solving on Scalar Fields*	*Assignment on Interaction Pictures*	Problem solving on Lorentz Group	Problem solving on commutations
	SLO-2	Problem solving on field Lagrangian	*Problem solving on Commutations*	*Problem Solving on Decay Rate*	Problem solving on Dirac Equation	Problem solving on spin statistics
S-5	SLO-1	Symmetries	*free quantum fields*	*Wick's Theorem*	Dirac Spinors	particles and antiparticles
	SLO-2	Conservation laws	*Vacuum States/Energy*	*Example of nucleon scattering*	Relations	Dirac's hole interpretation
S-6	SLO-1	Conserved currents	*particles*	*Feynman diagrams*	Chiral Spinors	Feynman Rules for fermions
	SLO-2	Noether's Theorem	*relativistic normalization*	*Feynman rules*	Weyl equation	Applications
S-7	SLO-1	Electromagnetic Field	*Complex Scalar Field*	*Scattering amplitudes*	Dirac Bilinears	Maxwell's Equations
	SLO-2	Maxwell's Equations	*commutation relations*	*Decays and cross sections*	Dirac Lagrangian	Gauge Symmetries
S-8	SLO-1	Problem solving on Conservation laws	*Problem solving on Field Operators*	*Problem solving on Feynman diagrams*	Problem solving on Dirac spinors	Problem solving on Feynman rules for fermions
	SLO-2	Problem solving on Electromagnetic fields	*Problem solving on Normalization*	*Problem solving on Scattering Amplitudes*	Problem solving on Dirac matrices	Assignment on Gauge Symmetries

S-9	SLO-1	Lorentz invariance	*the Heisenberg picture*	*Mandelstam Variables*	Majorana Fermions	Quantization of EM field
	SLO-2	Gauge transformations	*Conceptualization*	*Derivation*	Spinor	Propagators
S-10	SLO-1	Canonical Momentum	*causality*	*Fermi Golden Rule*	Symmetries	Elements of QED
	SLO-2	Equations of motion	*propagators*	*Decay Rate*	Lorentz Transformations	Basic Features
S-11	SLO-1	Hamiltonian formulation	*Meson Propagator*	*Green's functions*	Plane Wave Solutions	Lorentz invariant propagators and Feynman rules
	SLO-2	Hamiltonian density	*non-relativistic field theory*	*Proof*	Negative Energy States	QED processes.
S-12	SLO-1	Problem solving on Gauge Transformations	*Problem solving on nonrelativistic generalization*	*Problem solving on Mandelstam Variables*	Problem solving on Plane wave solutions	Problem solving on Feynman Diagrams
	SLO-2	Problem solving on Hamiltonian Density	*Problem solving on propagators*	*Assignment on Green's Functions*	Assignment of Majorana Neutrinos	Problem solving on QED Processes

Learning Resources	1. *M. Peskin and D. Schroeder,* An Introduction to Quantum Field Theory, *Addison-Wesley, 1995.* 2. *L. Ryder,* Quantum Field Theory, *2nd Ed., Cambridge University Press, 1996.* 3. *M. Srednicki,* Quantum Field Theory, *1st Ed., Cambridge University Press, 2007.* 4. *S. Weinberg,* The Quantum Theory of Fields, *Vol. 1, 1st Ed., Cambridge University Press, 2005.* 5. *A. Zee,* Quantum Field Theory in a Nutshell, *2nd Ed., Princeton University Press, 2010.*

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
-	Dr. AC Sharma, GGSIP UNIVERSITY, Delhi, acsharma@gmail.com	Dr. Rohit Dhir, SRMIST
-	Dr. Alka Upadhayay, Thapar University, Patiala, alka.iisc@gmail.com	Dr. Arijit Sen, SRMIST

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Course Code	*PCY21G01T*	Course Name	*Research Skills and Learning*	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)
CLR-1 :	*understand the concept of research and different types of research in the context of chemistry*		
CLR-2 :	*evaluate the different methods of scientific writing and reporting*		
CLR-3 :	*impart the knowledge about the statistical distribution and applications*		
CLR-4 :	*develop the skill of technical writing*		
CLR-5 :	*inculcate the knowledge of intellectual property and rights*		
CLR-6 :	*understand the important areas of research*		

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO -1	14 PSO -2	15 PSO-3
CLO-1 :	*understand the key areas of research*	*2*	*75*	*60*	H	H	H	L	H	H	H	H	H	L	H	H	H	H	H
CLO-2 :	*develop scientific documentation skills*	*2*	*80*	*70*	H	H	L	H	H	H	H	L	L	H	H	L	H	H	H
CLO-3 :	*develop competence on data collection and process of scientific documentation*	*2*	*70*	*65*	H	H	M	M	H	L	H	L	L	H	H	L	H	H	H
CLO-4 :	*understand the research ethics*	*2*	*70*	*70*	H	L	H	H	H	L	M	L	L	H	H	L	H	H	H
CLO-5 :	*submit proposals for funding agencies*	*2*	*80*	*70*	H	H	H	M	M	H	H	L	L	H	H	L	H	H	H
CLO-6 :	*understand the key areas of research*	*2*	*75*	*70*	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Objectives of research	Online databases	Analysis and Presentation of Data	Technical writing	Ethics in research
	SLO-2	Research methods and methodologies-Overview	E-journals, Journal access	Descriptive statistics	Activity in Technical writing	authors Acknowledgement
S-2	SLO-1	types of research-Descriptive vs analytical	Citation index, Impact factor,	Choosing and using statistical tests	Technical presentation	Group discussion on ethics in research
	SLO-2	types of research -applied vs fundamental	H-index, E-consortium	Sample test – Student –t – test	Activity in Technical presentation	Outcome of group discussion
S-3	SLO-1	types of research-quantitative vs qualitative	UGC infonet, E-book	F- test	Creativity in research – Basic idea	Plagiarism

Duration (hour)		9	9	9	9	9
	SLO-2	types of research-conceptual vs empirical	Preprint servers	κ^2 test	Creativity in research - Activity	Tools to avoid plagiarism
S-4	SLO-1	Literature-review	Search engines, Scirus, Google Scholar	Chemometrics	Good practicals – Units, numbers	Presentations - Power-point presentation.
	SLO-2	Consolidation of Literature-review	ChemIndustry, Wiki-Databases	Analysis of variance (ANOVA),	Reproducibility	Poster presentation
S-5	SLO-1	Sources of information	ChemSpider, Science Direct	Correlation and regression	Scientific writing - Abbreviations	Elements of excellent presentation
	SLO-2	Primary, secondary, tertiary sources	SciFinder, Scopus	Curve fitting	nomenclature	Communication skills
S-6	SLO-1	Journal abbreviations, abstracts,	Internet resources for Science	fitting of linear equations,	justification for scientific contributions	Activity based on research presentation
	SLO-2	reviews, monographs, dictionaries	Library research,	analysis of residuals	description of methods	Activity based on research presentation
S-7	SLO-1	Introduction to Chemical Abstracts	field research	General polynomial fitting	conclusions	Proposal submission for funding agencies
	SLO-2	Author Index	Laboratory research	linearizing transformations	the need for illustration, style	Knowledge of funding agencies
S-8	SLO-1	Formula Index	Data Analysis – Making and Recording Measurements	exponential function fit,	Writing references	Intellectual property
	SLO-2	Subject Index	Continued.	r and its abuse	Research report writing	Intellectual property rights
S-9	SLO-1	Substance Index	Maintaining a laboratory record	Basic aspects of multiple linear regression analysis	Activity based on scientific writing	Copy rights
	SLO-2	other Indices with examples	Tabulation and generation of graphs	Basic aspects of multiple linear regression analysis	Activity based on scientific writing	Patent rights

Learning Resources	
	1. Dawson, C.. Practical research methods. UBS Publishers, New Delhi, 2002 2. Walpole R.A., Myers R.H., Myers S.L.and Ye King: Probablity and statstics for engineers and scientist, Pearson Prentice Hall, Pearson Education, Inc. 2007 3. Kothari C.K., Research Methodology-Methods and Techniques (New Age International, New Delhi), 2004

	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 Understand	30%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	50%	-	50%	-	50%	-	50%	-
Level 3	Evaluate Create	30%	-	20%	-	20%	-	20%	-	20%	-
	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
Dr. Ravikiran Allada, Head R&D, Analytical, Novugen Pharma, Malaysia Email: ravianalytical@gmail.com	1. Prof. G. Sekar, IIT Madras, gsekar@iitm.ac.in	1. Dr. T. Pushpa Malini, SRMIST
	2. Prof. Vivek Polshettiwar, TIFR Mumbai, vivekpol@tifr.res.in	2. Dr.J.Arockia Selvi, SRMIST

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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
CLR-1 :	*develop a sound knowledge of the fundamental concepts in bio-organic chemistry*																		
CLR-2 :	*provide basic understanding about the biomolecules like amino acids, 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*																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	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 :	*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)		9	9	9	9	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	Classification and structure of amino acids	Enzymes, Classification	Nature of genetic material	Fatty acids classification	Classification of carbohydrates
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	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
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	Separation of amino acids	Mechanisms of enzyme action	Nucleotides and nucleosides	Properties of fatty acids	Optical isomerism of sugars
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	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,
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	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
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	Structure and biological functions of coenzyme-A	Tm, denaturation and renaturation	Spingomyelin	Biological importance of mono, di and polysaccharides
S-7	SLO-1	Structure of proteins	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	Thiamine pyrophosphate, pyridoxal phosphate	Basic ideas on replication	Plasmologens	An introduction to mucopolysaccharides
S-8	SLO-1	Determination of the primary structure of a protein, secondary, tertiary and quaternary structures	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	Determination of the primary structure of a protein, secondary, tertiary and quaternary structures	FAD, lipoic acid	Transcription and translation	Structure and function of glycolipids	Reactions of carbohydrates due to the presence of hydroxyl, aldehyde and ketone groups
S-9	SLO-1	Protein denaturation	Overview of reactions catalysed by the above cofactors	Determination of the base sequence of DNA	Cholesterol.	Reactions of carbohydrates due to the presence of hydroxyl, aldehyde and ketone groups
	SLO-2	Protein denaturation	Overview of reactions catalysed by the above cofactors	Determination of the base sequence of DNA	Cholesterol.	Reactions of carbohydrates due to the presence of hydroxyl, aldehyde and ketone groups

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 / 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	Expert from Higher Technical Institutions	Internal Experts
Dr. Ravikiran Allada, Head R&D, Analytical, Novugen Pharma, Malaysia Email: ravianalytical@gmail.com	1. Prof. G. Sekar, Professor, Department of Chemistry, IIT Madras Email: Pgsekar@iitm.ac.in	1. Dr. M. Arthanareeswari , SRMIST
	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

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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:
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 eigen values and eigen vectors
CLR-4 :	understand the concept of probability and random variable
CLR-5 :	acquire knowledge in probability distribution
CLR-6 :	familiarize in applying linear algebra and probability theory

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Scientific Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	apply formulation and solution procedure of system of linear equation	3	85	80	H	H	L	-	-	-	-	-	M	L	-	H	-	-	-
CLO-2 :	gain familiarity with linear transformation	3	85	80	M	H	-	M	M	-	-	-	M	-	-	H	-	-	-
CLO-3 :	gain knowledge in decomposition techniques of matrices	3	85	80	H	H	-		-	-	-	-	M	-	-	H	-	-	-
CLO-4 :	understand about probability and random variables	3	85	80	H	H	H	M	-	-	-	-	M	L	-	H	-	-	-
CLO-5 :	solve problems in probability distributions	3	85	80	M	H	L	-	-	-	-	-	M	-	-	H	-	-	-
CLO-6 :	analyze and solve problems linear algebra and probability theory	3	85	80	M	H	-	-	-	-	-	-	M	-	-	H	-	-	-

Duration (hour)		12	12	12	12	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	Bayes' theorem	Poisson distribution
	SLO-2	Representation of system of linear equation	Kernel of linear transformation	Spectral theorem	**Bayes' 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 distribution
	SLO-2	Inverse of a matrix by Gauss elimination method	Rank-nullity theorem	Eigenvalue decomposition	Discrete random variable	Geometric distribution
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 Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-

Level 3	Analyze	20%	-	30%	-	30%	-	30%	-	30%	-
	Evaluate										
	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
	Prof. B. V. Rathish Kumar, IIT Kanpur, bvrk@iitk.ac.in	Dr.K.Ganesan SRMIST Dr.S.Mohanaselvi, SRMIST

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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	Physics and Nanotechnology	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:	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:	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)		12	12	12	12	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
Dr. M Krishna Surendra, Saint Gobain Research, krishana.muvvala@saint-gobain.com	Prof. C Venkateshwaran, University of Madras, venkateshwaran@unom.ac.in	Dr. A. Karthigeyan, SRMIST
Mr. Navneethakrishanan, CLR Laboratories Pvt Ltd	. Prof. S Balakumar, University of Madras, balakumar@unom.ac.in	*Dr. Alok Kumar, SRMIST*

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Course Code	***PPY21S03L***	Course Name	***Advanced Characterization of Materials and Analysis Laboratory***	Course Category	S	Skill Enhancement Course	L	T	P	C
							0	0	6	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:	explore the synthesis and preparation procedures of various nanomaterials.
CLR-2:	study the structure and microstructures of as-prepared nanomaterials.
CLR-3:	learn the advanced characterization instruments.
CLR-4:	apply the basics of computational modeling and simulation using DFT.
CLR-5	*solve wave equation using Numerov's method*
CLR-6	*calculate the scattering of light using computational tools*

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 (%)	1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1:	*generate the interest on synthesis and fabrication of nanomaterials*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*provide basic knowledge of characterization methods*	2	80	70	H	M	M	H	M	H	H	H	M	H	M	H	M	H	M
CLO-3:	*exploring the advanced characterization techniques, like SEM, TEM, and XPS*	2	75	70	H	M	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-4:	*understanding the importance of computational modeling and simulation in DFT*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5	*solving the wave questions using Numerov's method*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6	*Skills to gain knowledge on advanced programming language*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H

DURATION (HOURS)		18	18	18	18	18
S1 to S6	SLO-1 / SLO-2	Preparation of metal oxide nanoparticles using wet chemical precipitation method.	Determination of average particle size and elemental analysis of metal oxide thin film using scanning electron microscopy (SEM) and composition using EDS	Determination of the wavelength absorbance, particle size, and band gap using UV-Vis spectroscopy of metal oxide nano thin film fabricated using dip coating / spin coating technique	Determination of roughness, and depth profile of metal oxide nano thin film fabricated using dip coating / spin coating technique by AFM.	Modeling, geometrical optimization and determination of total energy, and HOMO-LUMO gap of simple organic and inorganic molecules using Gaussview and Gaussian09.
	SLO-1	Examine the phase purity, crystallite size, strain, and	Estimation of particle size, interplanar spacing and	Determination of mineral concentration using XRF	Determination of resistivity of germanium crystal at	Solve Schrodinger wave equation in one dimension for

S7 to S12	SLO-2	lattice parameters of metal oxide nanoparticles using Powder X-ray diffraction technique.	composition analysis of metal oxide nanomaterials using High Resolution Transmission Electron Microscope (HR-TEM)	spectrometer for metal oxide / sulfide nanoparticles synthesized by chemical precipitation method.	different temperature and estimation of energy band gap using four probe method.	harmonic oscillator using Numerov's method.
S13 to S18	SLO-1	Metal oxide nano thin film fabrication using dip coating / spin coating technique	Identification of functional groups using FTIR spectroscopy for polymer coated metal oxide nanoparticles synthesized using wet chemical precipitation method.	Determination of electronic states and chemical composition of metal oxide thinfilms using X-ray photoelectron spectroscopy (XPS)	Determination of Hall coefficient, carrier density and carrier mobility for a given semiconductor wafer.	Calculation of scattering of light from metallic nano particles *OR* Solve the boundary value problem of nonlinear ordinary differential equation
	SLO-2					

Learning Resources

1. V. Raghvan, *Experiments in Materials Science*, 5th Ed., PHI Learning Pvt. Ltd., 2004.
2. P.M. Martin, *Handbook of Deposition Technologies for Films and Coatings*, 3rd Ed., Elsevier Inc., 2010.
3. Gauglitz, Günter, and Tuan Vo-Dinh, *Handbook of spectroscopy*, John Wiley and Sons, 2006.
4. Yang Leng, *Materials Characterization: Introduction to Microscopic and Spectroscopic Methods*, John Wiley and Sons, 2009.
5. Brundle, C. Richard, and Charles A. Evans, *Encyclopedia of Materials Characterization: Surfaces, Interfaces, Thin Films*, Gulf Professional Publishing, 1992.
6. Pretsch, Ernö, et al. *Structure Determination of Organic Compounds*, Vol. 13. Berlin: Springer, 2009.
7. Mario Birkholz, *Thin Film Analysis by X-ray Scattering*, John Wiley and Sons, 2006.
8. E.Hairer, S.P.Norsett, and G. Wanner, *Solving Ordinary, Differential Equations I*, Vol.1, 2000.
9. F. J. Garcı´a de Abajo, and A. Howie, *Retarded field calculation of electron energy loss in inhomogeneous dielectrics*, Phys. Rev. B 65, 115418, 2002.
10. Sam Zhang, Lin Li, Ashok Kumar, Materials Characterization Techniques, CRC Press, 2008.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)							
		CLA-1 (20%)		CLA-2 (20%)		CLA-3 (40%)		CLA-4 (20%)#	
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	-	30 %	-	30 %	-	30 %	-	30 %
Level 2	Apply / Analyze	-	40 %	-	40 %	-	40 %	-	40 %
Level 3	Evaluate / Create	-	30 %	-	30 %	-	30 %	-	30 %
	Total	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. M Krishna Surendra, Saint Gobain Research, krishana.muvvala@saint-gobain.com	Prof. C Venkateshwaran, University of Madras, venkateshwaran@unom.ac.in	Dr. Suresh Perumal, SRMIST
Mr. Navneethakrishanan, CLR Laboratories Pvt Ltd.	Prof. S Balakumar, University of Madras, balakumar@unom.ac.in	Dr. Ravikirana, SRMIST

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Course Code	Course Name		Course Category			L	T	P	C
PPY21I01L		*Massive Open Online Course*		I	Internship in Industry/higher technical institutions	0	0	0	2

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:	*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*

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Course Code	Course Name		Course Category			L	T	P	C
PPY21I02L		*Internship*		I	Internship in Industry/higher technical institutions	0	0	0	2

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:	*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 %

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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*	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:	*develop contextual approach to acquire new vocabulary*	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:	*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:																		
CLO-1:	*determine the accurate meanings of words*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*recognise parallel relationship between words*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*learn to solve problems*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	*understand and applies problem solving skills learned.*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*inculcate professional communication through Interviews & Group Discussions*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*acquire necessary skills for successful career*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		3	3	3	3	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 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	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	

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SEMESTER IV

Course Code	PPY21P01L	Course Name	*Project Work*	Course Category	P	Project Work	L	T	P	C
							0	0	24	12

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:	*Apply fundamental and disciplinary concepts/techniques to their principal fields of research*
CLR-2:	*Apply knowledge and skills acquired through earlier course work to the professional field of study.*
CLR-3:	*Able to identify, analyze, and solve problems in novel techniques of research through critical investigation.*
CLR-4:	*Integrate information from multiple sources and carry out the projects within multiple design constraints*
CLR-5:	*Apply oral, written and communication skills*
CLR-6:	*Utilize the skills, hard work, and commitment to achieve lifelong learning.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:
CLO-1:	*Demonstrate intelligence, ability, diligence and application of scientific learning for personal, societal, and professional ethical standards.*

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

**includes 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.*

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GENERIC ELECTIVES PHYSICS

Course Code	PPY21G01T	Course Name	Energy Storage and Devices	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:	Learning			Program Learning Outcomes (PLO)														
CLR-1:	provides basic knowledge in the multidisciplinary field of energy storage devices and their applications	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2:	manage basic principles for accessible and relevant energy storage systems qualitatively.	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-3:	*learn concept and operation of available and relevant energy storage systems*																		
CLR-4:	*identify different needs within energy storage.*																		
CLR-5:	*cause of efficiency losses in various energy storage systems*																		
CLR-6:	*identify available technologies and materials for energy storage and their application areas*																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1:	*understand the basic concepts of energy storage devices.*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*gain the knowledge of electrochemical energy storage devices.*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*realize the applications of magnetic and electric energy storage system*	2	75	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-4:	*know about the fuel cell based energy storage system*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*understand the basic concepts of hydrogen production and storage*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*understand the concept and operation of available and relevant energy storage systems.*	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	Definition and units of energy and power	Electrochemical energy storage-Battery	Magnetic and Electric energy storage system	Basics Fuel cell definition	Hydrogen production-From fossil fuels
	SLO-2	Definition and units of conservation of energy	Primary Batteries	Superconducting Magnetic Energy Storage (SMES)	Difference between batteries and fuel cells	Electrolysis
S-2	SLO-1	Definition of Second law of thermodynamics	Secondary Batteries	Capacitors and Batteries	Fuel cell history	Thermal decomposition
	SLO-2	Explanation of Second law of thermodynamics	Lithium Batteries	Comparison and application	Components of fuel cells	Thermal decomposition
S-3	SLO-1	Problem Solving on Energy and Power	Simple numerical problem On Electrochemical energy storage	Problem Solving on capacitors and batteries	Assignment to cover the history of fuel cell	Simple exercise on Electrolysis
	SLO-2	Problem Solving on Second law of thermodynamics	Simple numerical problem On Electrochemical energy storage	Problem Solving on capacitors and batteries	Assignment to cover the history of fuel cell	Simple exercise on Electrolysis
S-4	SLO-1	Energy resources	Solid state Batteries	Super capacitor	Principle of working of fuel cell	Photochemical
	SLO-2	Energy storage	Molten solvent Batteries	Super capacitor	Advantages and Disadvantages of fuel cell power plant	Photo catalytic
S-5	SLO-1	Need of energy storage	Lead Acid Batteries	Electrochemical double layer capacitor (EDLC)	Fuel cell types-Alkaline fuel cell	Hybrid storage
	SLO-2	Different modes of energy storage-Capacitors	Nickel cadmium Batteries	Principle of working of EDLC	Polymer electrolyte fuel cell	Hybrid storage
S-6	SLO-1	Problem Solving on capacitors	Assignment on Solid state battery	Assignment on EDLC	Seminar related to various fuel power plants in India	Assignment on Hydrogen storage
	SLO-2	Problem Solving on capacitors	Assignment on Solid state battery	Assignment on EDLC	Seminar related to various fuel power plants in India	Assignment on Hydrogen storage
S-7	SLO-1	Electrochemical energy storage	Advanced Batteries	Structure, Performance of EDLC	Phosphoric acid fuel cell	Metal hydrides
	SLO-2	Electrical energy storage	Advanced Batteries	Applications of EDLC	Molten carbonate fuel cell	Metallic alloy hydrides
S-8	SLO-1	Magnetic and , Chemical energy storage	Role of Carbon Nano-tubes in electrodes	Role of activated Carbon	Solid oxide fuel cell	Carbon Nano-tubes
	SLO-2	Hydrogen for energy storage	Role of Carbon Nano-tubes in electrodes	Role of Carbon Nano-tubes	Problems with fuel, Applications of fuel cells	Sea as the source of deuterium
S-9	SLO-1	Assignment on Electrochemical energy storage	Simple activity related to advanced batteries	Student seminar related to CNT	Assignment on Acid and Oxide fuel cell	Student seminar related to Deuterium
	SLO-2	Assignment on Electrochemical energy storage	Simple activity related to advanced batteries	Student seminar related to CNT	Assignment on Acid and Oxide fuel cell	Student seminar related to Deuterium

Learning Resources

1. R.A. Huggins, *Energy Storage*, 1st Ed., Springer, 2010.
2. J.-M. Tarascon, and Patrice Simon, *Electrochemical Energy Storage*, 1st Ed., Wiley, 2015.
3. F. Díaz-González, A. Sumper and O. Gomis-Bellmunt, *Energy storage in power systems*, 1st Ed., Wiley, 2016.
4. Srinivasan, *Fuel Cells from Fundamentals to Applications*, 1st Ed., Springer, 2006.
5. Basile, A. Iulianelli, *Advances in Hydrogen Production*, 1st Ed., *Storage and Distribution*, Woodhead Publishing, 2014.
6. N. Kularatna, *Energy Storage Devices for Electronic Systems: Rechargeable Batteries and Supercapacitors*, Academic Press, 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	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
Dr. DK Aswal, NPL, dkaswal@nplindia.org	Prof. V Subramanian, IIT Madras, manianvs@iitm.ac.in	Dr. Kamalabharathi
Dr. M Krishna Surendra, Saint Gobain Research, krishana.muvvala@saint-gobain.com	Prof. S Balakumar, University of Madras, balakumar@unom.ac.in	Dr. Gunasekran

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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 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 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
Dr. M Krishna Surendra, Saint Gobain Research, krishana.muvvala@saint-gobain.com	Prof. C Venkateshwaran, University of Madras, venkateshwaran@unom.ac.in	Dr. A. Karthigeyan, SRMIST
Mr. Navneethakrishanan, CLR Laboratories Pvt Ltd.	Prof. S Balakumar, University of Madras, balakumar@unom.ac.in	Dr. Debabrata Sarkar, SRMIST

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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):	At the end of this course, learners will be able to:	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
		Learning 1	2	3	**Program Learning Outcomes (PLO)** 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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	H	M	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 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
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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