COURSE STRUCTURE

For

M.Sc. PHYSICS

Based on CBCS & OBE model



Department of Physics BIT Mesra, Ranchi 2021

Course Structure for M.Sc.(Physics)

el			Code no.Name of the subjects		L	Т	Р	С	
Lev									
				THEORY					
		PC	PH 401	Mathematical Method in Physics	3	0	0	3	
	H		PH 402	Electrodynamics	3	0	0	3	
	-Te		PH 403	Classical Mechanics	3	0	0	3	
	ste		PH 404	Quantum Mechanics	2	1	0	3	
1	Je		PH 405	Modern Computational Techniques &	2	0	0	2	
-	n e			Programming					
	Š	OE		Open Elective II	3	0	0	3	
			LABORATORIES						
		PC	PH 406	Modern Computational Techniques &	0	0	4	2	
				Programming Lab					
			PH 407	Modern Physics Lab	0	0	4	2	
2		MC	MT204	Constitution of India	2	0	0	Non-	
								Credit	
						1	Fotal	21	

			Code no.	Name of the subjects	L	Т	Р	С
Level								
	II	Category		THEORY				
	Ĺ	PC	PH 408	Statistical Physics	3	1	0	4
	te		PH 409	Atomic and Molecular Spectroscopy	3	1	0	4
	GS		PH 410	Electronic Devices & Circuits	3	0	0	3
4	Ŭ		PH 411	Condensed Matter Physics	3	0	0	3
	ē	OE		Open Elective III	3	0	0	3
				SESSIONAL / LABORATOR	Y			
		PC	PH 412	Electronics Lab	0	0	4	2
			PH 413	Condensed Matter Physics Lab	0	0	4	2
]						Fotal	21

		CategoryCode no.Name of the subjects		L	Т	Р	С	
Level								
				THEORY				
	Π	PC	PH 501	Nuclear and Particle Physics	3	1	0	4
			PH 502	Advanced Quantum Mechanics	3	1	0	4
	fel		PH 503	Laser Physics and Applications31		1	0	4
	est	PE	PH 504 to PH 512	PE-V	4	0	0	4
5	eme		(Annexure II)	One paper from Either Group A or B or C or D or E: Specialization				
		PE	PH 500	Project (Phase-I) from Either Group				4
			(Annexure II)	A or B or C or D or E				
				LABORATORIES				
		PC	PH 513	Laser Physics Lab	0	0	4	2
				· · · ·			Total	22

		Category	Code no.	Name of the subjects		Т	Р	С	
Level									
				THEORY					
	H	PE	PH 513 to	PE - VI: One paper from Either	r 4	0	0	4	
	er		PH 530	Group A or B or C or D or E	:				
	st		(Annexure II)	Specialization					
5	Je			PE - VII: One paper from Either	r 4	0	0	4	
5	n			Group A or B or C or D or E	:				
	Š			Specialization					
			PH 550	Project (Phase-II) from Either Group	5			8	
				A or B or C or D or E					
				Total					

Total Credits of M.Sc. Physics (I to IV Semesters) = 80

<u>Note:</u> The contents of laboratory papers are designed to meet the course objectives and outcomes of their respective theory papers.

Annexure II

PE	Pre-requisites	Subjects	
PE -V	One paper from	Group A- Theoretical and Computational Physics:	
	Either Group A	Numerical Methods for Physicists	PH 504
	or B or C or D or	• Theory of Solids	PH 505
	Ε	Group B- Condensed Matter Physics:	
		• Theory of Solids	PH 505
		Functional Materials	PH 506
		Group C – Photonics:	
		• Fiber and Integrated Optics	PH 507
		Quantum & Nonlinear Optics	PH 508
		Group D- Electronics	
		Instrumentation and Control	PH 509
		Physics of Low dimensional Semiconductors Devices	PH 510
		Group E- Plasma Sciences:	
		Introduction to Plasma Physics	PH 511
		Plasma Processing of Materials	PH 512
DE VI	Two nonous fuo	Crown A. Theoretical and Computational Division	
PE-VI	I wo papers from	Group A- Theoretical and Computational Physics:	DU 514
	(Papers shall be	Theoretical and Computational Fluid Dynamics Theoretical and Computational Condensed Matter Physics	ГП 314 DU 515
	chosen from same	 Incordical and Computational Condensed Matter Physics Neglineer Demonics and Chass 	PH 516
	group in IX and X	Nonlinear Dynamics and Chaos	111,510
	Semesters)	Group B- Condensed Matter Physics:	
	,	Nonconventional Energy Materials	PH 517
		Cryogenic Physics	PH 518
		Physics of Thin Films	PH 519
		Theory of Dielectrics and Ferroics	PH 520
		• Theoretical and Computational Condensed Matter Physics	PH 515
		Crear C. Distanting	
		Group C- Photonics:	DH 521
		Photomic and Optoelectronic Devices	ГП 321 DH 522
		 Holography and Applications Quantum photonics and applications 	PH 523
		Quantum photonics and applications Introduction to Nenerhotonics	PH 524
		Introduction to Nanophotonics	111 524
		Group D- Electronics:	
		Microprocessor and Microcontroller Applications	PH 525
		Integrated Electronics	PH 526
		Microwave Electronics	PH 527
		Group E- Plasma Sciences:	
		• Theory of Plasmas	PH 528
		Plasma Confinement	PH 529
		• Waves and Instabilities in Plasma	PH 530
		Physics of Thin Films	PH 519

M.Sc. Physics (I -IV Semester)

Semester	Subjects	Credit	Total
Ι	Mathematical Method in Physics	3	21
	Electrodynamics	3	
	Classical Mechanics	3	
	Quantum Mechanics	3	
	Modern Computational Techniques &	2	
	Programming		
	Open Elective I	3	
	Modern Computational Techniques &	2	
	Programming Lab		
	Lab-II (Modern Physics Lab)	2	
II	Statistical Physics	4	21
	Atomic and Molecular Spectroscopy	4	
	Electronics Devices & Circuits	3	
	Condensed Matter Physics	3	
	Open Elective II (Other Dept)	3	
	Lab III (Electronics Lab)	2	
	Labs IV (Condensed Matter Physics Lab)	2	
III	Nuclear and Particle Physics	4	22
	Advanced Quantum Mechanics	4	
	Laser Physics and Applications	4	
	PE - V	4	Papers shall be
	One paper from Either Group A or B or C or D or		chosen from
	E: Specialization		I.MSc. IX and X
			Semesters
	Project from Either Group A or B or C or D or E	4	
	Lab –V (Laser Physics Lab)	2	
IV	PE - VI	4+4	16
	One paper from the same Group A or B or C or D		
	or E		
	PE - VII		
	One paper from the same Group A or B or C or D		
	or E	-	
	Project (Phase-II) from Either Group A or B or C	8	
	or D or E		
		Total	80

<u>Internship (In-house/External)</u> of at least 2 months should be done by the students (Non-credit)

Course Assessment tools & Evaluation procedure for Theory Papers

Direct Assessment						
Assessment Tool	% Contribution during CO Assessment					
Assignment	10					
Seminar before a commitee	10					
Three Quizes	30 (10+10+10)					
End Sem Examination Marks	50					

Indirect Assessment

- 1. Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

Course Assessment tools & Evaluation procedure for Laboratory Papers

Assessment Tool	% Contribution		
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)		
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)		

Semester I

COURSE INFORMATION SHEET

Course code: PH 401 Course title: Mathematical Methods in Physics Pre-requisite(s): Mathematical Physics Co- requisite(s): Credits: 3 L: 3 T: 0 P: 0 Class schedule per week: Class: M.Sc.		
Semester / Level: I		
Branch: PHYSICS Name of Teacher:		
Code: Title: Mathematical Methods in Physics	L-T-P-C	
PH 401	[3-0-0-3]	
Course Objectives: The objectives of the course are		
1. To train the students to solve problems related to complex variables which contain re	al and imaginary p	oarts.
2. To teach the use of different special functions in solving physical problems.		
3. To provide an understanding of Integral Transform and Probability.		
4. To teach about an understanding of Tensors.		
5. To give the basic knowledge of Group theory.		
Course Outcomes: After completion of the course students should be able to		
1. The students will be able to solve different physical problems which contain comp	plex variables.	
2. They will be familiarized with different special functions like Associated Legendre	e Polynomials,	
Polynomials, etc. and their solutions in solving different physical problems.	·	
3. This module will be helpful to obtain knowledge of Fourier and Laplace Transform	ns in solving	
different problems of Mechanics and Electronics etc. The module will also impart	some basic	
knowledge of Probability.		
4. Students will be able to learn about the concept and uses of Tensors.		
5. Useful to obtain the basic knowledge of Group theory and its applications.		
Modula 1 Complex verifications		[4]
Analytic functions Cauchy-Riemann conditions Cauchy's Integral theore	em and Integral	נטן
formula, Laurent expansion. Singularities, Evaluation of residues, Residue the	orem.	
Module-2 Special Functions		[8]
Associated Legendre Polynomials, Recurrence relations, Rodrigue's formula,	Orthogonality of	L - J
Legendre Polynomials, Hermite Polynomials, Green's function.	C .	
Module-3 Integral Transform		[10]
Laplace Transform, Inversion, Applications of Laplace Transform; Fou	rier Transform,	
Inversion, Fourier Sine and Cosine transform, Convolution Theorem, Fouri	er transforms of	
derivatives, Applications of Fourier Transform.		
Flementary probability theory simple properties random variables binor	nial and normal	
distribution centre limit theorem	inai and normai	
Module-4 Tensors		[8]
Covariant, Contravariant and Mixed tensors, Tensors of rank 2, Algebra or	f tensors: Sum,	
Difference & Product of Two Tensors, Contraction, Quotient Law of Tensors	s, Pseudotensors,	
dual tensors, Tensors in General Coordinates, Tensor derivative operators, Ja	cobians, Inverse	
of Jacobians. Diad and Triad.		
Module-5 Introductory group theory		[8]
Review of sets, Mapping and Binary Operations, Relation, Types of Re	a group Co gota	
of a subgroup; SU(2). O(3).	a group, co-sets	

Text books:

T1: Hans J. Weber George B. Arfken, Mathematical Methods for Physicists, (2005), Academic Press.

T2: L. A. Pipes, Applied Mathematics for Engineering and Physics (1958) McGraw-Hill.

T3: Elements of Group Theory for Physicists by A. W. Joshi, 1997, John Wiley.

Reference books:

R1: Charlie Harper, Introduction to Mathematical Physics (2003), Prentice-Hall India.

R2: Erwin Kreyszig, Advanced Engineering Mathematics (1999), Wiley.

R3: N. P. Bali, A. Saxena and N.C. S. W. Iyengar, A Text Book of Engineering Mathematics (1996), Laxmi Publications (P) Ltd.

R4: Group Theory and its Applications to Physical Problems by Morton Hamermesh, 1989, Dover

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	Ν
Laboratory experiments/teaching aids	Ν
Industrial/guest lectures	Ν
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and internets	Υ
Simulation	Ν

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
End Sem Examination Marks					
Quiz 1	\checkmark	\checkmark			
Quiz 2			\checkmark		
Quiz 3					

Indirect Assessment -

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Objectives onto Course Outcomes

Course Outcome #	Program Outcomes				
	а	b	с	d	e
1	Н	L	L	L	L
2	L	Н	L	L	L
3	L	L	Η	L	L
4	L	L	L	Η	L
5	L	L	L	L	Н

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #			Program (Outcomes		
	а	b	с	d	e	f
1	Н	Н	Н	М	Н	Н
2	Н	Н	Н	М	Н	Н
3	Н	Н	Н	М	Н	Н
4	Н	Н	Н	М	Н	Н
5	Н	Н	Н	М	Н	Н

	Mapping Between COs and Course Delivery (CD) methods									
CD	Course Delivery methods		Course Outcome	Course Delivery Method						
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1 and CD2						
CD2	Tutorials/Assignments		CO2	CD1 and CD2						
CD3	Seminars		CO3	CD1 and CD2						
CD4	Mini projects/Projects		CO4	CD1 and CD2						
CD5	Laboratory experiments/teaching aids		CO5	CD1 and CD2						
CD6	Industrial/guest lectures									
CD7	Industrial visits/in-plant training									
CD8	Self- learning such as use of NPTEL materials and internets									
CD9	Simulation									

Week	Lect.	Fentati	Ch.	Fopics to be covered	Гext	COs	Actual	Methodo	Remarks
No.	No.	ve	No.		Book /	mappe	Content	logy	by
		Date			Refere	d	covered	used	faculty if
					nces				any
1-2	L1-L6			Analytic functions, Cauchy-	T1, R1	1		PPT	
				Riemann conditions, Cauchy's				Digi	
				Integral theorem and Integral				Class/	
				formula, Laurent expansion,				Chock	
				Singularities, Evaluation of				-Board	
				residues, Residue theorem.				-Doard	
3-5	L7-			Associated Legendre Polynomials,	T1,	2			
	L14			Recurrence relations, Rodrigue's	T2, R2				
				formula, Orthogonality of Legendre					
				Polynomials, Hermite Polynomials,					
				Green's function.					
5-7	L15-			Laplace Transform, Inversion,	T1,R3	3			
	L20			Applications of Laplace					
				Transform; Fourier Transform,					
				Inversion, Fourier Sine and Cosine					
				transform, Convolution Theorem,					
				Fourier transforms of derivatives,					
				Applications of Fourier Transform.					
7-8	L21-			Elementary probability theory,	T2, R2	3			
	L24			simple properties, random					
				variables, binomial and normal					
				distribution, central limit theorem					

9-11	L25-		Covariant, Contravariant and	T1, T2	4		
	L32		Mixed tensors, Tensors of rank 2,				
			Algebra of tensors: Sum,				
			Difference & Product of Two				
			Tensors, Contraction, Quotient				
			Law of Tensors, Pseudo tensors,				
			dual tensors, Tensors in General				
			Coordinates, Tensor derivative				
			operators, Jacobians, Inverse of				
			Jacobians. Diad and Triad.				
11-14			Review of sets, Mapping and	T3, R4	5		
			Binary Operations, Relation, Types				
			of Relations, Groups: Elementary				
			properties of groups, uniqueness of				
			solution, Subgroup, Centre of a				
			group, Co-sets of a subgroup:				
			SU(2), O(3).				

Course code: PH 402 Course title: Electrodynamics Pre-requisite(s): Electricity and Magnetism Co- requisite(s): Credits: 3 L: 3 T: 0 P: 0 Class schedule per week: Class: M.Sc. Semester / Level: I Branch: PHYSICS Name of Teacher:

Code: PH 402	Title: Electrodynamics	L-T-P-C [3-0-0-3]				
Cou	a course onebles the students:					
	Introducing the mathematical tools used in electrodynamics	1				
B	Review of electrostatics and magnetostatics in matter					
<u> </u>	Providing easy headway into the covariant formulation of Maxwell's equations.					
D	Teaching basic principles of waveguides and transmission lines.					
E.	E. Rendering insights into fields generated by oscillating sources, and their applications.					
Cou Aft	arse Outcomes er the completion of this course, students will be:					
1.	Ability to use basic mathematical tools to solve problems in electrodynamics.					
2.	Gaining proficiency in electrostatics and magnetostatics.					
3. Obtaining command on four-vector and tensor notations.						
4.	4. Learning about TM, TE and TEM modes in waveguides.					
5.	5. Understanding radiations by moving charges.					
Module-1 Module- 2	Module-1The concept of a scalar potential. Poisson's and Laplace's equations for scalar potential. G theorem, Electrostatic field energy density. Solutions of Laplace's equation in rectangular, sph and cylindrical coordinates using the method of separation of variables, Method of in Multipole expansion of potential due to a localized charge distribution.Module- 2Electrostatics in matter; Polarization and electric displacement vector. Electric field at the bou of an interface, Linear dielectrics. Magnetostatics, Biot-Savart Law, Ampere's Law, Scalar Vector potentials, Magnetic moment of a current distribution.					
Module- 3	Electromagnetic induction, Faraday's Law, Maxwell's equations, Maxwell's equations in ma Conservation of charge, Poynting's theorem, Solutions of Maxwell's Equations, Cova formulation of electrodynamics. Inhomogeneous wave equations and their solutions.	atter, [8] iriant				
Module- 4	Electromagnetic waves in matter, Reflection and refraction at a plane interface between dielect Fresnel's equations. Phase velocity and group velocity, spreading of a pulse propagating dispersive medium, propagation in a conductor, skin depth. Transmission lines and v guides; Dynamics of charged particles in static and uniform electromagnetic fields.	trics, [8] in a wave				
Module- 5	EM Field of a localized oscillating source. Fields and radiation in dipole and quadru approximations. Antenna; Radiation by moving charges, Lienard-Wiechert potentials, total per radiated by an accelerated charge, Lorentz formula.	ipole [8] ower				
Reference1. Introdu2. Classic3. Lecture	res: action to Electrodynamics by D. J. Griffiths eal Electrodynamics by J. D. Jackson es on Electromagnetism by A. Das					

<u>Course Outcome (CO) Attainment Assessment tools & Evaluation procedure</u> <u>Direct Assessment</u>

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

Indirect Assessment -

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks					
End Sem Examination Marks					
Quiz I					
Quiz II					

Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4	<u>5</u>
А	Н	М	-	М	L
В	Н	Н	-	L	-
С	Н	М	Н	Н	М
D	Н	L	-	Н	L
E	Н	L	М	М	Н

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes							
	a	b	c	d	e	f		
1	Н	Н	Н	Н	Н	Н		
2	Н	Н	Н	Н	Н	Η		
3	Н	Н	Η	Η	Н	Η		
4	H	Н	Н	Η	Н	Η		
5	Н	Н	Н	Н	Н	Н		

Week	Lect.No.	Fentati	Ch.	Fopics to be covered	Гext	COsma	Actual	Metho	Remar
No.		ve	No.		Book /	pped	Content	dology	ks by
		Date			References		covered	used	faculty
									f any
1	L1-L4			The concept of a scalar potential.	T1,T3	1			
				Poisson's and Laplace's equations for					
				scalar potential. Green's theorem,					
				Electrostatic field energy density.					
				Solutions of Laplace's equation in					
				rectangular coordinates					

2	1510	I autoria a succession in autorial and	T1 T2	1			
2	L3-L8	Laplace's equation in spherical and	11,13	1			
		cylindrical coordinates using the					
		method of separation of variables,					
		Method of images, Multipole expansion					
		of potential due to a localized charge					
		distribution.					
3	L9-	Electrostatics in matter; Polarization and	T1,T3	2			
	L12	electric displacement vector. Electric					
		field at the boundary of an interface,					
		Linear dielectrics. Magnetostatics, Biot-					
		Savart Law, Ampere's Law,					
4	L13-	Scalar and Vector potentials,	T1,T3	2			
	L16	Magnetic moment of a current					
		distribution. Macroscopic					
		magnetostatics, Magnetization. M and					
		H vectors, Boundary conditions.					
5	L17-	Electromagnetic induction, Faraday's	T1,T3	3			
	L20	Law. Maxwell's equations. Maxwell's					
		equations in matter. Conservation of					
		charge Poynting's theorem					
6	I 21-	 Solutions of Maxwell's Equations	Т1 Т3	3			
0	L21 L 24	Covariant formulation of	11,15	5			
	1.24	electrodynamics. Inhomogeneous wave					
		equations and their solutions					
7	1.25	Electrometric controls.	T1 T2	4			
/	L25-	Electromagnetic waves in matter,	11,13	4			
	L28	Reflection and refraction at a plane					
		interface between dielectrics, Fresnel's					
		equations. Phase velocity and group					
		velocity, spreading of a pulse					
		propagating in a dispersive medium,					
8	L29-32	propagation in a conductor, skin	T1,T3	4			
		depth. Transmission lines and wave					
		guides; Dynamics of charged particles					
		in static and uniform electromagnetic					
		fields.					
9	L33-	EM Field of a localized oscillating	T1,T3	5			
	L36	source. Fields and radiation in dipole					
		and quadrupole approximations.					
10	L37-	Antenna; Radiation by moving charges.	T1,T3	5			
	L40	Lienard-Wiechert potentials, total	,				
		power radiated by an accelerated					
		charge Lorentz formula					
	1		1	1	1	1	1

Course code: PH 403 **Course title: Classical Mechanics** Pre-requisite(s):): Classical Dynamics (or similar papers) Or Mechanics and Electricity & Magnetism at UG level **Co- requisite(s):** Credits: P: 0 **3** L: 3 T: 0 **Class schedule per week:** Class: M.Sc. Semester / Level: I **Branch: PHYSICS** Name of Teacher: Code: **Title: Classical Mechanics** L-T-P-C PH 403 [3-0-0-3] **Course Objectives**

This course enables the students:

	chaolos die stadents.	
A.	To define the concepts of Langrangian Mechanics.	
В.	To interpret the concepts of Hamiltonian Mechanics.	
C.	To explain generating function, canonical transformation & Poisson brackets.	
D.	To illustrate the dynamics of a rigid body and non-inertial frames of reference.	
E.	To formulate the concepts of coupled oscillators.	

Course Outcomes

After the completion of this course students will be able to:

Alter		inpletion of this course, students will be able to.	
	1.	Formulate the Lagrangian mechanics concepts and solve the problems with the help of	
		Lagrangian mechanics.	
	2.	Compare the formulation of Hamiltonian Lagrangian mechanics and solve the problems	
		of classical and relativistic mechanics	
	3.	Solve the problems of generating function, canonical transformation & Poisson brackets.	
	4.	Formulate the equations of rigid body dynamics and demonstrate the examples of non-	
		inertial frames of reference.	
	5.	Solve the equations of coupled oscillator and to examine the two coupled pendulums, and	
		double pendulum related problems.	
Modu	le-1	Constraints, classification of constraints, generalized coordinates, principal of virtual work, D	[10]
		Alembert's principal, Langrange's equations of motion, properties of kinetic energy function,	
		theorem on total energy, generalized momenta, cyclic-coordinates, integrals of motion, Jacobi	
		integrals and energy conservation, concept of symmetry, invariance under Galilean	
		transformation, velocity dependent potential.	
		Two body central force problem: reduction of two body problem to equivalent one body	
		problem, equation of motion under central force and first integrals, differential equation for an	
		orbit, Kepler's law, stability of orbits, virial theorem, scattering in a central force field.	
Modu	le-2	Hamilton's function and Hamilton's equation of motion, configuration space, phase space and	[7]
		state space, Lagrangian and Hamiltonian of relativistic particles, Relativistic Lagrangian and	
		Hamiltonian of a charged particle in an electromagnetic field.	
Modu	le-3	Generating function, Conditions for canonical transformation and problem. Poisson Brackets,	[5]
		its definitions, identities, Poisson theorem, Jacobi-Poisson theorem, Jacobi identity, invariance	
		of PB under canonical transformation. Lagrange bracket.	
Modu	le-4	Dynamics of a Rigid Body: Rigid body and space reference system, Euler's angles, angular	[10]
		momentum and inertia tensor, principal moment of inertia, rotational kinetic energy of rigid	
		body, symmetric bodies, moments of inertia for different body system, Euler's equation of	
		motion for a rigid body by Newtonian method and Lagrange's method	
		Non-inertial frames of reference, fictitious force, uniformly rotating frames, coriolis force,	
		Foucault's pendulum, Larmor precession, effects of Coriolis force on: river flow on the surface	
		of the earth, air flow on the surface of the earth, projectile motion	
Modu	le-5	Coupled Oscillator: Potential energy and equilibrium of one dimensional oscillator,	[8]
		differential equations for coupled oscillator, kinetic and potential energies of the coupled	
		oscillators, theory of small oscillations, examples of coupled oscillator: two coupled	
		pendulums, double pendulum	

Reference books:

- 1. Classical Mechanics by H. Goldstein, Pearson Education Asia.
- 2. Classical Dynamics of Particles and Systems by Marion and Thomtron, Third Edition, Horoloma Book Jovanovich College Publisher.
- 3. Classical Mechanics by P. V. Panat, Narosa Publishing Home,, New Delhi.
- 4. Classical Mechanics by N. C. Rana and P. S. Joag, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.
- 5. Introduction to Classical Mechanics by R. G. Takwale and P. S. Puranik, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.
- 6. Landau and Lifsitz

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	N
Mini projects/Projects	N
Laboratory experiments/teaching aids	N
Industrial/guest lectures	N
Industrial visits/in-plant training	N
Self- learning such as use of NPTEL materials and internets	Y
Simulation	N

<u>Course Outcome (CO) Attainment Assessment tools & Evaluation procedure</u> <u>Direct Assessment</u>

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizzes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination	\checkmark	\checkmark			
End Sem Examination	\checkmark	\checkmark		\checkmark	
Quiz I	\checkmark	\checkmark			
Quiz II				\checkmark	

Indirect Assessment -

- 1. Student Feedback on Faculty
- 2. Student Feedback on Course Outcome
- **3.** Teacher's assessment

Mapping between Objectives and Outcomes

Mapping between Course Objectives and Course Outcomes

		Course Outcomes					
Course Objectives	1	2	3	4	<u>5</u>		
Α	Н	Μ	Μ	L	L		
В	Н	Н	Μ	L	L		
С	М	Μ	Η	L	L		
D	L	L	L	Η	L		
Е	L	L	L	L	Н		

Mapping of Course Outcomes onto Program Outcomes								
Course	Program Outcomes							
Outcome #	а	b	с	d	e	f		
1	Н	Н	Н	Н	Н	Н		
2	Н	Н	Н	Н	Н	Н		
3	Н	М	М	Н	Н	М		
4	Н	L	L	М	Н	М		
5	Н	М	Н	М	Н	М		

Mapping of Course Outcomes onto Program Outcomes

	Mapping Between COs and Course Delivery (CD) methods							
CD	Course Delivery methods	Course Outcome	Course Delivery Method					
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1 and CD2					
CD2	Tutorials/Assignments	CO2	CD1 and CD2					
CD3	Seminars	CO3	CD1 and CD2					
CD4	Mini projects/Projects	CO4	CD1 and CD2					
CD5	Laboratory experiments/teaching aids	CO5	CD1 and CD2					
CD6	Industrial/guest lectures	-	-					
CD7	Industrial visits/in-plant training	-	-					
CD8	Self- learning such as use of NPTEL materials and internets	-	-					
CD9	Simulation	-	-					

Week	Lect.	Tentative	Ch.	Topics to be covered	Text	COs	Actual	Methodol	Remarks
No.	No.	Date	No.		Book /	mapp	Content	ogy	by
					Refere	ed	covered	used	faculty
					nces				if any
	L1-L3			Constraints, classification	T1				
				of constraints, generalized	T2				
				coordinates, principal of					
				virtual work, D Alembert's					
				principal, Langrange's					
				equations of motion					
	L4-			properties of kinetic energy	T1				
	L6			function, theorem on total	T2				
				energy, generalized					
				momenta, cyclic-					
				coordinates, integrals of					
				motion, Jacobi integrals					
				and energy conservation,					
				concept of symmetry					
	L7-			invariance under Galilean	T1				
	L10			transformation, velocity	T2				
				dependent potential.					
				Two body central force					
				problem: reduction of two					
				body problem to equivalent					
				one body problem,					
				equation of motion under					
				central force and first					
				integrals, differential					

	equation for an orbi Kepler's law, stability c	t, f		
	orbits, virial theorem	l,		
	field	e		
L11-	Hamilton's function an	d T1		
L13	Hamilton's equation of	f T2		
I 14	motion	- TT1		
L14	space and state space			
I 15-	Lagrangian an	12 d T1		
L13	Hamiltonian of relativisti	c T2		
	particles, Relativisti	c		
	Lagrangian an	d		
	Hamiltonian of a charge	d		
	particle in a	n		
I 10	electromagnetic field.	<u>т</u> 1		
L18, 1 19	Conditions for canonica	1, 11 $1 T^2$		
	transformation an	d 12		
	problem.			
L20-	Poisson Brackets, it	s T1		
L22	definitions, identities	s, T2		
	Poisson theorem, Jacobi	-		
	Poisson theorem, Jacob	1		
	under canonica	5		
	transformation. Lagrang	e		
	bracket.	-		
L23-	Dynamics of a Rigid Body	r: T1		
L27	Rigid body and spac	e T2		
	reference system, Euler	S		
	angles, angular momentur	n 1		
	moment of inertia			
	rotational kinetic energy of	., f		
	rigid body, symmetri	c		
	bodies, moments of inerti	a		
	for different body system	l,		
	Euler's equation of motio	n		
	Ior a rigid body b Newtonian method an	y d		
	Lagrange's method	u		
L28-	Non-inertial frames of	f T1		
L32	reference, fictitious force	e, T2		
	uniformly rotating frames	s,		
	coriolis force, Foucault'	S		
	pendulum, Larmo	r		
	Coriolis force on rive	I r		
	flow on the surface of th	e		
	earth, air flow on th	e		
	surface of the earth	l,		
	projectile motion.			

L32,	Coupled Oscillator:	T1
L33	Potential energy and	T2
	equilibrium of one	
	dimensional oscillator,	
L34-	differential equations for	T1
L38	coupled oscillator, kinetic	T2
	and potential energies of	
	the coupled oscillators,	
	theory of small oscillations,	
L39,	examples of coupled	T1
L40	oscillator: two coupled	T2
	pendulums, double	
	pendulum.	

Course code: PH 404 Course title: Quantum Mechanics Pre-requisite(s): Previous papers of Quantum Mechanics Co- requisite(s): Credits: 3L: 2 T:1 P: 0 Class schedule per week: Class: M.Sc. Semester / Level: I Branch: PHYSICS Name of Teacher:

Name of Teacher: Code: **Title: Quantum Mechanics** L-T-P-C PH 404 [2-1-0-3] **Course Objectives** This course enables the students to: A. define Heisenberg & Dirac formulation of quantum mechanics and explain their importance.-Outline the basics of crystallography and define various types of imperfections in crystals. B. demonstrate the linear harmonic oscillator and hydrogen-like atom using Dirac formulation-Explain elastic and plastic deformation in solids and summarize the strain hardening mechanisms. C. explain the angular momentum operators associated with spherical and symmetrical systems-Define ceramics and explain its types and applications. D. illustrate scattering theory and determine the scattering parameters.-Define polymers and composites and categorize them on the basis of their applications. E. formulate the approximation methods to solve real problems which are insolvable analytically-Define Nanotechnology and outline the various properties of nano materials and their fabrication techniques. **Course Outcomes** After the completion of this course, students will be able to: 1. formulate the Heisenberg & Dirac formulation of quantum mechanics-explain various types of imperfections in crystals. 2. solve the linear harmonic oscillator and hydrogen-like atom problems using Dirac formulation-analyze the mechanisms behind elastic and plastic deformation is solids and compare different strengthening techniques. 3. demonstrate angular momentum operators associated with spherical and symmetrical systems.-summarize ceramics and its types and relate their applications with properties. 4. explain scattering theory, formulate and solve scattering equation-classify polymers and composites based on their properties and applications. apply the Variational principle and WKB Approximation to solve the real problems-Classify nanomaterials, 5. their fabrication techniques and co relate the effects of confinement to nanoscale on their properties. Module-1 **Introduction to Dirac and Heisenberg Formulation:** [10] Linear vector space, Dirac Bra-Ket notations. Determination of eigen-values and eigen-functions using matrix representations. Coordinate and momentum representation. Uncertainty principle. Module-2 Harmonic Oscillator and Hydrogen atom problem: [10] Linear harmonic oscillator, Heisenberg and quantum mechanical treatments. Asymptotic behaviour, energy levels, correspondence with classical theory. Spherically symmetric potential in three dimensions, hydrogen atom, wave functions, eigenvalues, degeneracy, etc. Module-3 Angular momentum and its addition: [10] Theory of angular momentum, symmetry, invariance and conservation laws, relation between rotation and angular momentum. Commutation rules, eigenvalues and eigen

functions of the angular momentum. Stern-Gerlach experiment, spin, spin operators, Pauli's spin matrices. Spin states of two spin-1/2 particles. Addition of angular momenta, Clebsch-Gordon coefficients. Principle of indistinguishablity of identical

	particles, Pauli's exclusion principle.				
Module-4	Scattering theory: Scattering Theory, differential and total scattering cross-section	[5]			
	laws, partial wave analysis and application to simple cases; Integral form of				
	scattering equation, Born approximation validity and simple applications.				
Module-5 Approximation Methods: Variational Principle, WKB approximation, solution					
	near a turning point, connection formula, tunnelling through barrier. boundary				
	conditions in the quasi classical case.				
Text b	ooks:				
1. J.J	. Sakurai, Modern Quantum Mechanics , Addison-Wesley Publishing Company, 1994.				
2. No	uredine Zettili, Ounatum Mechanics: Concepts and Application, Wiley Publications 2016.				
3. R.	Shankar, Principles of Quantum Mechanics, Plenum Press, 1994.				
Refere	nce books:				
increa c					
1. L.]	. Schiff, Quantum Mechanics, Tata McGraw Hill, New Delhi				
2 L	D Landau and E. M. Lifshitz, Quantum Mechanics, Pergamon, Berlin				
2. L.I	Dendad and E. M. Ensintz, Quantum Moonanies, Pergamon, Dermi.				

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP	Yes
projectors	
Tutorials/Assignments	Yes
Seminars	No
Mini projects/Projects	No
Laboratory experiments/teaching aids	No
Industrial/guest lectures	No
Industrial visits/in-plant training	No
Self- learning such as use of NPTEL materials and	Yes
internets	
Simulation	No

<u>Course Outcome (CO) Attainment Assessment tools & Evaluation procedure</u> <u>Direct Assessment</u>

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizzes	30 (10+10+10)
End Sem Examination Marks	50

AssessmentCompoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	Yes	Yes	Yes	No	No
End Sem Examination Marks	Yes	Yes	Yes	Yes	Yes
Assignment	Yes	Yes	Yes	Yes	Yes

Indirect Assessment -

- 1. Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Course		Program Outcomes					
Outcome #	a	b	с	d	e	f	
1	Н	Н	Н	L	М	L	
2	Н	Н	М	L	L	L	
3	Н	М	М	L	L	L	
4	Н	М	М	L	L	L	
5	Н	Н	Н	L	Н	L	

Mapping of Course Outcomes onto Program Outcomes

Course	Course Objectives					
Outcome #	a	b	с	d	e	
1	Н	М	М	М	L	
2	М	Н	М	М	L	
3	М	М	Н	L	L	
4	М	М	Н	L	L	
5	М	М	L	L	Н	

	Mapping Between COs and Course Delivery (CD) methods						
		(Course	Course	Delivery		
CD	Course Delivery methods		Outcome	Method			
CD1	Lecture by use of boards/LCD projectors/OHP projectors	(CO1	CD1, CD2	2 and CD8		
CD2	Tutorials/Assignments	(CO2	CD1, CD2	2 and CD8		
CD3	Seminars	(203	CD1, CD2	2 and CD8		
CD4	Mini projects/Projects	(CO4	CD1, CD2	2 and CD8		
CD5	Laboratory experiments/teaching aids	(205	CD1, CD2	2 and CD8		
CD6	Industrial/guest lectures			·			
CD7	Industrial visits/in-plant training						
CD8	Self- learning such as use of NPTEL materials and internets						
CD9	Simulation						

Week No.	Lect. No.	Tent ative Date	Modul e No.	Topics to be covered	Text Book / Refere nces	Cos mapped	Actual Content covered	Methodolog yused	Remarks by faculty if any
1	L1		Ι	Linear vector space	T2	CO-1		PPT Digi Class/Chal k Board	
	L2-L3			Dirac Bra-Ket notations	T2	CO-1		PPT Digi Class/Chal k-Board	
2	L4-6			Determinationofeigen-valuesandeigen-functionsusingmatrix epresentations.	T1	CO-1		PPT Digi Class/Chal k-Board	
3	L7-8			Coordinate and	T1	CO-1		PPT Digi Class/Chal	

			momentum			k-Board	
			representation				
3-4	L9- L10		Uncertainty principle	Т3	CO-1	PPT Digi Class/Chal k-Board	
4	L11	II	Linear harmonic oscillator	Т3	CO-2	PPT Digi Class/Chal k-Board	
4-5	L12- 13		Heisenberg and quantum mechanical treatments.	Т3	CO-2	PPT Digi Class/Chal k-Board	
5	L14		Asymptotic behaviour, energy levels,	T1	CO-2	PPT Digi Class/Chal k-Board	
5	L15		correspondence with classical theory.	T1	CO-2	PPT Digi Class/Chal k-Board	
6	L16- 17		Spherically symmetric potential in three dimensions,		CO-2	PPT Digi Class/Chal k-Board	
6-7	L18- 19		hydrogen atom, wave functions, eigenvalues, degeneracy, etc.	T1, T2, T3	CO-2	PPT Digi Class/Chal k-Board	
7	L20- 21	III	Theory of angular momentum, symmetry, invariance and conservation laws,	T2	CO-3	PPT Digi Class/Chal k-Board	
8	L22- 23		relation between rotation and angular momentum.	T2	CO-3	PPT Digi Class/Chal k-Board	
8-9	L24- 25		Commutation rules, eigenvalues and eigen functions of the angular momentum.	T1	CO-3	PPT Digi Class/Chal k-Board	
9	L26- 27		Stern-Gerlach experiment, spin, spin operators	T1	CO-3	PPT Digi Class/Chal k-Board	
10	L28		Pauli's spin matrices. Spin states of two spin-1/2 particles.	T1, T2, T3	CO-3	PPT Digi Class/Chal k-Board	
10	L29		Addition of angular momenta, Clebsch- Gordon coefficients.	T1, T2, T3	CO-3	PPT Digi Class/Chal k-Board	
10	L30		Principleofindistinguishablityofidentical particles,	T1, T2, T3	CO-3	PPT Digi Class/Chal k-Board	
11	L31		Pauli's exclusion principle	T3	CO-3	PPT Digi Class/Chal	

	-	1	1		1		
							k-Board
11	L29		IV	Scattering Theory, differential and total scattering cross- section laws	T2	CO-4	PPT Digi Class/Chal k-Board
11	L30			partialwaveanalysisandapplicationtocases	T2	CO-4	PPT Digi Class/Chal k-Board
12	L31			Integral form of scattering equation	T1	CO-4	PPT Digi Class/Chal k-Board
12	L32- 33			Born approximation validity and simple applications	T2	CO-4	PPT Digi Class/Chal k-Board
13	L34		V	Variational Principle, WKB approximation	T2	CO-5	PPT Digi Class/Chal k-Board
13	L35			solution near a turning point	T2	CO-5	PPT Digi Class/Chal k-Board
13	L36			connectionformula,tunnellingthroughbarrier	T2	CO-5	PPT Digi Class/Chal k-Board
14	L37			boundary conditions in the quasi classical case	T2	CO-5	PPT Digi Class/Chal k-Board

Course code: PH 405 Course title: Modern Computational Techniques & Programming Pre-requisite(s): Mathematical Physics Co- requisite(s): Credits: 2 L: 2 T: 0 P: 0 Class schedule per week: Class: M.Sc. Semester / Level: I Branch: PHYSICS Name of Teacher:

Code: PH405	Title: Modern Computational Techniques & Programming I						
Course (Diectives:	[= • • =]					
The idea	behind the course is to teach students to solve problem in physics using MAPLE and MATLAB. In	this regard					
the object	tives are to	-					
1. T	each to calculate various errors which arise while solving different equations.						
2. T	rain them to solve systems of linear equations.						
3. T	each them the concept of interpolation.						
4. li 5. T	rain them to calculate integrals and differentials using different numerical methods.						
Program	Program Outcomes: After completion of the course, students should be able to						
2. E	ffectively use methods like matrix inversion, Gauss elimination and LU decomposition to solve line quations.	ar					
3. E	Chrich a given set of data points using interpolation methods like cubic spline, Newton's divided diff	erence,					
4. N	Jumerically differentiate and integrate expressions.						
5. S	olve equations from physics like heat equation, diffusion equation, etc. numerically.						
Module-1	Approximation Methods Errors and Roots of Equations Accuracy and precision Truncation	[8]					
inicaule 1	and round-off errors, Bracketing Methods (false position, bisection), Iteration Methods (Newton-Raphson and secant).	[0]					
Module-2	Systems of linear algebraic equations Gauss elimination, matrix inversion and LU decomposition methods.	[4]					
Module-3	Curve fitting and Interpolation Least squares regression, Linear, multiple linear and nonlinear regressions, Cubic spline. Newton's divided difference and Lagrange interpolating polynomials.	[6]					
Module-4	Numerical differentiation and integration, Divided difference method for differentiation, Newton-Cotes formula, Trapezoidal and Simpson's rules, Romberg and Gauss quadrature methods.	[5]					
Module-5	Ordinary and Partial differential equations, Euler's method and its modifications, Runge-Kutta methods, Boundary value and Eigen value problems. Finite difference equations, Elliptic equations, Laplace's equation and solutions, Parabolic equations, Solution of the heat conduction equation	[12]					
Text bo	bks:						
T1: Ir	troductory Methods of Numerical Analysis, S.S. Sastry, Prentice Hall of India (1983)						
Referen	ce books:						
R1: N	lumerical Analysis, V. Rajaraman						
R2: N	lumerical Methods for Engineering, S.C. Chopra and R.C. Canale, McGraw-Hill (1989).						
R3: 1	Numerical Methods for Scientists and Engineers, Prentice Hall of India (1988).						

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Υ
Tutorials/Assignments	Υ
Seminars	Ν
Mini projects/Projects	Ν
Laboratory experiments/teaching aids	Ν
Industrial/guest lectures	Ν
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and internets	Υ
Simulation	Υ

<u>Course Outcome (CO) Attainment Assessment tools & Evaluation procedure</u> <u>Direct Assessment</u>

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	C05
End Sem Examination Marks					
Quiz 1					
Quiz 2					
Quiz 3					

Indirect Assessment -

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Objectives onto Course Outcomes

Course Outcome #	Program Outcomes				
	a	b	с	d	e
1	Н	L	L	L	L
2	L	Н	L	L	L
3	L	L	Н	L	L
4	L	L	L	Н	L
5	L	L	L	L	Н

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	а	b	с	d	e	f
1	Н	Н	Н	М	Н	Н
2	Н	Н	Н	М	Н	Н
3	Н	Н	Н	М	Н	Η
4	Н	Н	Н	М	Н	Н
5	Н	Н	Н	М	Н	Н

Mapping Between COs and Course Delivery (CD) methods					
CD	Course Delivery methods	Course Outcome	Course Delivery Method		
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2 and CD9		
CD2	Tutorials/Assignments	CO2	CD1, CD2and CD9		
CD3	Seminars	CO3	CD1, CD2 and CD9		
CD4	Mini projects/Projects	CO4	CD1, CD2 and CD9		
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2 and CD9		
CD6	Industrial/guest lectures				
CD7	Industrial visits/in-plant training				
CD8	Self- learning such as use of NPTEL materials and internets				
CD9	Simulation				

Week	Lect.	Tent	Ch	Topics to be covered	Text	COs	Actual	Methodol	Remarks
No.	No.	ative	•		Book /	map	Content	ogy	by
		Date	No.		Refere	ped	covered	used	faculty if
					nces				any
1-3	L1- L12			Approximation Methods, Errors and Roots of Equations, Accuracy and precision, Truncation and round-off errors, Bracketing Methods (false position, bisection),	T1, R1	1		PPT Digi Class/Cho ck -Board	
				Iteration Methods (Newton- Raphson and secant).					
3-5	L13- L24			Systems of linear algebraic equations Gauss elimination, matrix inversion and LU decomposition methods.	T1	2			
5-8	L25- LL36			Curve fitting and Interpolation Least squares regression, Linear, multiple linear and nonlinear regressions, Cubic spline. Newton's divided difference and Lagrange interpolating polynomials.	T1, R2	3			
8-10	L37- L48			Numerical differentiation and integration, Divided difference method for differentiation, Newton-Cotes formula,	T1, R1	4			

		Trapezoidal and Simpson's rules Romberg and Gauss quadrature methods.				
10-14	L49- L60	Ordinary and Partial differential equations, Euler's method and its modifications, Runge-Kutta methods, Boundary value and Eigen value problems. Finite difference equations, Elliptic equations, Laplace's equation and solutions, Parabolic equations Solution of the heat conduction equation	T1, R3	5		

Course code: PH 406 Course title: Modern Computational Techniques & Programming Lab Pre-requisite(s): Mathematical Physics Co- requisite(s): Credits: 2L: 0 T: 0 P: 4 Class schedule per week: Class: M.Sc. Semester / Level: I Branch: PHYSICS Name of Teacher:

Name of Teacher: **Title: Modern Computational Techniques & Programming Lab** L-T-P-C [0-0-4-2] 1. Evaluate f(0.8) using Taylor's series for f(x), where $f(x) = 5x^4 - 2x^2 + 3x - 2$ 2. Find the truncation error by comparing the following functions with their values calculated using zeroth, first,...,seventh order Taylor's expansion: a) $sin(\pi/3)$ b) $\frac{1}{1-0.1}$ 3. Let $u = \frac{5xy^3}{z^2}$. If $\Delta x = \Delta y = \Delta z = 0.01$ and x = y = z = 2, calculate the maximum relative and absolute errors. 4. Find the roots of the function $10\sin(x) = 2x^2 + 1.$ Maple is not able to find an exact (symbolic) solution of the equation. There are two general approaches to obtaining an approximate solution that you might consider in a case like this; graphical and numerical. 5. Solve the following set of linear equation by (i) Gauss elimination (ii) Matrix inversion and (iii) LU decomposition methods.

x + 3y - 2z = 103x + 5y + 6z = 72x + 4y + 3z = 8

6. Fit the given set of data points to a gaussian function of the form $a_0 * exp^{-(x^2-a_1)}$:

(-3, 0.0188), (-2.68, 0.1112), (-2.37, 0.5468), (-2.05, 2.2223), (-1.74, 7.3486), (-1.42, 19.8502), (-1.11, 43.9048), (-0.79, 79.6264), (-0.47, 118.49122), (-0.16, 144.6785), (0.16, 144.6785), (0.4737, 118.4912), (0.7895, 79.6264), (1.11, 43.9048), (1.42, 19.8502), (1.74 7.3486), (2.05, 2.2223), (2.37, 0.5468), (2.68, 0.1112), (3, 0.01877)

Find the values of a_0 and a_1 .

7. Using the table below, find f(x) as a polynomial in x for data points provided below: (-1,5), (2,-6), (5,4), (6, 9), (7,10), (9,13), (11, 16), (13,18)

8. Using the values of x and y provided in the table below, obtain dy/dx and d^2x/d^2y for x = 1.2.

×	Y
1.0	2.7188
1.2	3.3289
1.4	4.0068
1.6	4.9538
1.8	6.0489
2.0	7.4567
2.2	9.2258
2.4	11.8976

9. Evaluate the integral $\int_0^1 \frac{x^3}{e^x - 1}$ using trapezoidal and Simpson's rules correct to five decimal places. Which method gives the most accurate result?

10. A solid of revolution is formed by rotating about the x-axis the area between the x-axis, the lines x = 0 and x = 1, and a curve through the points with the following coordinates:

×	Y
0.00	1.0000
0.25	0.9900
0.50	9600
0.75	0.9100
1.00	0.8400

11. Solve the following differential equation (overdamped Langevin equation):

 $\gamma \frac{dx}{dt} = -kx + \sqrt{2k_BT} \,\xi(t),$

where , *T* and *k* are constants, and $\xi(t)$ is a random variable sampled from a normal distribution. Take $k_B = 1$. Start with the initial condition x(t = 0) = 0.

12. Solve Laplace equation in Cartesian coordinates, in a region defined by a parallelepiped of dimensions L_1 , L_2 and L_3 . The equation is

$$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} + \frac{\partial^2 \phi}{\partial z^2} = 0.$$

The potential vanishes on 5 faces of the parallelepiped. On the 6th face at $z = L_3$, the potential is a known function f(x, y).

13. Solve the heat equation $\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2}$

Subject to the initial conditions: $u = sin(\pi x)$ at t = 0 for $0 \le x \le 1$ and u = 0 at x = 0 and x = 1 for t > 0.

14. Consider a system of 100 identical particles interacting via a Lennard-Jones potential:

$$U_{LJ}(r) = 4\epsilon \left[\left(\frac{\sigma}{r}\right)^{12} - \left(\frac{\sigma}{r}\right)^{6} \right] ,$$

which is terminated and shifted at $r = r_{cut} = 2.5\sigma$, so that the truncated potential \bar{U}_{LJ} is defined as,

$$\bar{U}_{LJ}(r) = \begin{cases} U_{LJ}(r) - U_{LJ}(r_{\text{cut}}) & \text{if } r < r_{\text{cut}} \\ 0 & \text{if } r > r_{\text{cut}} \end{cases}$$

All the quantities are defined in terms of reduced Lennard-Jones units with mass m, interaction parameter ϵ and length scale σ having unit values. Using NVT simulations, plot the equilibrium energy of the system against temperature.

References:

- 1. Numerical Mathematical Analysis, J.B. Scarborough, John Hopkins (1966).
- 2. Introductory Methods of Numerical Analysis, S.S. Sastry, Prentice Hall of India (1983)
- 3. Numerical Methods for Engineering, S.C. Chopra and R.C. Canale, McGraw-Hill (1989).
- 4. Numerical Methods for Scientists and Engineers, Prentice Hall of India (1988).
- Electromagnetics and Calculation of Fields, Nathan P-Ida and J.P.A. Bastos, Springer-Verlag (1992).

Course Assessment tools & Evaluation procedure

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

Course code: PH 407 Course title: Modern Physics Lab Pre-requisite(s): Co- requisite(s): Credits: 2L: 0 T: 0 P: 4 Class schedule per week: Class: I.M.Sc. Semester / Level: VII / I Branch: PHYSICS Name of Teacher:

Modern Physics Lab

L-T-P-C [0-0-4-2]

Name of the Experiment

- 1. To determine specific charge of electron by Thomson's method/circular trajectory method. (Thomson's experiment)
- 2. To Verify the inverse Square law using Planck's constant measuring instrument.(Inverse square law)
- 3. Determination of Planck's constant using Light Emitting Diode (LEDs) (Planck's constant)
- 4. Verification of energy quantisation by Franck-Hertz Experiment. (Franck-Hertz Experiment)
- 5. Study of the voltage and current of the solar cells in series and parallel combinations. (Characteristic of Solar cell)
- 6. To measure the charge of electron and show that it is quantised with the smallest value of 1.6× 10-19 coulombs (Millikan's oil drop experiment)
- 7. To study the variation of count rate with applied voltage and thereby determine the plateau, the operating voltage and slope of plateau (G M Counter)
- 8. To observe the dielectric constant by comparison of electrical conductivity of different materials to that of a metal.(Dielectric constant)

Course Assessment tools & Evaluation procedure

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

Semester II

COURSE INFORMATION SHEET

C		
Course	code: PH 408	
Course	title: Statistical Physics	
Pre-ree	uisite(s): Mathematical Physics	
Co- rec	uisite(s): Quantum Physics	
Credits	4 L: 3 T: 1 P: 0	
Class s	chedule per week:	
Class:	I.M.Sc.	
Semest	er / Level: II	
Branch	: PHYSICS	
Name o	f Teacher:	
Code:	Title: Statistical Physics	L-T-P-C
PH 408		[3-1-0-4]
Course	Objectives	
1	To understand the dependence of equilibrium properties of various systems on their microscopic cons	stituents
1.	and compute thermodynamic parameters by using classical statistics.	, indentis
2.	To learn to use methods of quantum statistics to obtain properties of systems made of microscopic pa	rticles
	which either obey Fermi-Dirac statistics or Bose-Einstein statistics.	
3.	To grasp the concepts of first order and second order phase transitions and critical phenomena.	
4.	To understand phase transition arising in Ising model.	
5.	To learn to obtain the properties of out-of-equilibrium systems using concepts from equilibrium phys	ics.
Course	Outcomes: Students should be able to	
1	Use various ensemble theories to calculate the thermodynamic properties of different systems	
2	Compute properties of systems behaving as ideal Fermi gas or ideal Bose gas	
2.	Compute properties of systems behaving as facal rethin gas of facal bose gas.	
5.	Classify transitions as first order or second order.	
4.	The student should be able to reproduce the exact solution of Ising model in one dimension and solve	it using
	mean field theory.	
5.	Understand the approach required to predict the evolution of non-equilibrium systems.	
Module	-1 Formalism of Equilibrium Statistical Mechanics	[8]
	Concept of phase space, Liouville's theorem, basic postulates of statistical mechanics,	
	ensembles: microcanonical, canonical, grand canonical and their partition functions,	
	connection to thermodynamics, fluctuations, applications of various ensembles, equation of	
	state for a non-ideal gas. Van der Waals' equation of state. Meyer cluster expansion, virial	
	coefficients.	
Module	-2 Quantum Statistics	[8]
1110 4410	Formalism of Fermi-Dirac and Bose-Einstein statistics Applications of the formalism to: (a)	[0]
	Ideal Bose gas Debye theory of specific heat properties of black-body radiation Bose-	
	Einstein condensation degeneracy BEC in a harmonic potential (b) Ideal Fermi gas	
	properties of simple metals. Pauli paramagnetism electronic specific heat	
Module	 Phose Transitions and Critical Phonomena 	[9]
wiodule	First and Second order Phase transitions Diamagnetism paramagnetism and	[0]
	farromagnetism Landau theory critical phenomena. Critical exponents, scaling hypothesis	
Madula	4 Joing Model : Joing Model mean field theory, event solution in one dimension	[6]
Madala	-4 Ising Model: Ising Model, mean-field theory, exact solution in one dimension.	[0]
Module	-5 Nonequilibrium Systems: Correlation of space-time dependent fluctuations, fluctuations and	[10]
	transport pnenomena, Diffusion equation, Random walk and Brownian motion, Langevin	
	theory, fluctuation dissipation theorem, Fokker-Planck equation.	
Text b	boks:	
T1: Sta	tistical Physics, Landau and Lifshitz, Pergamon Press	
Refere	nce books:	
R1: Stat	istical Physics, R. K. Patharia, Pergamon Press	

R2: Statistical Physics, Kerson Huang, John Wiley and Sons R3: Statistical Physics, S. K. Ma, World Scientific Publishing, Singapore

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	Ν
Laboratory experiments/teaching aids	Ν
Industrial/guest lectures	Ν
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and internets	Y
Simulation	N

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizzes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	C05
End Sem Examination Marks					
Quiz 1					
Quiz 2					
Quiz 3					

Indirect Assessment -

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Objectives onto Course Outcomes

Course Outcome #		Program Outcomes					
	а	b	с	d	e		
1	Н	L	L	L	L		
2	L	Н	L	L	L		
3	L	L	Н	L	L		
4	L	L	L	Н	L		
5	L	L	L	L	Н		

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #			Program O	outcomes		
	а	b	с	d	e	f
1	Н	Н	Н	М	Н	Н
2	Н	Н	Н	М	Н	Н

3	Н	Н	Н	М	Н	Н
4	Н	Н	Н	М	Н	Н
5	Н	Н	Н	М	Н	Н

	Mapping Between COs and Course Delivery (CD) methods							
CD	Course Delivery methods	Course Outcome	Course Delivery Method					
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1 and CD2					
CD2	Tutorials/Assignments	CO2	CD1 andCD2					
CD3	Seminars	CO3	CD1 and CD2					
CD4	Mini projects/Projects	CO4	CD1 and CD2					
CD5	Laboratory experiments/teaching aids	CO5	CD1 and CD2					
CD6	Industrial/guest lectures							
CD7	Industrial visits/in-plant training							
CD8	Self- learning such as use of NPTEL materials and internets							
CD9	Simulation							

Week	Lect.	Tent	Ch.	Topics to be covered	Text	COs	Actual	Methodology	Remar
No.	No.	ative	No.		Book /	mappe	Content	used	ks by
		Date			Refere	d	covered		faculty
					nces				if any
1-3	L1-			Concept of phase space,	T1	1		PPT Digi	
	L8			Liouville's theorem, basic				Class/Chock	
				postulates of statistical				-Board	
				mechanics, ensembles:					
				microcanonical, canonical,					
				grand canonical and their					
				to thermodynamics					
				fluctuations applications of					
				various ensembles, equation of					
				state for a non-ideal gas. Van					
				der Waals' equation of state,					
				Meyer cluster expansion, virial					
				coefficients.					
3-6	L9-			Formalism of Fermi-Dirac and	T1,	2			
	L16			Bose-Einstein statistics.	R1, R2				
				Applications of the formalism					
				to: (a) Ideal Bose gas, Debye					
				theory of specific heat,					
				radiation Rosa Einstein					
				condensation degeneracy BEC					
				in a harmonic potential (b)					
				Ideal Fermi gas, properties of					
				simple metals, Pauli					
				paramagnetism, electronic					
				specific heat					
6-8	L17-			First and Second order Phase	T1,R2	3			
	L24			transitions, Diamagnetism,	3				

		paramagnetism, and ferromagnetism, Landau theory, critical phenomena, Critical exponents, scaling hypothesis.				
8-10	L25-	Ising Model, mean-field theory,	T1, R3	4		
	L30	exact solution in one dimension.				
11-14	L31-	Correlation of space-time	T1, R3	5		
	L40	dependent fluctuations,				
		fluctuations and transport				
		phenomena, Diffusion equation,				
		Random walk and Brownian				
		motion, Langevin theory,				
		fluctuation dissipation theorem,				
		Fokker-Planck equation.				

Course code: PH 409 **Course title: Atomic and Molecular Spectroscopy Pre-requisite(s): Modern Physics** Co- requisite(s): Credits: P: 0 **4**L: 3 T: 1 **Class schedule per week:** Class: I.M.Sc. Semester / Level: VIII / II **Branch: PHYSICS** Name of Teacher:

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1	۲		1.			
L		()a	e:		

Code: PH 409	Title: Atomic and Molecular Spectroscopy	L-T-P-C [3-1-0-4]
Course	e Objectives	
This c	ourse enables the students:	
А.	To learn about the intricacies of spectra of Hydrogen-like atoms	
В.	To understand the details of rotational, vibrational and Raman spectra of molecu	les.
C.	To know about the different regions of spectra, and the corresponding instrumen	tations.
D.	To learn about NMR spectra and its application	
E.	To get a feeling of the principles of mass spectroscopy and ionization methods.	

Course Outcomes

Aft	er the completion of this course, students will be:	
1.	Able to deal with problems related to Hydrogen-like atomic spectra	
2.	Having knowledge about the rotational, vibrational and Raman spectroscopy of molecu	les
3.	Able to comprehend the instrumentation techniques that are used in different region spectra	is of
4.	Understanding NMR spectra and visualize the physical phenomenon	
5.	Learning about mass spectroscopy and its usage	
Module	-1 Atomic Physics: Quantum states of an electron in an atom; Electron spin; Stern-Gerlach experiment; Spectrum of Hydrogen, helium and alkali atoms; Relativistic corrections for energy levels of hydrogen; Hyperfine structure and isotopic shift; Spectral terms, L-S and J-J coupling schemes, Singlet-Triplet separation for interaction energy of L-S coupling. Lande Interval rule, Zeeman, Paschen Back & Stark effect; width of spectral lines	[10
Module	-2 Molecular Spectroscopy: Types of molecular spectroscopy, applications, Rotational, vibrational and electronic spectra of diatomic and polyatomic molecules; Born Oppenheimer approximation, Frank – Condon principle and selection rules. Molecular hydrogen, Fluorescence and Phosphorescence, Instrumentations of IR and Microwave Spectroscopy and Applications. Raman Effect, Rotational Raman spectra. Vibrational Raman spectra. Stokes and anti-Stokes lines and their Intensity difference, Instrumentation and applications.	[12]
Module	-3 Characterization of electromagnetic radiation, regions of spectrums, spectra representation, basic elements if practical spectroscopy, resolving power, width and intensity of spectral transition, Fourier transform spectroscopy, concept of stimulated emission.	[10]
Module	-4 NMR Spectroscopy: Nuclear spin, nuclear resonance, saturation, spin-spin and spin-lattice relaxations, chemical shift, de shielding, coupling constant, instrumentation and applications.	[8]
Text books:

- 1. Introduction to Atomic Spectra", H.E. White, McGraw-Hill.
- 2. Fundamentals of Molecular Spectroscopy" C. N. Banwell, Tata McGraw-Hill
- 3. Atomic Physics", G. P. Harnwell & W.E. Stephens, McGraw-Hills Book Company, Inc.
- 4. Modern Spectroscopy", J. M. Hollas, John Wiley

Reference books:

- 1. "Physics of Atoms and Molecules" by Bransden & Joachain, Pearson
- 2. "Introduction to Spectroscopy" by Pavia et. al., Cengage Learning India Pvt. Ltd.

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizzes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination					
Marks					
End Sem Examination					
Marks					
Quiz I					
Quiz II					

Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4	<u>5</u>
А	Н	-	L	L	-
В	-	Н	Н	-	-
С	L	Н	Н	-	-
D	-	-	L	Н	-
E	-	-	-	-	Н

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	а	b	с	d	e	f
1	Н	М	Н	М	L	М
2	Н	Н	Н	М	Н	М
3	L	Н	М	М	Н	М
4	L	М	М	М	Н	М
5	М	М	М	М	М	М

Lecture wise Lesson planning Details.

I

Week	Lect.	Tentative	Ch.	Topics to be covered	Гext	COs	Actual	Methodology	Remarks by
No.	No.	Date	No.	-	Book /	mapped	Content	used	faculty if any
					Refere		covered		
					nces				
1	L1-			Atomic Physics:	T2, R1	1		PPT Digi	
	L3			Quantum states of an				Class/Choc	
				electron in an atom;				k	
				Electron spin; Stern-				D 1	
				Gerlach experiment;				-Board	
				Spectrum of					
				Hydrogen, helium and					
				alkali atoms;					
				Relativistic					
				corrections for energy					
				levels of hydrogen					
2	L4-			Hyperfine structure	T2, R1	1			
	L6			and isotopic shift;					
				Spectral terms, L-S					
				and J-J coupling					
				schemes, Singlet-					
				Triplet separation for					
				interaction energy of					
				L-S coupling					
3	L7-			Lande Interval rule,	T2, R1	1			
	L9			Zeeman, Paschen					
				Back & Stark effect;					
4	I 10			width of spectral lines	T2 D1	2			
4	L10-			Molecular Speetroseenvy Types	12, KI	2			
	LIZ			spectroscopy: Types					
				spectroscopy					
				applications					
				Rotational vibrational					
				and electronic spectra					
				of diatomic and					
				polyatomic molecules:					
				Born Oppenheimer					
				approximation. Frank					
				– Condon principle					
				and selection rules.					
5	L13-			Molecular hydrogen,	T2, R1	2			
	L15			Fluorescence and					
				Phosphorescence,					
				Instrumentations of IR					
				and Microwave					
				Spectroscopy and					
				Applications. Raman					
				Effect					

6	L16-	Rotational Raman	T2, R1	2		
	L19	spectra. Vibrational	,			
		Raman spectra Stokes				
		and anti-Stokes lines				
		and their Intensity				
		difference				
		Instrumentation and				
		and annihilation and				
7	1.20	applications.	TO D 1	2		
/	L20-	Characterization of	12, R1	3		
	L22	electromagnetic				
		radiation, regions of				
		spectrums, spectra				
		representation, basic				
		elements if practical				
		spectroscopy				
8	L23-	resolving power,	Т2	3		
	L25	width and intensity of				
		spectral transition,				
		Fourier transform				
		spectroscopy, concept				
		of stimulated				
		emission.				
9	L26-	NMR Spectroscopy:	T2, R2	4		
	L29	Nuclear spin, nuclear				
		resonance, saturation,				
		spin-spin and spin-				
		lattice relaxations				
10	L30-	chemical shift, de	T2, R2	4		
	L33	shielding, coupling				
		constant,				
		instrumentation and				
		applications.				
11	L34-	Principle and	R2	5		
	L37	applications of Mass				
		Spectroscopy,				
		Thomson's method of				
		determining e/m of				
		electrons, Aston mass				
		 spectrograph,				
12	L38-	Dempster's mass	R2	5		
	L41	spectrometer,				
		Ionization Methods,				
		instrumentation and				
		applications.				

Course code: PH 410 Course title: Electronic Devices & Circuits Pre-requisite(s): Digital and Analog Systems Co- requisite(s): Credits: 3L: 3 T: 0 P: 0 Class schedule per week: Class: I.M.Sc. Semester / Level: VIII / II Branch: PHYSICS Name of Teacher:

Code:

PH 410

Title: Electronic Devices & Circuits	5
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L-T-P-C
[3-0-0-3]

Course Objectives:

- To impart knowledge about a To impart knowledge about a variety of special, power and microwave solid state electronic devices, their structure and the underlying physical principles.
- To expose the students to the integrated circuit chip development technologies and associated processes
- Amplifiers would be dealt with in all its expanse and rigor to give a good feel of the associated design and mathematical intricacies.
- A rigorous treatment on integrated circuit operational amplifiers is to be delivered to supplement their understanding on amplifiers
- Linear and non-linear applications of op-amps are introduced to add to the knowledge on the variety of circuits encompassing all major class of applications.
- Nanoelectronic devices and concepts are introduced to give a feel of the future electronics devices and the quantum effects that manifest.

Course Outcomes:

- Understanding the physics of the devices their characteristics and applications, to be able to use them in electronic circuits
- Students would develop an insight into the technologies that go into an IC chip that they would be extensively using during and after the course
- In depth understanding would enable the students to appreciate the beauty of the subject and design amplifiers that are technically sound.
- Students would develop a comprehensive understanding of contemporary integrated circuit amplifier design.
- Students would be aware of various signal conditioning, processing and generation techniques thus being better equipped to understand their use in larger and complex systems.
- Students would enjoy the new and stimulating ideas behind the future novel devices and would also appreciate the link between electronics and the quantum effects that come into play.

Madula 1	Floaturnia Devices	0
Module-1	Electronic Devices	0
	Varactor diode, photo-diode, Schottky diode, solar cell, Principle of Operation and I-V	
	Characteristics of IFET MOSFET Thyristors (SCR LASCR Triac and Diac) Microwave	
	aminonductor deviceor Turnel diede INDATT Curn effect and Curn diede	
	semiconductor devices: runner diode, intra i r, Guini effect and Guini diode.	
Module-2	Integrated circuits: Monolithic IC's, Hybrid IC's. Materials for IC fabrication (Si and GaAs),	8
	Crystal growth and wafer preparation, processes Epitaxy, Vapour phase epitaxy (VPE), Molecular	
	beam epitaxy (BME), MOCVD Oxidation, Ion implantation, Optical lithography, electron beam	
	lithography, Etching processes.	
Module-3	Amplifiers using discrete devices	12
	Amplifiers using BJTs, FETs, MOSFETs and their analysis. Feedback in amplifiers,	
	characteristics of negative feedback amplifiers, input resistance, output resistance, method of	
	analysis of a feedback amplifier, feedback types and their analyses, Bode plots, two-pole and	
	three-pole transfer function with Feedback, approximate analysis of a multipole feedback	
	amplifier, stability, gain and phase margins, compensation, dominant-pole compensation, pole-	
	zero compensation.	
Module 4	Operational amplifiers	10
	Differential Amplifier, emitter-coupled differential amplifier, transfer characteristics of a	
	differential amplifier, current mirror and active load, Measurement of op-amps parameters,	
	frequency response of op-amps, dominant-pole compensation, pole-zero compensation, lead	

	compensation, step response of op-amps.	
Module 5	Applications of Op-Amps	12
	Linear: instrumentation amplifier, precision rectifiers, active filters (low-pass, high-pass, band-	
	pass, band-reject/ notch), Analog computation circuits	
	Nonlinear: Comparators, Schmitt trigger, multivibrators, AMV and MMV using 555 timer,	
	waveform generation, D/A converters, binary weighted, A/D converters, simultaneous, counter	
	type, dual slope converter.	
	Single electron devices: Quantum point contact, Coulomb blockade, Resonant tunneling	
	transistor, Single electron transistor (SET).	
Text bo	oks:	
T1: Phy	sics of Semiconductor Devices- S. M. Sze	
	d State Electronic Devices B. C. Streatman DIII	

T2: Solid State Electronic Devices- B. G. Streetman, PHI

T3: VLSI Technology, S. M. Sze Mc Graw Hill

T4: Integrated Electronics, Jacob Millman and Christos Halkias, -Tata McGraw Hill Publication

T5: Thomas L. Floyd. ELECTRONIC. DEVICES. 9th Edition. Prentice Hall.

T6: Louis Nashelsky and Robert Boylestad, Electronic Devices and Circuit Theory

T7: Khan and Dey, A First course in Electronics, PHI

T8: Operational amplifiers and Linear Integrated Circuits- R. A. Gayakwad, PHI.

T9: Linear Integrated Circuits- D. R. Choudhary and S. B. Jain, New Age Publications

Reference books:

R1: Operational amplifier and Linear Integrated Circuits- R. F. Coughlin, F. F. Driscoll, PHI

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	Ν
Laboratory experiments/teaching aids	N
Industrial/guest lectures	N
Industrial visits/in-plant training	N
Self- learning such as use of NPTEL materials and internets	Y
Simulation	N

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizzes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5	CO6	CO7
Quiz-I							
Quiz-II							
Quiz-III							
Assignment							
End Sem Exam							

Indirect Assessment -

- **1.** Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

<u>Mapping between Objectives and Outcomes</u> Mapping between Course Objectives and Course Outcomes

mapping between course objectives and course outcomes							
Course Objectives	1	2	3	4	5	6	
Α	Н	Н	Н	Н	Н	Н	
В	Н	Н	Η	L	Η	Η	
С	Η	L	Η	L	М	L	
D	Н	М	М	Н	Н	М	
Е	Н	Н	Н	Н	Н	М	
F	Н	Н	Н	L	М	Н	
G	Н	Н	L	Μ	L	L	

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #			Prog	gram Out	comes		
	a	b	c	d	e	f	g
1	Н	Н	Н	Н	Н	М	Н
2	Н	Н	Н	Н	Н	М	Н
3	Н	Н	Н	Н	Н	М	Н
4	Н	Н	Н	Н	Н	М	Н
5	Н	Н	Н	Н	Н	М	Н

	Mapping Between COs and Course Delivery (CD) methods						
CD	Course Delivery methods	Course Outcome	Course Delivery Method				
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1 and CD2				
CD2	Tutorials/Assignments	CO2	CD1 and CD2				
CD3	Seminars	CO3	CD1 and CD2				
CD4	Mini projects/Projects	CO4	CD1 and CD2				
CD5	Laboratory experiments/teaching aids	CO5	CD1 and CD2				
CD6	Industrial/guest lectures	CO6	CD1 and CD2				
CD7	Industrial visits/in-plant training	-	-				
CD8	Self- learning such as use of NPTEL materials and internets	-	-				
CD9	Simulation	-	-				

Week	Lect.	Fentative	Ch.	Fopics to be covered	Гext	COs	Actual	Methodol	Remarks	5
No.	No.	Date	No.		Book / Refere	mapped	Content covered	ogy used	by faculty	if
					nces			asea	any	
1	L1		Mod	Varactor diode,	T1					
			ule-1	Schottky diode,						
	L2			photo-diode,	T1					
	L3			solar cell,	T1					
	L4			Principle of	T1, T2,					
	L5			Operation and I-V	T4					
				Characteristics of						
				JFET, MOSFET.						
	L6			Thyristors (SCR,	T1, T4					
	L7			LASCR, Triac and						
				Diac)						

1.8		Tunnel diode	Т1		
10		IMPATT Gunn			
		affect and Cum			
		diode.	T 1 T 2		
L9	Mod	Integrated circuits:	T1, T3		
	ule-	Monolithic IC's,			
	II	Hybrid IC's.			
		Materials for IC			
		fabrication (Si and			
		GaAs)			
L10		Crystal growth and	T1, T3		
		wafer preparation.			
		processes Epitaxy.			
		Vanour nhase			
		enitaxy (VPF)			
I 11		Molecular beem	T1 T3		
		opitavy (DME)	11, 15		
		epitaxy (DIVIE),			
L 10		MOC VD Oxidation	T 1 T 2		
L12		Ion implantation	11, 13		
L13		Optical lithography	T1, T3		
L14		electron beam	T1, T3		
		lithography, Etching			
		processes			
L15	Mod	Amplifiers using	T4, T5,		
	ule-	discrete devices	T6		
	III	Amplifiers using			
		BJTs			
L16		Amplifiers using	T4 T5		
		FFTs MOSFFTs	T6		
		and their analysis	10		
I 17		Eachack in	Т4 Т5		
			14, 1J, T6		
		ampimers,	10		
		characteristics of			
		negative reedback			
		amplifiers			
L18		input resistance,	14, 15,		
		output resistance,	16		
L19		method of analysis	T4, T5,		
		of a feedback	T6		
		amplifier			
L20		feedback types and	T4, T5,		
		their analyses, Bode	T6		
		plots, two-pole and			
		three–pole transfer			
		function with			
		Feedback.			
		approximate analysis			
		of a multipole			
		feedback amplifier			
I 21		stability gain and	Т4 Т5		
		nhase marging	т6		
		phase margins	10		

L22		compensation.	T4, T5,		
		dominant-pole	T6		
		compensation, pole-			
		zero compensation			
L23	Mod	Operational	Τ4,		
	ule-	amplifiers	T7		
	IV	Differential			
		Amplifier,			
L24		emitter-coupled	Τ4,		
 L25	_	differential amplifier	T7		
 126	_				
 L20	_	current mirror and	Т7 Т9		
		active load	17,17		
L28		transfer	T4. T7		
		characteristics of a	,		
		differential amplifier			
 L29		Measurement of op-	T4, T7		
		amps parameters,			
		frequency response			
		of op-amps			
L30		dominant-pole	T4, T9		
		compensation, pole-			
		zero compensation,			
		lead compensation,			
		step response of op-			
		0.000.000			
 		amps.			
L31	Mod	Applications of Op-	T5		
L31	Mod ule-	Applications of Op- Amps	T5		
L31	Mod ule- V	Applications of Op- Amps Linear:	T5		
L31	Mod ule- V	Applications of Op- Amps Linear: instrumentation	T5		
L31	Mod ule- V	Applications of Op- Amps Linear: instrumentation amplifier	T5		
L31 L32	Mod ule- V	Applications of Op- Amps Linear: instrumentation amplifier Precision rectifiers	T5 T5,T9		
L31 L32 L33	Mod ule- V	Applications of Op- Amps Linear: instrumentation amplifier Precision rectifiers Active filters (low-	T5 T5,T9 T5,T9		
L31 L32 L33	Mod ule- V	Applications of Op- Amps Linear: instrumentation amplifier Precision rectifiers Active filters (low- pass, high-pass,	T5 T5,T9 T5,T9		
L31 L32 L33	Mod ule- V	Applications of Op-AmpsLinear:instrumentationamplifierPrecision rectifiersActive filters (low-pass, high-pass,band-pass, band-	T5 T5,T9 T5,T9		
L31 L32 L33	Mod ule- V	Applications of Op- AmpsLinear: instrumentation amplifierPrecision rectifiersActive filters (low- pass, high-pass, band-pass, band- reject/ notch),	T5 T5,T9 T5,T9		
L31 L32 L33	Mod ule- V	Applications of Op-AmpsLinear:instrumentationamplifierPrecision rectifiersActive filters (low-pass, high-pass,band-pass, band-reject/ notch),Analog computation	T5 T5,T9 T5,T9		
L31 L32 L33	Mod ule- V	Applications of Op-AmpsLinear:instrumentationamplifierPrecision rectifiersActive filters (low-pass, high-pass,band-pass, band-reject/ notch),Analog computationcircuits	T5 T5,T9 T5,T9		
L31 L32 L33 L34	Mod ule- V	Applications of Op- Amps Linear: instrumentation amplifier Precision rectifiers Active filters (low- pass, high-pass, band-pass, band- reject/ notch), Analog computation circuits Nonlinear:	T5 T5,T9 T5,T9 T5,T9		
L31 L32 L33 L34	Mod ule- V	Applications of Op- Amps Linear: instrumentation amplifier Precision rectifiers Active filters (low- pass, high-pass, band-pass, band- reject/ notch), Analog computation circuits Nonlinear: Comparators,	T5 T5,T9 T5,T9 T5,T9		
L31 L32 L33 L34	Mod ule- V	Applications of Op- Amps Linear: instrumentation amplifier Precision rectifiers Active filters (low- pass, high-pass, band-pass, band- reject/ notch), Analog computation circuits Nonlinear: Comparators, Schmitt trigger	T5 T5,T9 T5,T9 T5,T9		
L31 L32 L33 L34 L35	Mod ule- V	Applications of Op- Amps Linear: instrumentation amplifier Precision rectifiers Active filters (low- pass, high-pass, band-pass, band- reject/ notch), Analog computation circuits Nonlinear: Comparators, Schmitt trigger multivibrators, AMV	T5 T5,T9 T5,T9 T5,T9 T5,T9		
L31 L32 L33 L34 L35	Mod ule- V	Amps.Applications of Op-AmpsLinear:instrumentationamplifierPrecision rectifiersActive filters (low-pass, high-pass,band-pass, band-reject/ notch),Analog computationcircuitsNonlinear:Comparators,Schmitt triggermultivibrators, AMVand MMV using 555	T5 T5,T9 T5,T9 T5,T9 T5,T9		
L31 L32 L33 L34 L35	Mod ule- V	Amps.Applications of Op-AmpsLinear:instrumentationamplifierPrecision rectifiersActive filters (low-pass, high-pass,band-pass, band-reject/ notch),Analog computationcircuitsNonlinear:Comparators,Schmitt triggermultivibrators, AMVand MMV using 555timer	T5 T5,T9 T5,T9 T5,T9 T5,T9		
L31 L32 L32 L33 L34 L35 L36	Mod ule- V	Applications of Op- Amps Linear: instrumentation amplifier Precision rectifiers Active filters (low- pass, high-pass, band-pass, band- reject/ notch), Analog computation circuits Nonlinear: Comparators, Schmitt trigger multivibrators, AMV and MMV using 555 timer Waveform generation	T5 T5,T9 T5,T9 T5,T9 T5,T9 T5,T9		
L31 L32 L32 L33 L34 L35 L36	Mod ule- V	Applications of Op- Amps Linear: instrumentation amplifier Precision rectifiers Active filters (low- pass, high-pass, band-pass, band- reject/ notch), Analog computation circuits Nonlinear: Comparators, Schmitt trigger multivibrators, AMV and MMV using 555 timer Waveform generation, D/A converters binery	T5 T5,T9 T5,T9 T5,T9 T5,T9 T5,T9		
L31 L32 L32 L33 L34 L35 L36	Mod ule- V	Applications of Op- Amps Linear: instrumentation amplifier Precision rectifiers Active filters (low- pass, high-pass, band-pass, band- reject/ notch), Analog computation circuits Nonlinear: Comparators, Schmitt trigger multivibrators, AMV and MMV using 555 timer Waveform generation, D/A converters, binary weighted Δ/D	T5 T5,T9 T5,T9 T5,T9 T5,T9 T5,T9		
L31 L32 L32 L33 L34 L35 L36	Mod ule- V	Amps.Applications of Op-AmpsLinear:instrumentationamplifierPrecision rectifiersActive filters (low-pass, high-pass,band-pass, band-reject/ notch),Analog computationcircuitsNonlinear:Comparators,Schmitt triggermultivibrators, AMVand MMV using 555timerWaveformgeneration, D/Aconverters, binaryweighted, A/Dconverters	T5 T5,T9 T5,T9 T5,T9 T5,T9 T5,T9		
L31 L32 L32 L33 L34 L35 L36	Mod ule- V	Amps.Applications of Op-AmpsLinear:instrumentationamplifierPrecision rectifiersActive filters (low-pass, high-pass,band-pass, band-reject/ notch),Analog computationcircuitsNonlinear:Comparators,Schmitt triggermultivibrators, AMVand MMV using 555timerWaveformgeneration, D/Aconverters, binaryweighted, A/Dconverters, simultaneous	T5 T5,T9 T5,T9 T5,T9 T5,T9 T5,T9		
L31 L32 L32 L33 L34 L35 L36	Mod ule- V	Applications of Op- AmpsLinear: instrumentation amplifierPrecision rectifiersActive filters (low- pass, high-pass, band-pass, band- reject/ notch), Analog computation circuitsNonlinear: Comparators, Schmitt trigger multivibrators, AMV and MMV using 555 timerWaveform generation, D/A converters, binary weighted, A/D converters, simultaneous, counter type, dual	T5 T5,T9 T5,T9 T5,T9 T5,T9 T5,T9		

L37	Mod ule- VI	Singleelectrondevices:Quantumpoint contact	T2, T1
L38		Coulomb blockade	T2, T1
L39		Resonant tunneling transistor	T2, T1
L40		Single electron transistor (SET).	T2, T1

		COURSE INFORMATION SHEET	
Course	code: l	PH 411	
Course	title: C	Condensed Matter Physics	
Pre-req	uisite(s	s): Quantum Mechanics	
Co- req	uisite(s	s):	
Credits	:	3 L: 3 T: 0 P: 0	
Class sc	hedule	e per week:	
Class: N	A.Sc.		
Semeste	er / Lev		
Branch	: PHY	SICS	
Name of	f Teac	her: Dr S K Rout	
Course	Object	aves	
	To m	ibles the students:	
A. D		the crystal structure to symmetry, recognize the correspondence between real and reciprocal	space.
D.	Tob	me knowledge of the behaviour of electrons in solids based on classical and quantum theorie	8.
C.		ecome rammar with the different types of magnetism and magnetism based phenomenoli.	
D. E		everop an understanding of the different peremeters associated with superconductivity and the theory	of
Е.	10 g	reconductivity	01
	super	conductivity.	
Course	Outco	mes	
After the	e comp	letion of this course students will be	
1.	Able	to correlate the X-ray diffraction pattern for a given crystal structure based on the correspond	ling
	recip	rocal lattice.	
2.	Able	to explain how the predicted electronic properties of solids differ in the classical free electro	n theory,
	quan	tum free electron theory and the nearly free electron model.	,
3.	Åble	to explain various magnetic phenomena and describe the different types of magnetic orderin	g based
	on th	e exchange interaction.	
4.	Able	to differentiate between ferroelectric, anti-ferroelectric, piezoelectric and pyroelectric materi	als.
5.	Able	to differentiate between type-I and type-II superconductors and their theories.	
Code:PH	[411	Title : Condensed Matter Physics	L-T-P-C
			[3-0-0-3]
Module	-1	CRYSTAL DIFFRACTION AND RECIPROCAL LATTICE Revision of concepts,	[8]
		crystal structure, Bravais Lattice, lattice translation vector, symmetry operations, simple	
		crystal structures, Miller indices, lattice planes, Braggs' law, reciprocal lattice to SC,	
		BCC, FCC, Laue's equation and Bragg's law in terms of reciprocal lattice vector,	
		diffraction and the structure factor, Ewald's construction, structure determination using	
		Laue's method, powder crystal diffraction, rotating crystal method, scattered wave	
		amplitude, Fourier analysis of the basis, structure factor of lattices (sc, bcc, fcc), atomic	
		form factor.	
Module	-2	ENERGY BAND THEORY	[8]
		Classical free electron theory, wave mechanical treatment of electron in 1D and 3D well,	
		Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron	
		theory, density of states, Fermi-Dirac statistics, effect of temperature on Fermi	
		distribution function, electrons in a periodic potential, Bloch's theorem, Kronig Penney	
		Model, construction of Brillouin zone, reduced zone scheme, concept of energy band,	
		energy band structure of conductors, semiconductors and insulators.	
Module	-3	MAGNETISM	[8]
		Magnetic Susceptibility, diamagnetism, paramagnetism, the ground state of an ion and	
		Hund's rules, adiabatic demagnetization, crystal fields, orbital quenching, Jahn-Teller	
		effect, nuclear magnetic resonance, electron spin resonance, Mossbauer spectroscopy,	
		magnetic dipolar interaction, exchange interaction, ferromagnetism, antiferromagnetism,	
		ferrimagnetism, spin glasses.	
Madula	_4	DIFLECTRICS AND FERROFLECTRICS	[8]

	Macroscopic Maxwell equation of electrostatics, theory of local field, theory of polarisability, dielectric constant, Claussius-Mosotti relation, optical properties of ionic crystals, dielectric breakdown, dielectric losses, ferroelectric, anti-ferroelectric, piezoelectric, pyroelectric, frequency dependence of dielectric properties, classification of ferroelectric crystal, ferroelectric phase transitions, relaxor ferroelectrics.			
Module-5	SUPERCONDUCTIVITY Basic properties of superconductors, phenomenological thermodynamic treatment, London equation, penetration depth, superconducting transitions, order parameter, Ginzburg-Landau theory, Cooper pair, electron-phonon interaction, BCS theory, coherence length, flux quantization, Josephson junction, high T _c superconductors, mixed state.	[8]		
state. <u>Textbooks:</u> 1. Introduction to Solid State Physics 8 th Edition , Charles Kittel, John Wiley and Sons, 2005.				

2. Solid State Physics, Neil W. Ashcroft, N. David Mermin, Saunders College Publishing, 1976.

References:

- 1. Condensed Matter Physics 2nd Edition, Michael. P Marder, John Wiley and Sons, 2010.
- 2. Magnetism in Condensed Matter, Oxford Master Series in Condensed Matter Physics 4, Stephen Blundell, Oxford University Press, 2001.

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Yes
Tutorials/Assignments	Yes
Seminars	Yes
Mini projects/Projects	No
Laboratory experiments/teaching aids	No
Industrial/guest lectures	No
Industrial visits/in-plant training	No
Self- learning such as use of NPTEL materials and internets	Yes
Simulation	No

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizzes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	Yes	Yes	Yes	No	No
End Sem Examination Marks	Yes	Yes	Yes	Yes	Yes
Assignment	Yes	Yes	Yes	Yes	Yes

Indirect Assessment –

- 1. Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Frogram Outcomes							
Course Outcome #	Program Outcomes						
	а	b	с	d	e	f	
1	Н	Н	Н	L	L	М	
2	Н	Н	Н	L	М	L	
3	Н	Н	Н	L	М	L	
4	М	Н	М	L	М	L	
5	М	Н	Н	L	L	L	

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #		Course Objective				
	a	b	с	d	e	
1	Н	L	М	М	М	
2	L	Н	М	М	L	
3	L	М	Н	L	М	
4	L	L	М	Н	L	
5	L	М	М	L	Н	

	Mapping Between COs and Course Delivery (CD) methods							
CD	Course Delivery methods		Course Outcome	Course Delivery Method				
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1,CD2 and CD8				
CD2	Tutorials/Assignments		CO2	CD1,CD2 and CD8				
CD3	Seminars		CO3	CD1,CD2 and CD8				
CD4	Mini projects/Projects		CO4	CD1,CD2 and CD8				
CD5	Laboratory experiments/teaching aids		CO5	CD1,CD2 and CD8				
CD6	Industrial/guest lectures							
CD7	Industrial visits/in-plant training							
	Self- learning such as use of NPTEL materials and	\square						
CD8	internets							
CD9	Simulation							

We	Lect.	Tent	Modul	Topics to be covered	Text	COs	Actual	Methodology	Remar
ek	No.	ative	e		Book /	map	Content	used	ks by
No.		Date	No.		Refere	ped	covered		faculty
					nces				if any
1	L1		Ι	Revision of concepts, crystal	T1, T2	1, 2		PPT Digi	
				structure, Bravais Lattice,				Class/Chalk	
								-Board	
1	L2			lattice translation vector,	T1, T2			PPT Digi	
				symmetry operations, simple				Class/Chalk	
				crystal structures, Miller indices,				-Board	
				lattice planes, Braggs' law,					
1	L3-			reciprocal lattice to SC, BCC,	T1, T2			PPT Digi	
	L4			FCC, Laue's equation and Bragg's				Class/Chalk	
				law in terms of reciprocal lattice				-Board	
				vector,					

2 L6 L6 Factor, Class/ -Board 2 L7 Ewald's construction, T1, T2 PPT D Class/ -Board 3 L8 structure determination using tractor, rotating crystal diffraction, rotating crystal method, T1, T2 PPT D Class/ -Board 4 L11 II Classical free electron theory, atomic form factor. T1, T2 PPT D Class/ -Board 4 L12 II Classical free electron theory, atomic form factor. T1, T2 PPT D Class/ -Board 4 L12 II Classical free electron theory, atomic form factor. T1, T2 PPT D Class/ -Board 5 L14- Electrons in 1D and 3D well Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theory T1, T2 PPT D Class/ -Board 5 L14- Electrons in a periodic potential, 15 T1, T2 PPT D Class/ -Board 5 L16 Energy band structure of conductors, semiconductors and insulators. T1, T2, PPT D Class/ -Board PPT D Class/ -Board 5 L16 Energy band structure of conductors, semiconductors and insulators. T1, T2, PPT D PPT D Class/ -Board	factor, Class/Chalk -Board Ewald's construction, T1, T2 PPT Digi Class/Chalk -Board structure determination using Laue's method, powder crystal diffraction, rotating crystal method, T1, T2 PPT Digi Class/Chalk -Board scattered wave amplitude, Fourier analysis of the basis, structure factor of lattices (sc, bcc,fcc), atomic form factor. T1, T2 PPT Digi Class/Chalk -Board II Classical free electron theory, electron in 1D and 3D well Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theory T1, T2 PPT Digi Class/Chalk -Board density of states, Fermi-Dirac statistics, effect of temperature on Fermi distribution function T1, T2 PPT Digi Class/Chalk -Board electrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band, T1, T2 PPT Digi Class/Chalk -Board Energy band structure of conductors, semiconductors and insulators. T1, T2, PPT Digi Class/Chalk -Board	2	L5			diffraction and the structure	T1, T2	PPT Digi
2 L6 Board Board 2 L7 Ewald's construction, T1, T2 PPT E 3 L8 structure determination using Laue's method, powder crystal diffraction, rotating crystal method, T1, T2 PPT D 3 L8 scattered wave amplitude, Fourier factor of lattices (sc, bcc,fcc), atomic form factor. T1, T2 PPT D 4 L11 II Classid free electron theory, wave mechanical treatment of electron in 1D and 3D well Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theory T1, T2 PPT D 4 L12- I3 Generative of states, Fermi-Dirac for electron in a periodic potential, T1, T2 PPT D 5 L16 Electrons in a periodic potential, concept of energy band, energy energy	Ewald's construction,T1, T2PPT Digi Class/Chalk -Boardstructure determination using Laue's method, powder crystal diffraction, rotating crystal method,T1, T2PPT Digi Class/Chalk -Boardscattered wave amplitude, Fourier factor of lattices (sc, bcc,fcc), atomic form factor.T1, T2PPT Digi Class/Chalk -BoardIIClassical free electron theory, electron in 1D and 3D well Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theory density of states, Fermi-Dirac statistics, effect of temperature on Fermi distribution functionT1, T2PPT Digi Class/Chalk -Boardelectrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band, Energy band structure of conductors, semiconductors and insulators.T1, T2PPT Digi Class/Chalk -BoardIIIMagneticSusceptibility, T1, T2T1, T2PPT Digi Class/Chalk -BoardIIIMagneticSusceptibility, T1, T2PPT Digi Class/Chalk -Board					factor,		Class/Chalk
2 L6 Ewald's construction, T1, T2 PPT D 2 L7 structure determination using Laue's method, powder crystal diffraction, rotating crystal method, T1, T2 PPT D 3 L8 scattered wave amplitude, Fourier analysis of the basis, structure factor of lattices (sc, bcc,fcc), atomic form factor. T1, T2 PPT D 4 L11 II Class/a tomic form factor. T1, T2 PPT D 4 L12- 13 Classical free electron theory, wave mechanical treatment of electron in 1D and 3D well Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theory T1, T2 PPT D 5 L14- Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band, T1, T2 PPT D 5 L16 Energy band structure of cnergy band, T1, T2 PPT D 5 L16 Energy band structure of conductors and insulators. T1, T2 PPT D 6 L17 III Magnetic Susceptibility, T1, T2, PPT D PPT D	Ewald's construction,T1, T2PPT Digi Class/Chalk -Boardstructuredeterminationusing class/Chalk -BoardT1, T2PPT Digi Class/Chalk -Boarddiffraction, method, scattered wave amplitude, Fourier analysis of the basis, structure factor of lattices (sc, bcc,fcc), atomic form factor.T1, T2PPT Digi Class/Chalk -BoardIIClassical free electron theory, electron in 1D and 3D well Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theoryT1, T2PPT Digi Class/Chalk -Boarddensity of states, Fermi-Dirac statistics, effect of temperature on Fermi distribution functionT1, T2PPT Digi Class/Chalk -Boardelectrons in a periodic potential, Nodel, construction of Brillouin zone, reduced zone scheme, concept of energy band, Energy band structure of conductors, semiconductors and insulators.T1, T2PPT Digi Class/Chalk -BoardIIIMagneticSusceptibility, T1, T2PT Digi Class/Chalk -BoardIIIMagneticSusceptibility, T1, T2,PPT Digi Class/Chalk -Board							-Board
2 L7 Class/ -Board 3 L8 structure determination using Laue's method, powder crystal diffraction, rotating crystal method, T1, T2 PPT D Class/ -Board 3 L8 scattered wave amplitude, Fourier analysis of the basis, structure factor of lattices (sc, bcc,fcc), atomic form factor. T1, T2 PPT D Class/ -Board 4 L11 II Classid scattered wave amplitude, Fourier analysis of the basis, structure factor of lattices (sc, bcc,fcc), atomic form factor. T1, T2 PPT D Class/ -Board 4 L11 II Classid scattered wave mechanical treatment of electron in 1D and 3D well Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theory T1, T2 PPT D Class/ -Board 4 L12- 13 I3 statistics, effect of temperature on Fermi distribution function T1, T2 PPT D Class/ -Board 5 L14- 15 Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band, T1, T2 PPT D Class/ -Board 5 L16 Energy band structure of conductors, semiconductors and insulators. T1, T2, energy band PPT D Class/ -Board 117 III Magnetic Susceptibility, energy band T1, T2, energy PPT D Class/ -Board	Image: Class of Charles and the second se	2	L6			Ewald's construction.	T1. T2	PPT Digi
2 L7 Base Structure determination using Laue's method, powder crystal diffraction, rotating crystal method, T1, T2 PPT D Class/Laue's method, powder crystal diffraction, rotating crystal method, 3 L8 scattered wave amplitude, Fourier factor of lattices (sc, bcc,fcc), atomic form factor. T1, T2 PPT D Class/Laue's method, 4 L11 II Classical free electron theory, wave mechanical treatment of electron in 1D and 3D well Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theory T1, T2 PPT D Class/Laue's method, electron theory 5 L14- I5 Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band, tructure of insulators. T1, T2 PPT D Class/Laus/Laue's concept of energy band, tructure of class/Laue's submitted for electrons and insulators. 5 L16 Energy band structure of concept of energy band, tructure of conductors, semiconductors and insulators. T1, T2 PPT D L17 III Magnetic Susceptibility, T1, T2, PPT D PPT D PPT D	structure determination using Laue's method, powder crystal diffraction, rotating crystal method, T1, T2 PPT Digi Class/Chalk -Board scattered wave amplitude, Fourier factor of lattices (sc, bcc,fcc), atomic form factor. T1, T2 PPT Digi Class/Chalk -Board II Classical free electron theory, electron in 1D and 3D well Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theory T1, T2 PPT Digi Class/Chalk -Board density of states, Fermi-Dirac statistics, effect of temperature on Fermi distribution function T1, T2 PPT Digi Class/Chalk -Board electrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band, Energy band structure of Energy band structure of tenergy band PPT Digi tenergy band structure of tenergy band III Magnetic Susceptibility, T1, T2, PPT Digi							Class/Chalk
2 L7 structure determination using Laue's method, powder crystal diffraction, rotating crystal method, T1, T2 PPT D Class/4 3 L8 scattered wave amplitude, Fourier analysis of the basis, structure factor of lattices (sc, bcc, fcc), atomic form factor. T1, T2 PPT D Class/4 4 L11 II Classical free electron theory, wave mechanical treatment of electron in 1D and 3D well Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theory T1, T2 PPT D Class/4 4 L12- density of states, Fermi-Dirac statistics, effect of temperature on Fermi distribution function T1, T2 PPT D Class/4 5 L14- Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band, insulators. T1, T2 PPT D Class/4 5 L16 Energy band structure of conductors and insulators. T1, T2 PPT D Class/4 5 L16 III Magnetic Susceptibility, T1, T2, PPT D PPT D 6 III Magnetic Susceptibility, T1, T2, PPT D PPT D 7 III Magnetic Susceptibility, T1, T2, PPT D 8 Class/4 Soard Soard 9 III Magnetic Susceptibility, T1, T2, PPT D <td>structuredeterminationusing Laue'sT1, T2PPT Digi Class/Chalk -Boardimited diffraction, rotating method,rotating crystal method,T1, T2PPT Digi Class/Chalk -Boardscattered wave amplitude, Fourier analysis of the basis, structure factor of lattices (sc, bcc,fcc), atomic form factor.T1, T2PPT Digi Class/Chalk -BoardIIClassical free electron theory, wave mechanical treatment of electron in 1D and 3D well Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theoryT1, T2PPT Digi Class/Chalk -Boarddensity of states, Fermi-Dirac statistics, effect of temperature on electrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band,T1, T2PPT Digi Class/Chalk -BoardIIIMagneticSusceptibility, T1, T2,PPT Digi Class/Chalk -Board</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>-Board</td>	structuredeterminationusing Laue'sT1, T2PPT Digi Class/Chalk -Boardimited diffraction, rotating method,rotating crystal method,T1, T2PPT Digi Class/Chalk -Boardscattered wave amplitude, Fourier analysis of the basis, structure factor of lattices (sc, bcc,fcc), atomic form factor.T1, T2PPT Digi Class/Chalk -BoardIIClassical free electron theory, wave mechanical treatment of electron in 1D and 3D well Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theoryT1, T2PPT Digi Class/Chalk -Boarddensity of states, Fermi-Dirac statistics, effect of temperature on electrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band,T1, T2PPT Digi Class/Chalk -BoardIIIMagneticSusceptibility, T1, T2,PPT Digi Class/Chalk -Board							-Board
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3 L8 method, rotating for your For any or your 3 L8 scattered wave amplitude, Fourier analysis of the basis, structure factor of lattices (sc, bcc,fcc), atomic form factor. T1, T2 PPT D 4 L11 II Classical free electron theory, wave mechanical treatment of electron in 1D and 3D well -Board 4 L12- density of free electron theory T1, T2 PPT D 4 L12- density of states, Fermi-Dirac T1, T2 PPT D 4 L12- density of states, Fermi-Dirac T1, T2 PPT D 13 statistics, effect of temperature on Fermi distribution function T1, T2 PPT D 5 L14- Electrons in a periodic potential, T1, T2 PPT D Class/density 5 L16 Energy band structure of T1, T2 PPT D Class/density Subord ference Class/density -Board 117 III Magnetic Susceptibility, T1, T2, PPT D PPT D	Initiation, forming berystalDotationmethod,scattered wave amplitude, Fourier analysis of the basis, structure factor of lattices (sc, bcc,fcc), atomic form factor.T1, T2PPT Digi Class/Chalk -BoardIIClassical free electron theory, wave mechanical treatment of electron in 1D and 3D well Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theoryT1, T2PPT Digi Class/Chalk -Boarddensity of states, Fermi-Dirac statistics, effect of temperature on Fermi distribution functionT1, T2PPT Digi Class/Chalk -BoardBloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band,T1, T2PPT Digi Class/Chalk -BoardIIIMagneticSusceptibility,T1, T2,PPT Digi					diffraction rotating crystal		-Board
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4L12- 13density of states, Fermi-Dirac telectron theoryT1, T2PPT D Class/d -Board5L14- 15electrons in a periodic potential, reduced zone, reduced zone scheme, concept of energy band,T1, T2PPT D Class/d -Board5L16Energy band structure of insulators.T1, T2PPT D Class/d -BoardL17IIIMagnetic class/d susceptibility, T1, T2,PPT D PT D Class/d PPT D	electron in 1D and 3D well-BoardWiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theoryPPT Digidensity of states, Fermi-Dirac statistics, effect of temperature on Fermi distribution functionT1, T2PPT Digielectrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band,T1, T2PPT DigiEnergy band structure of insulators.T1, T2PPT DigiIIIMagneticSusceptibility, T1, T2,PPT Digi					wave mechanical treatment of		Class/Chaik
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4L12- 13failure of free electron theoryT1, T2PPT D4L12- 13density of states, Fermi-Dirac statistics, effect of temperature on Fermi distribution functionT1, T2PPT D5L14- 15electrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band,T1, T2PPT D5L16Energy band structure of insulators.T1, T2PPT DL17IIIMagnetic diamagnetismSusceptibility, ParamagnetismT1, T2, R2PPT DClass/dClass/d-Board5L17IIIMagnetic diamagnetismSusceptibility, ParamagnetismT1, T2, R2PPT D	Ineory of thermal conductivity, failure of free electron theoryT1, T2PPT Digidensity of states, Fermi-Dirac statistics, effect of temperature on Fermi distribution functionT1, T2PPT Digielectrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band,T1, T2PPT DigiEnergy band structure of conductors, semiconductors and insulators.T1, T2,PPT DigiIIIMagneticSusceptibility,T1, T2,PPT Digi					wiedemann-Franz law, quantum		
4 L12- 13 Image: Construction of the electron theory Image: Construction theory Image: Construction theory 5 L14- 15 Image: Construction of the electron theory 5 L14- 15 Image: Construction of the electron theory 5 L16 Image: Construction of the electron theory 5 L16 Image: Construction of the electron theory Image: Construction of the electron the	Tailure of free electron theoryT1, T2PPT Digidensity of states, Fermi-Dirac statistics, effect of temperature on Fermi distribution functionT1, T2PPT Digielectrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band,T1, T2PPT DigiEnergy band structure of insulators.T1, T2PPT DigiEnergy band structure of insulators.T1, T2,PPT DigiIIIMagneticSusceptibility,T1, T2,PPT Digi					theory of thermal conductivity,		
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13Statistics, effect of temperature on Fermi distribution functionClass/d -Board5L14- 15electrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band,T1, T2PPT D Class/d -Board5L16Energy band structure of conductors, semiconductors and insulators.T1, T2PPT D Class/d -BoardL17IIIMagnetic diamagnetism ParamagnetismSusceptibility, R2T1, T2, Class/dPPT D Class/d	statistics, effect of temperature on Fermi distribution functionClass/Chalk -Boardelectrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band,T1, T2PPT Digi Class/Chalk -BoardEnergy band structure of conductors, semiconductors and insulators.T1, T2PPT Digi Class/Chalk -BoardIIIMagneticSusceptibility, T1, T2,PPT Digi	4	L12-			density of states, Fermi-Dirac	11, 12	PPT Digi
5L14- 15electrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band,T1, T2PPT D Class/d -Board5L16Energy band structure of insulators.T1, T2PPT D Class/d -BoardL17IIIMagnetic diamagnetismSusceptibility, ParamagnetismT1, T2, R2PPT D Class/d Class/d	Fermi distribution function-Boardelectrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band,T1, T2PPT Digi Class/Chalk -BoardEnergy band structure of conductors, semiconductors and insulators.T1, T2PPT Digi Class/Chalk -BoardIIIMagneticSusceptibility, T1, T2,PPT Digi		13			statistics, effect of temperature on		Class/Chalk
5 L14- 15 electrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band, T1, T2 PPT D Class/d -Board 5 L16 Energy band structure of insulators. T1, T2 PPT D Class/d -Board L17 III Magnetic diamagnetism Susceptibility, Paramagnetism T1, T2, R2 PPT D Class/d -Board	electrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band, T1, T2 PPT Digi Class/Chalk -Board Energy band structure of conductors, semiconductors and insulators. T1, T2 PPT Digi Class/Chalk -Board III Magnetic Susceptibility, T1, T2, PPT Digi	_	T 1 4		-	Fermi distribution function	T 1 T 2	-Board
15 Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band, -Board -Board 5 L16 Energy band structure of conductors, semiconductors and insulators. T1, T2 PPT D Class/d -Board L17 III Magnetic diamagnetism Susceptibility, Paramagnetism T1, T2, R2 PPT D Class/d -Board	Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band, Class/Chalk -Board Energy band structure of conductors, semiconductors and insulators. T1, T2 PPT Digi Class/Chalk -Board III Magnetic Susceptibility, T1, T2, PPT Digi	5	L14-			electrons in a periodic potential,	T1, T2	PPT Digi
Model, construction of Brillouin zone, reduced zone scheme, concept of energy band, -Board 5 L16 Energy band structure of conductors, semiconductors and insulators. T1, T2 PPT D Class/d L17 III Magnetic diamagnetism Susceptibility, Paramagnetism T1, T2, R2 PPT D Class/d	Model, construction of Brillouin zone, reduced zone scheme, concept of energy band, -Board Energy band structure of conductors, semiconductors and insulators. T1, T2 PPT Digi Class/Chalk -Board III Magnetic Susceptibility, T1, T2, PPT Digi		15			Bloch's theorem, Kronig Penney		Class/Chalk
zone, reduced zone scheme, concept of energy band, zone, reduced zone scheme, concept of energy band, PPT D 5 L16 Energy band structure of conductors, semiconductors and insulators. T1, T2 PPT D L17 III Magnetic Susceptibility, diamagnetism T1, T2, PPT D PPT D	zone, reduced zone scheme, concept of energy band, PPT Digi Energy band structure of conductors, semiconductors and insulators. T1, T2 PPT Digi III Magnetic Susceptibility, T1, T2, PPT Digi					Model, construction of Brillouin		-Board
5 L16 Concept of energy band, PPT D 5 L16 Energy band structure of conductors, semiconductors and insulators. T1, T2 PPT D L17 III Magnetic Susceptibility, T1, T2, diamagnetism PPT D Class/diamagnetism Paramagnetism R2 Class/diamagnetism	concept of energy band,T1, T2PPT DigiEnergy band structure of conductors, semiconductors and insulators.T1, T2PPT DigiIIIMagneticSusceptibility,T1, T2,PPT Digi					zone, reduced zone scheme,		
5 L16 Energy band structure of conductors, semiconductors and insulators. T1, T2 PPT D L17 III Magnetic Susceptibility, T1, T2, diamagnetism PT D L17 III Magnetic Susceptibility, T1, T2, diamagnetism PT D	Energy band structure of conductors, semiconductors and insulators.T1, T2PPT Digi Class/Chalk -BoardIIIMagneticSusceptibility,T1, T2,PPT Digi					concept of energy band,		
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L17 III Magnetic Susceptibility, T1, T2, PPT D diamagnetism Paramagnetism R2 Class/	III Magnetic Susceptibility, T1, T2, PPT Digi					insulators.		-Board
diamagnetism Paramagnetism R2 Class/			L17		III	Magnetic Susceptibility,	T1, T2,	PPT Digi
	diamagnetism, Paramagnetism, R2 Class/Chalk					diamagnetism, Paramagnetism,	R2	Class/Chalk
The ground state of an ion and -Board	The ground state of an ion and -Board					The ground state of an ion and		-Board
Hund's rules, adiabatic	Hund's rules, adiabatic					Hund's rules, adiabatic		
demagnetization	demagnetization					demagnetization		
L18 Crystal fields, orbital quenching T1, T2, PPT D	Crystal fields, orbital quenching T1 T2 PPT Digi		L18			Crystal fields, orbital quenching	T1, T2,	PPT Digi
R2 Class/							R2	Class/Chalk
-Board	R2 Class/Chalk							-Board
L19 Jahn-Teller effect Nuclear T1, T2, PPT D	R2 R2 Class/Chalk -Board		L19			Jahn-Teller effect Nuclear	T1, T2,	PPT Digi
magnetic resonance R2 Class/	R2Class/Chalk -BoardJahn-TellereffectNuclearT1, T2,PPT Digi					magnetic resonance	R2	Class/Chalk
-Board	R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk							-Board
L20- Electron spin resonance T1, T2, PPT D	R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -Board		L20-			Electron spin resonance	T1, T2,	PPT Digi
21 Mossbauer spectroscopy, R2 Class/	R2R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, PPT DigiPPT Digi		21			Mossbauer spectroscopy,	R2	Class/Chalk
	R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -Board							-Board
-Board	R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -Board		L22			Magnetic dipolar interaction,	T1, T2,	PPT Digi
L22 Magnetic dipolar interaction, T1, T2, PPT D	R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardMossbauer spectroscopy, Magnetic dipolar interaction, T1, T2,PPT DigiMagnetic dipolar interaction, T1, T2,PPT Digi					Exchange interaction,	R2	Class/Chalk
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L22Magnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT D Class/ -BoardL23-Ferromagnetism, Ferromagnetism,anti-T1, T2, PPT D	Explain fields, or start quenchingT1, T2, R2PT Digi Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardMagnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT Digi Class/Chalk -BoardFerromagnetism,anti-T1, T2,PPT Digi		L24			ferromagnetism, Ferrimagnetisms.	R2	Class/Chalk
L22Magnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT D Class/ -BoardL23- L24Ferromagnetism, ferromagnetism,Ferrimagnetisms, R2R2PPT D Class/ Class/ R2	Provide field of the problemProvide field of the problemProvide field of the provide field of the pro					Spin glasses.		-Board
L22Magnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT D Class/ -BoardL23- L24Ferromagnetism, ferromagnetism,Ferrimagnetisms, Spin glasses.PT D R2Class/ Class/ R2	R2R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonance Mossbauer spectroscopy,T1, T2, R2PPT Digi Class/Chalk -BoardMagnetic dipolar interaction, Exchange interaction, Ferromagnetism, anti- ferromagnetism, Ferrimagnetisms, Spin glasses.T1, T2, R2PPT Digi Class/Chalk -Board		L25		IV	Macroscopic Maxwell equation of	T1, T2,	PPT Digi
L22Magnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT D Class/ -BoardL23- L24Ferromagnetism, ferromagnetism,Ferrimagnetisms, Spin glasses.R2Class/ Class/ Class/ R2L25IVMacroscopic Maxwell equation of T1, T2,PPT D T1, T2,	R2R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardMagnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT Digi Class/Chalk -BoardFerromagnetism, ferromagnetism, Spin glasses.T1, T2, R2PPT Digi Class/Chalk -BoardIVMacroscopic Maxwell equation of T1, T2,PPT Digi PPT Digi					electrostatics	R1	Class/Chalk
L22Magnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT D Class/ -BoardL23- L24Ferromagnetism, ferromagnetism,Ferrimagnetisms, Spin glasses.R2Class/ Class/ Class/ R2L25IVMacroscopic Maxwell equation of electrostaticsT1, T2, R1PPT D Class/ Class/ R1	R2R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardMagnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT Digi Class/Chalk -BoardFerromagnetism, ferromagnetism, Ferrimagnetisms, Spin glasses.T1, T2, R2PPT Digi Class/Chalk -BoardIVMacroscopic Maxwell equation of electrostaticsT1, T2, R1PPT Digi Class/Chalk -Board							-Board
The ground state of an ion and -Board	The ground state of an ion and -Board					The ground state of an ion and		-Board
Hund's rules, adiabatic	Hund's rules, adiabatic					Hund's rules, adiabatic		
demagnetization	demagnetization					demagnetization		
			T 10		_		T1 T2	
L18 Crystal fields, orbital quenching T1, T2, PPT D	Crystal fields, orbital quenching 1 TL T2 1 1 PPT Digit		L18			Crystal fields, orbital quenching	T1, T2,	PPT Digi
R2 Class/							R2	Class/Chalk
-Board	R2 Class/Chalk							-Board
L19 Jahn-Teller effect Nuclear T1, T2, PPT D	R2 R2 Class/Chalk -Board		L19			Jahn-Teller effect Nuclear	T1, T2,	PPT Digi
magnetic resonance R2 Class/	R2Class/Chalk -BoardJahn-TellereffectNuclearT1, T2,PPT Digi					magnetic resonance	R2	Class/Chalk
-Board	R2Class/Chalk -BoardJahn-Teller effect Nuclear T1, T2, magnetic resonancePPT Digi Class/Chalk							-Board
L20- Electron spin resonance T1, T2, PPT D	R2 Class/Chalk Jahn-Teller effect Nuclear magnetic resonance T1, T2, R2 R2 Class/Chalk -Board PPT Digi Class/Chalk -Board		L20-			Electron spin resonance	T1. T2.	PPT Digi
21 Mossbauer spectroscopy, R2 Class/	R2R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, PPT Digi		21			Mossbauer spectroscopy,	R2	Class/Chalk
	R2R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonance Mossbauer spectroscopy,T1, T2, R2PPT Digi Class/Chalk -Board							-Board
-Board	R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -Board		L22			Magnetic dipolar interaction,	T1, T2,	PPT Digi
L22 Magnetic dipolar interaction, T1, T2, PPT D Exchange interaction P2	R2R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardMagnetic dipolar interaction, Fxahanga interactionT1, T2, R2PPT Digi Class/Chalk -BoardMagnetic dipolar interaction, Fxahanga interactionT1, T2, R2PPT Digi Class/Chalk -Board					Exchange interaction,	κ∠	Class/Clialk Doord
L22Magnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT D Class/ 	R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardMagnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT Digi Class/Chalk -BoardMagnetic dipolar interaction, R2T1, T2, R2PPT Digi Class/Chalk -Board		I 23-		1	Ferromagnetism anti	T1 T2	PPT Digi
L22Magnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT D Class/ -BoardL23-Ferromagnetism, anti-anti- T1, T2,PPT D PPT D	Explain head, or that quenchingT1, T2, R2PT Digit Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digit Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digit Class/Chalk -BoardMossbauer spectroscopy, Exchange interaction, Ferromagnetism,T1, T2, R2PPT Digit Class/Chalk -BoardFerromagnetism, Ferromagnetism,T1, T2, R2PPT Digit Class/Chalk -Board		L24			ferromagnetism, Ferrimagnetisms.	R2	Class/Chalk
L22Magnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT D Class/ -BoardL23- L24Ferromagnetism, ferromagnetism,Ferrimagnetisms, R2P1, T2, R2PPT D Class/ Class/ R2	Provide field of the second questioningPrivate PrivateR2R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonance Mossbauer spectroscopy,T1, T2, R2PPT Digi Class/Chalk -BoardMagnetic dipolar interaction, Exchange interaction, Ferromagnetism, anti- ferromagnetism, Ferrimagnetisms, R2T1, T2, R2PPT Digi Class/Chalk -BoardFerromagnetism, Ferrimagnetisms, R2R2Class/Chalk -Board					Spin glasses.		-Board
L22Magnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT D Class/ -BoardL23- L24Ferromagnetism, ferromagnetism,Ferrimagnetisms, Spin glasses.anti- R2T1, T2, R2PPT D Class/ Class/ R2	R2R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonance Mossbauer spectroscopy,T1, T2, R2PPT Digi Class/Chalk -BoardMagnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT Digi Class/Chalk -BoardMagnetic dipolar interaction, Ferromagnetism, Ferrimagnetisms, Spin glasses.T1, T2, R2PPT Digi Class/Chalk -Board		L25		IV	Macroscopic Maxwell equation of	T1, T2,	PPT Digi
L22Magnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT D Class/ -BoardL23- L24Ferromagnetism, ferromagnetism,Ferrimagnetisms, Spin glasses.R2Class/ Class/ Class/ R2L25IVMacroscopic Maxwell equation of Ferromagnetism of T1, T2,PPT D PPT D PPT D	R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardMossbauer spectroscopy, Exchange interaction, Ferromagnetism, Ferrimagnetisms, Spin glasses.T1, T2, R2PPT Digi Class/Chalk -BoardFerromagnetism, Ferrimagnetisms, Spin glasses.T1, T2, R2PPT Digi Class/Chalk -BoardIVMacroscopic Maxwell equation of T1, T2,PPT Digi					electrostatics	R1	Class/Chalk
L22Magnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT D Class/ -BoardL23- L24Ferromagnetism, ferromagnetism,Ferrimagnetisms, Spin glasses.T1, T2, R2PPT D Class/ Class/ R2L25IVMacroscopic Maxwell equation of electrostaticsT1, T2, R1PPT D Class/ Class/ R1	R2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardMagnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT Digi Class/Chalk -BoardFerromagnetism, ferromagnetism, Spin glasses.T1, T2, R2PPT Digi Class/Chalk -BoardIVMacroscopic Maxwell equation of electrostaticsT1, T2, R1PPT Digi Class/Chalk -Board							-Board
L22Magnetic dipolar interaction, Exchange interaction,T1, T2, R2PPT D Class/ -BoardL23- L24Ferromagnetism, ferrimagnetisms, Spin glasses.T1, T2, R2PPT D Class/ -BoardL25IVMacroscopic Maxwell equation of electrostaticsT1, T2, R1PPT D Class/ Class/ R1	R1PriprR2Class/Chalk -BoardJahn-Teller effect Nuclear magnetic resonanceT1, T2, R2PPT Digi Class/Chalk -BoardElectron spin resonanceT1, T2, R2PPT Digi Class/Chalk -BoardMossbauer spectroscopy, Mossbauer spectroscopy,R2Class/Chalk -BoardMagnetic dipolar interaction, Exchange interaction, Ferromagnetism, anti- ferromagnetism, Ferrimagnetisms, Spin glasses.T1, T2, R2PPT Digi Class/Chalk -BoardIVMacroscopic Maxwell equation of electrostaticsT1, T2, R1PPT Digi Class/Chalk -Board	1	1	1	1			1

L26		Theory of local field, theory of	T1, T2,	PPT Digi
		Polarisability, dielectric constant,	R1	Class/Chalk
		Claussius-Mosotti relation		-Board
L27		Optical properties of ionic	T1, T2,	PPT Digi
		crystals.	R1	Class/Chalk
				-Board
L28-		Dielectric breakdown, dielectric	T1, T2,	PPT Digi
29		losses, ferroelectric, anti-	R1	Class/Chalk
		ferroelectric.		-Board
L30-		Piezoelectric, Pyroelectric,	T1, T2,	PPT Digi
31		frequency dependence of	R1	Class/Chalk
		dielectric properties.		-Board
L32		Classification of ferroelectric	T1, T2,	PPT Digi
		crystal, ferroelectric phase	R1	Class/Chalk
		transitions, relaxor ferroelectrics.		-Board
L33	V	Basic properties of	T1, T2,	PPT Digi
		Superconductors,	R1	Class/Chalk
		Phenomenological		-Board
		thermodynamic treatment		
L34-		London equation, penetration	T1, T2,	PPT Digi
35		depth	R1	Class/Chalk
				-Board
L36		Superconducting transitions, order	T1, T2,	PPT Digi
		parameter, Ginzburg-Landau	R1	Class/Chalk
		theory		-Board
L37		Cooper pair, electron-phonon	T1, T2,	PPT Digi
		interaction, BCS theory	R1	Class/Chalk
				-Board
L38		Josephson junction	T1, T2,	PPT Digi
			R1	Class/Chalk
				-Board
L39		Coherence length, Flux	T1, T2,	PPT Digi
		quantization	R1	Class/Chalk
				-Board
L40		High T _c superconductors, mixed	T1, T2,	PPT Digi
		state.	R1	Class/Chalk
				-Board

Course code: PH 412 Course title: Electronics Lab Pre-requisite(s): Co- requisite(s): Credits: 2 L: 0 T: 0 P: 4 Class schedule per week: Class: I.M.Sc. Semester / Level: I Branch: PHYSICS Name of Teacher:

	Electronics Lab	
	[L-T-P-C 0-0-4-21
	L	001-1
List of	f Experiments:	
1.	Verification of truth tables of OR, NOT and AND gates using NAND gates	
2.	Verification of truth tables of OR, NOT and AND gates using NOR gates	
3.	Realization of XOR and XNOR gates using NAND and NOR gates	
4.	Design and verification of a 2 bit binary half adder	
5.	Design and verification of a 2- bit binary full adder	
6.	Design of a half subtractor and verification of its truth table	
7.	Design of a half subtractor and verification of its truth table	
8.	Design and implementation of clocked R-S flipflops using NAND gates	
9.	Design and implementation of clocked J-K flipflops using NAND gates	
10.	. Design and testing of monostable vibrator using IC 555 timer	
11.	. Design and testing of astable multivibrator using IC 555 timer	
12.	. Design and testing of Schmidt Trigger using IC 741	
13.	. Design and testing of modulo 9 ripple counter using IC CD4029.	
14.	. Design and testing of CMOS switch and 2:1 multiplexer using IC 4066.	

Course Assessment tools & Evaluation procedure

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

Course code: PH 413 Course title: Condensed Matter Physics Lab Pre-requisite(s): Co- requisite(s): Credits: 2 L: 0 T: 0 P: 4 Class schedule per week: Class: I.M.Sc. Semester / Level: I Branch: PHYSICS Name of Teacher:

Condensed Matter Physics Lab

L-T-P-C [0-0-4-2]

List of experiments:

- 1. To study the permeability of a ferrite substance as a function of frequency. (Take atleast 20 data)
- 2. To study the relative permittivity of a dielectric material as a function of temperature. (Take atleast 20 data).
- 3. Analysis of XRD data using JCPDS software.
- 4. Analysis of FESEM data using ImageJ software to calculate density function.
- 5. Analysis of XRD data using CheckCell software.
- 6. Measurement of resistance of a semiconductor as a function of temperature.
- 7. Measurement of susceptibility using lock in amplifier.
- 8. Synthesis of a ceramic sample using a programmable furnace.
- 9. Analysis of XRD data using FullProf software.
- 10. Design of crystal structure using VESTA software.

Course Assessment tools & Evaluation procedure

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

Semester III

COURSE INFORMATION SHEET

Course code: PH 501 Course title: Nuclear and Particle Physics Pre-requisite(s): Modern Physics Co- requisite(s): Credits: 4L: 3 T:1 P: 0 Class schedule per week: Class: I.M.Sc. Semester / Level: IX / III Branch: PHYSICS Name of Teacher:

ode: PH 501	Title: Nuclear and Particle Physics	L-T-P-C [3-1-0-4]			
Module	Course Objective:				
1	To impart the knowledge regarding the fundamental and basics of Nucleus and i	ts			
	models.				
2	To provide the knowledge of the Two-nucleus problem, concept of nuclear force.				
3	To acquire knowledge about the nucleus by the study of scattering of particles.				
4	To have a good understanding of interaction of charged particles with matter.				
5	To have an elementary idea of particles and their classification.				

Course Name : Nuclear and Particle Physics					
Modul	e Course Outcome:				
1	Student will have an idea developed about the nucleus.				
2	Student will have a concept and nature of nuclear force.				
3	Student will learn about the method and analysis of Scattering process.				
4	Student will have an idea about the interaction of particles with matter.				
5	Student will understand te nature, interaction etc of the elementary particles.				
Module-1	Nuclear Models Liquid drop Model, semi-empirical mass formula, transitions between odd				
	A isobars, transitions between even isobars, odd-even effects and magic numbers, Shell				
	model, collective model.				
Module-2	Two nucleon problem, The deuteron, ground state of deuteron, nature of nuclear forces,				
	excited state of deuteron, spin dependence of nuclear force, meson theory of nuclear force				
Module-3	Scattering, Cross section, differential cross section, scattering cross section, nucleon				
	nucleon scattering, proton-proton and neutron-neutron scattering at low energies.				
Module-4	Interaction of radiation with matter, Interaction of charged particles with matter, stopping				
	power of heavy charged particles, energy loss of electrons, absorption of gamma rays,				
	photoelectric effect, Compton effect and pair production.				
Module-5	Classification of elementary particle, Eightfold way, Baryon octate and meson octate,				
	Quark model, Baryon Decuplet, meson nonlet, Intermediate vector Boson, Strong				
	electromagnetic and week interactions, standard model, lepton classification and quark				
	classification.				
<u>Referen</u>	<u>ces</u>				

1. Nuclear Theory-Roy and Nigam

2. Introductory Nuclear Physics- Kenneth S-Krane

3. Nuclear Physics: D. Halliday

4. Elements of Nuclear Physics: Pandya and Yadav

5. Introduction to Elementary Particle: David Griffiths

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	Ν
Laboratory experiments/teaching aids	N
Industrial/guest lectures	Ν
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and internets	Y
Simulation	N

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizzes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks					
End Sem Examination Marks	\checkmark	\checkmark	\checkmark	\checkmark	
Quiz I			\checkmark	\checkmark	
Quiz II					

Indirect Assessment -

- **1.** Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

<u>Mapping between Objectives and Outcomes</u> Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4	5	
Α	Н	М	L	L	L	
В	Μ	Н	L	L	L	
С	М	L	Н	L	L	
D	L	L	L	Η	L	
Е	L	М	L	L	Н	

Mapping of Course Outcomes onto Program Outcomes

Course					Pr	ogram	Outco	mes				
Outcome #	Α	b	c	D	E	f	g	h	Ι	J	k	1
1	Н	Н	L	Μ	Μ	N						
2	Н	Н	L	Μ	Μ	H						
3	Н	Н	Μ	Μ	Μ	H						

4	Н	Н	Μ	Μ	Μ	H			
5	Н	Н	L	Μ	Μ	H			

	Mapping Between COs and Course Delivery (CD) methods							
CD	Course Delivery methods	Course Outcome	Course Method	Delivery				
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1 CD2					
CD2	Tutorials/Assignments	CO2	CD1 CD2					
CD3	Seminars	CO3	CD1 CD2					
CD4	Mini projects/Projects	CO4	CD1 CD2					
CD5	Laboratory experiments/teaching aids	CO5	CD1 CD2					
CD6	Industrial/guest lectures							
CD7	Industrial visits/in-plant training							
CD8	Self- learning such as use of NPTEL materials and internets							
CD9	Simulation							

Week	Lect.	Tentative	Ch.	Topics	to	be	Text	COs	Actual	Methodology	Remarks b	y
No.	No.	Date	No.	covered			Book	mapped	Conten	Used	faculty	if
							/		t		any	
							Refere		covere			
							nces		d			
1	L1-			Nuclear	Mo	dels	T1 R1					
	L2			Liquid	C	lrop						
				Model,	se	emi-						
				empirical	n	nass						
				formula,								
	L3-			transitions	5		T1 R1					
	L4			between	odd	А						
				isobars,								
				transitions	5							
				between	e	even						
				isobars,								
	L5-			odd-even	eff	ects	T1 R1					
	L8			and	m	agic						
				numbers,	S	hell						
				model, c	ollec	tive						
				model. L								
	L9-			Two	nucl	leon	T1 T2					
	L11			problem,		The						
				deuteron,	gro	und						
				state of de	eutero	on,						
	L12-			nature of	nuc	lear	T1-T2					
	L13			forces,	exc	ited						
				state of de	eutero	on,						
	L14-			spin dep	bende	ence	T1 T2					
	L15			of nuclear	forc	e,						
	L-16			meson th	eory	of	T1 T2					
				nuclear fo	rce							
	L17-			Scattering	, C	ross	T1 T2					
	L20			section,	<u> </u>		R1					

	differential areas			
	differential cross			
	section, scattering			
	cross section,			
L20-	nucleon nucleon	T1 T2		
L24	scattering, proton-	R1		
	proton and			
	neutron neutron			
	scattering at low			
	energies			
L25-	Interaction of	T1 R1		
L28	radiation with			
	matter, Interaction			
	of charged			
	narticles with			
	matter			
		T1 D1		
L29-	stopping power of	IIKI		
L32	heavy charged			
	particles, energy			
	loss of electrons,			
	absorption of			
	gamma ravs.			
	photoelectric			
	effect Compton			
	offect, compton			
	effect and pair			
	production		 	
L33-	Classification of	T1 T3		
L35	elementary			
	particle,			
L36-	Eightfold way,	T1 T3		
1.38	Baryon octate and			
200	meson octate			
	Quark model			
	Quark model,			
	Baryon Decupiet,			
	meson nonlet,			
	Intermediate			
	vector Boson			
L39-	Strong	T1 T3		
L40	electromagnetic			
	and week			
	interactions			
	standard mad-1			
	stanuaru model,			
	lepton			
	classification and			
	quark			
	classification.			

Course code: PH 502 Course title: Advanced Quantum Mechanics Pre-requisite(s): Quantum Mechanics Co- requisite(s): Credits: 4L: 3 T:1 P: 0 Class schedule per week: Class: I.M.Sc. Semester / Level:IX / III Branch: PHYSICS

Code: PH 502	Title: Advanced Quantum Mechanics	[L-T-P-C [3-1-0-4]					
Module	Course Objective:						
1	To learn how to apply Perturbation Theory (Time Independent) in non-degenerate and degenerate situations.						
2	To apply approximate method in Quantum Mechanics to treat molecules.						
3	To learn how to apply semi-classical method to treat the interaction of atoms with field.						
4	To learn how to treat Two –level systems Quantum Mechanically.						
5	To learn the basics of relativistic quantum Mechanics.						
Module	Course Outcome:						
1	Will be able to solve and analyse various quantum mechanical problem related to Time Independent Perturbation Theory.						
2	Will be able to treat molecules quantum mechanically .						
3	Will be able to apply semi-classical method to treat atom field interactions.						
4	Will be able to treat Two- Level System Quantum Mechanically.						
5	Will be able to understand the central concept and principles of relativistic Quantum Mechanics.						
Module-1	Perturbation theory, time-independent perturbation theory (non-degenerate and degenerate) and applications. Stark effect and other simple cases. Relativistic perturbation to hydrogen atom. Energy levels of hydrogen including fine structure, Lamb shift and hyperfine splitting. Zeeman effect (normal and anomalous) time, first and second order, the effect of the electric field on the energy levels of an atom (Stark effect)	15					
Module-2	Quantum mechanics of molecules, Born-Oppenheimer approximation	5					
Module-3	Time-dependent perturbations, first order transitions, Semi- classical theory of interaction of atoms with field. Quantization of radiation field. Hamiltonian of field and atom, Fermi golden rule, the Einstein's A & B coefficients.	10					
Module-4	Atom field interaction, density matrix equation, closed and open two-level atoms, Rabi oscillations.	10					
Module-5	Relativistic wave equations: Klein-Gordon equation for a free particle and particle under the influence of an electromagnetic potential, Dirac's relativistic Hamiltonian, Dirac's relativistic wave equation, positive and negative energy states, significance of negative energy states.	10					
Book: 1. Quantu <u>Reference</u> 1. Quantu	um Mechanics by L. I. Schiff. (Tata McGraw Hill, New Delhi) <u>s:</u> um Mechanics by L. D. Landau and E. M. Lifshitz (Pergamor	n Berlin)					

Ghatak

and

S.

by

Mechanics

2. Quantum

3.

A.

A Textbook of Quantum Mechanics by P. T. Mathews (Tata McGraw Hill)

K.

(McMillan

India)

Lokanathan

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	N
Mini projects/Projects	N
Laboratory experiments/teaching aids	N
Industrial/guest lectures	N
Industrial visits/in-plant training	N
Self- learning such as use of NPTEL materials and internets	Y
Simulation	N

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End SemExamination Marks	50
Quiz	10+10
Teacher's assessment	5

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	\checkmark				
End Sem Examination Marks	\checkmark		\checkmark	\checkmark	
Quiz I			\checkmark	\checkmark	
Quiz II					

Indirect Assessment -

- 1. Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping between Course Objectives and Course Outcomes **Course Objectives** 4 5 1 2 3 Η L Μ Μ L А В L Η L L L С Μ L Η Μ L D М L М Η L E L L L Η L

Mapping of Course Outcomes onto Program Outcomes

Course		Program Outcomes										
Outcome #	а	В	c	d	e	f		h	i	j	k	1
1	Н	Η	Н	Μ	Η	Н						
2	Н	Η	Н	Μ	Η	Н						
3	Н	Η	Н	Μ	Η	Н						
4	Η	Η	Η	Μ	L	Н						
5	Н	Η	Н	Μ	Μ	Н						

	Mapping Between COs and Course Delivery (CD) methods									
			Course	Course Delivery						
CD	Course Delivery methods		Outcome	Method						

CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1 CD2
CD2	Tutorials/Assignments	CO2	CD1 CD2
CD3	Seminars	CO3	CD1 CD2
CD4	Mini projects/Projects	CO4	CD1 CD2
CD5	Laboratory experiments/teaching aids	CO5	CD1 CD2
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

Week	Lect.	Tent	С	Topics to be covered	Text	COs	Actual	Method	Remark
No.	No.	ative	h.		Book /	map	Content	ology	s by
		Date	Ν		Refere	ped	covered	Used	faculty
			0.		nces				if any
1	L1-L6			Perturbation theory, time-	T1-				
				independent perturbation theory	T2-R1				
				(non-degenerate and degenerate)					
				and applications.					
	L7-L9			Stark effect and other simple	T1-				
				cases. Relativistic perturbation to	T2_R				
				hydrogen atom.	1				
	L10-			Energy levels of hydrogen	T1 T2				
	L12			including fine structure, Lamb	R1				
				shift and hyperfine splitting					
	L13-		l	Zeeman effect (normal and	T1 T2				
	L15			anomalous) time, first and second	R1				
				order, the effect of the electric					
				field on the energy levels of an					
				atom (Stark effect)					
	L16-			Quantum mechanics of molecules,	T1 T3				
	L20			Born-Oppenheimer approximation	R1				
	L21-			Time-dependent perturbations,	T1 T3				
	L24			first order transitions, Semi-	R1				
				classical theory of interaction of					
				atoms with field.					
	L25-			Quantization of radiation field.	T1 T2				
	L28			Hamiltonian of field and atom,	R1				
	L29-			Fermi golden rule, the Einstein's	T1 T2				
	L30			A & B coefficients.					
	L31-			Atom field interaction, density	T1 T2				
	L34			matrix equation,					
	L35-			closed and open two-level atoms,	T1 T2				
	L38			Rabi oscillations.	Т3				
	L39-			Relativistic wave equations:	T1 T2				
	L44			Klein-Gordon equation for a free	T3				
				particle and particle under the					
				influence of an electromagnetic					
				potential,					
	L44-			, Dirac's relativistic Hamiltonian,	T1 T2				

L50		Dirac's relativistic wave equation, positive and negative energy states, significance of negative energy states.	Т3		

Course code:	PH 503			
Course title:	Lasers I	Physics a	and Appli	ications
Pre-requisite	e(s): Way	ves and	Optics	
Co- requisite	e(s):			
Credits: 3	L: 3	T: 1	P: 0	
Class schedu	le per w	eek:		
Class: I.M.S	2.			
Semester / L	evel: IX	/ III		
Branch: PHY	ISICS			
Name of Tea	cher:			

Code:		Title: Lasers Physics and Applications	L-T-P-C						
PH 503	3		[3-1-0-4]						
Cours	se Obi	lectives							
This	course	enables the students:							
	A.	To identify conditions for lasing phenomenon and properties of the laser.							
	B.	To discuss stable, unstable resonators and cavity modes.							
	C. To compare continuous and pulsed lasers.								
D. To classify different types of lasers with respect to design and working principles									
	Е	To illustrate various applications of laser e.g. holographic non-destructive testing.							
Cour	se Ou	tcomes							
After	the co	ompletion of this course, students will be:							
	1.	To evaluate conditions for lasing phenomenon and properties of the laser.							
	2.	To calculate cavity modes of a given cavity and identify the given resonator is stable or unstable	one.						
	3.	To evaluate Q-switching and the mode-locked lasing phenomenon.							
	4.	To appraise different type of lasers with respect to design and working principles.							
	5.	To assess applications of a laser for measurement of distance, holography and medical surgeries	etc.						
Modu	Interaction of radiations with atoms and ions: Spontaneous and Stimulated emissions, Stimula	ited [15]							
		absorption. Population inversion, gain oscillation, gain saturation, threshold, rate equation, 3 an	d 4						
		level systems, laser line shape, hole burning, Lamb dip, output power. Properties of las	ser:						
		coherence, monochromaticity, divergence.							
Modu	ıle-2	Theory of resonator. Stable and unstable resonator, Optical cavities, Cavity modes, longitudi	nal [10]						
		and transverse modes of the cavity.							
Modu	ıle-3	Continuous wave, Pulsed, Q- switched and Modelocked lasers.	[5]						
Modu	ıle-4	Different type of lasers, design (in brief) and functioning of different lasers - Ruby laser, Nd: Y.	AG [10]						
		laser, He-Ne laser, CO ₂ laser, Argon ion laser, Dye laser, Excimer laser. Free electron laser							
Modu	ıle-5	Measurement with laser, alignment, targeting, tracking, velocity measurement, surface qua	lity [10]						
		measurement. Measurement of distance (interferometric, pulse echo, Beam modulation). la	iser						
		gyroscope, Holographic nondestructive testing (NDT). Application in communication. Mater	rial						
		Processing: cutting, welding, drilling and surface treatment. Medical Applications, Laser trappin	ng.						
Boo	k:								
T	1: 0.	Svelto; Principles of Lasers, Springer (2004)							
T.	2: Lase	er Fundamentsls: William T. Silfvast, Cambridge University Press (1998)							
R	1 K. S	himoda, Introduction to laser Physics, Springer Verlag, Berlin (1984)							
R	2: Las	er Electronics: J.T.Verdeyen, 3rdEd, Prentice Hall (1994)							
	2 I a a	an Annlightians in Surface Science and Technology IIC Dubahay John Wiley & Song (1000)							

R3 Laser Applications in Surface Science and Technology; H.G.Rubahn; John Wiley & Sons (1999)

1. R4 Optical Methods in Engineering Metrology: Ed D.C.Williams; Chapman & Hall

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	N
Mini projects/Projects	N
Laboratory experiments/teaching aids	N
Industrial/guest lectures	N
Industrial visits/in-plant training	N
Self- learning such as use of NPTEL materials and internets	Y
Simulation	N

<u>Course Outcome (CO) Attainment Assessment tools & Evaluation procedure</u> Direct Assessment

Assessment Tool	% Contribution during CO Assessment					
Assignment	10					
Seminar before a commitee	10					
Three Quizzes	30 (10+10+10)					
End Sem Examination Marks	50					

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	\checkmark		\checkmark		
End Sem Examination Marks	\checkmark		\checkmark	\checkmark	\checkmark
Quiz I			\checkmark	\checkmark	
Quiz II				\checkmark	\checkmark

Indirect Assessment -

- 1. Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4	5
Α	Н	Μ	Μ	L	Μ
В	М	Н	М	L	L
С	L	L	Н	L	L
D	-	L	L	Η	L
E	L	Μ	L	L	Н

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #		Program Outcomes						
	а	b	с	d	e	f		
1	Н	Н	Н	Η	L	Н		
2	Н	Н	Н	Η	М	Н		
3	Н	Н	Н	М	L	Μ		
4	Н		Н	Η	L	М		
5	М	Н	Н	Н	Н	Н		

Mapping Between COs and Course Delivery (CD) methods						
CD	Course Delivery methods	Course Outcome	Course Delivery Method			
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1 and CD2			
CD2	Tutorials/Assignments	CO2	CD1 and CD2			
CD3	Seminars	CO3	CD1 and CD2			
CD4	Mini projects/Projects	CO4	CD1 and CD2			
CD5	Laboratory experiments/teaching aids	CO5	CD1 and CD2			
CD6	Industrial/guest lectures	-	-			
CD7	Industrial visits/in-plant training	-	-			
CD8	Self- learning such as use of NPTEL materials and internets	-	-			
CD9	Simulation	-	-			

Week No.	Lect. No.	Tent ative Date	Ch. No.	Topics to be covered	Text Book / Refere nces	COs mapp ed	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1-L2		1	Interaction of radiations with atoms and ions	T1, T2,	1,2		PPT Digi Class/Chock -Board	
	L3-L7			SpontaneousandStimulatedemissions,Stimulatedabsorption.Populationinversion,gain oscillation		1,		Digi Class/Chock -Board	
	L8- L10			gain saturation, threshold, rate equation, 3 and 4 level systems,		1,2		Digi Class/Chock -Board	
	L11- L14			laser line shape, hole burning, Lamb dip, output power.		1,2,3		Digi Class/Chock -Board	
	L15			Properties of laser: coherence, monochromaticity, divergence.		1,2		Digi Class/Chock -Board	
	L16- L18			Theory of resonator. Stable and unstable resonator,		1		Digi Class/Chock -Board	
	L19- L25			Optical cavities, Cavity modes, longitudinal and transverse modes of the cavity.		2		Digi Class/Chock -Board	
	L26- L30			Continuous wave, Pulsed, Q- switched and Modelocked lasers.		3		Digi Class/Chock -Board	
	L31-35			Different type of lasers, design (in brief) and functioning of different lasers -		4		Digi Class/Chock -Board	

L36- L40	Ruby laser, Nd: YAG laser, He-Ne laser, CO_2 laser, Argon ion laser, Dye laser, Excimer laser. Free electron laser	4	Digi Class/Chock -Board
L41- L45	Measurement with laser, alignment, targeting, tracking, velocity measurement, surface quality measurement.	5	Digi Class/Chock -Board
L46- L50	Measurement of distance (interferometric, pulse echo, Beam modulation). laser gyroscope, Holographic nondestructive testing (NDT). Application in communication. Material Processing: cutting, welding, drilling and surface treatment. Medical Applications, Laser trapping.		Digi Class/Chock -Board

Course code: PH 513 Course title: Laser Physics Lab Pre-requisite(s): Laser Physics and Applications Co- requisite(s): Credits: 2 L: 0 T: 0 P: 4 Class schedule per week: Class: I.M.Sc. Semester / Level: I Branch: PHYSICS Name of Teacher: Dr K. Bose

	Laser Physics Lab	
	·	L-T-P-C [0-0-4-2]
1.	To determine the wavelength of sodium light using Michelson Interferometer	
2.	Demonstrate interference fringe pattern using Mach Zhender interferometer.	
3.	Study of mercury spectrum using grating and spectrometer.	
4.	Determine the coherence length of a diode laser using a Michelson Interferometer.	
5.	Perform Faraday Effect experiment and find verdet constant of flint glass.	
6.	To study the birefringence with respect to applied voltage in an electro optic crystal.	
·/. o	To determine the Kerr constant of the liquid (Nitro Benzene)	
ð. Q	To find the velocity of ultrasonic wave in a liquid using ultrasonic diffraction appara	tus
).	To find the velocity of unusonic wave in a riquid using unusonic diffraction appara	

Course Assessment tools & Evaluation procedure

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

Semester IV

PE- VI & VII

Two papers from the same Group A or B or C or $\,$ D or E

Project from the same Group A or B or C or D or E

PE-V

Group	A- <u>Theoretical and Computational Physics:</u>	
1.	Numerical Methods for Physicists	
2.	Theory of Solids	
	COURSE INFORMATION SHEET	
ourse co	ode: PH 504	
ourse u re-reau	ue: Numerical Methods for Physicists site(s): Mathematical Physics	
o- requi	site(s):	
redits:	4 L: 4 T: 0 P: 0	
lass sch	edule per week:	
lass: I.N	1.Sc. / Level: DE V	
emester ranch•]	/ Level: PE V PHYSICS	
ame of	Feacher:	
Grou	p: A Option 1	
ode:	Title: Numerical Methods for Physicists	L-T-P-C
H 504		[4- 0-0- 4
	Theory & Programming using C for solving problems on following topics:	
Cou	rse Objectives	1
This	course enables the students:	
A.	To learn about optimization techniques	
B.	To understand the concepts of functional approximations	
C.	To know about algebraic eigenvalue problems	
D.	To gain knowledge on integral equations	
E.	To gain familiarity with the numerical solutions of partial differental equations	
L		
Cou	rse Outcomes	
Afte	r the completion of this course, students will be:	
1.	Able to perform optimization via coding	
2.	Able to do construct programs on functional approximations	
3.	Solving eigenvalue problems numerically	
4.	Comfortable in dealing with integral equations	
5.	Numerically able to solve partial differential equations	
Module	1 Optimization	[10]
	Golden Section Search, Brent's Method, Methods Using Derivative, Minimization in Several Dimensions, Quasi-Newton Methods, Direction Set Methods, Linear Programming	
Module	2 Functional Approximations	[10]
	Choice of Norm and Model, Linear Least Squares, Nonlinear Least Squares, Discrete Fourier Transform, Fast Fourier Transform (FFT), FFT in Two or More Dimensions, Functional Approximations	
Module	3 Algebraic Eigenvalue Problems	[10]
	Introduction, Power Method, Inverse Iteration, Eigenvalue Problem for a Real Symmetric Matrix, QL Algorithm for a Symmetric Tridiagonal Matrix, Algebraic Eigenvalue Problem	
Module	4 Integral Equations	[10]
	Introduction, Fredholm Equations of the Second Kind, Expansion Methods, Eigenvalue Problem, Fredholm Equations of the First Kind, Volterra Equations of the Second Kind, Volterra Equations of the First Kind	

Module-5	Partial Differential Equations	[10]				
	Wave Equation in Two Dimensions, General Hyperbolic Equations, Elliptic Equations, Successive Over-Relaxation Method, Alternating Direction Method, Fourier Transform Method, Finite Element Methods, Algorithms for Vector and Parallel Computers					
References						
1. "Numeric	al methods for Scientists and Engineers" by H. M. Antia, Springer Science and Business Media.					
2. "Numeric	cal Recipes in C" by William H. Press, Saul A. Teukolsky, William T. Vetterling & Brian P.	Flannery,				
Cambridge University Press.						
3. "Program	ming in C# A Primer" by E Balagurusamy, McGraw Hill Education.					

Course Assessment tools & Evaluation procedure

Direct Assessment	
Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizzes	30 (10+10+10)
End Sem Examination Marks	50

Indirect Assessment -

- 1. Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination					
Marks					
End Sem Examination					
Marks					
Quiz I					
Quiz II					

Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4	5
А	Η	L	-	-	-
В	М	Н	L	-	М
С	М	L	Н	-	М
D	М	L	L	Н	М
E	М	L	L	L	Н

Course Outcome #	Program Outcomes						
	a	b	c	d	e	f	
1	L	Μ	Μ	Μ	L	Μ	
2	L	Μ	Μ	Μ	L	Μ	
3	L	Н	Μ	Μ	L	Μ	
4	L	Н	Μ	Μ	Н	Μ	
5	L	Н	Μ	Μ	Н	Μ	

Week	Lect	Tentati	Ch.	Topics to be covered	Text	Cos	Actual	Methodolo	Remar
No.	No.	ve	No.	•	Book /	map	Content	gyused	ks by
		Date			Referenc	ped	covered	80	faculty
					es	I			if any
1	L1-			Golden Section Search, Brent's	T1,T2,T3	1		Board,	
	L3			Method, Methods Using	, ,			Computers	
				Derivative				1	
2	L4-			inimization in Several	T1,T2,T3	1		Board,	
	L6			Dimensions, Quasi-Newton				Computers	
				Methods				•	
3	L7-			Direction Set Methods, Linear	T1,T2,T3	1		Board,	
	L9			Programming				Computers	
4	L10-			Choice of Norm and Model,	T1,T2,T3	2		Board,	
	L12			Linear Least Squares, Nonlinear				Computers	
				Least Squares					
5	L13-			Discrete Fourier Transform, Fast	T1,T2,T3	2		Board,	
	L15			Fourier Transform (FFT),				Computers	
6	L16-			FFT in Two or More	T1,T2,T3	2		Board,	
	L18			Dimensions, Functional				Computers	
				Approximations					
7	L19-			Introduction,Power Method,	T1,T2,T3	3		Board,	
	L21			Inverse Iteration,				Computers	
8	L22-			Eigenvalue Problem for a Real	T1,T2,T3	3		Board,	
	L24			Symmetric Matrix , QL				Computers	
				Algorithm for a Symmetric					
				Tridiagonal Matrix					
9	L25-			Algebraic Eigenvalue Problem	T1,T2,T3	3		Board,	
	L27							Computers	
10	L28-			Introduction, Fredholm	T1,T2,T3	4		Board,	
	L30			Equations of the Second Kind,				Computers	
				Expansion Methods					
11	L31-			Eigenvalue Problem, Fredholm	T1,T2,T3	4		Board,	
	L33			Equations of the First Kind				Computers	
12	L34-			Volterra Equations of the	T1,T2,T3	4		Board,	
	L36			Second Kind, Volterra				Computers	
T 1 T				Equations of the First Kind					
1311,1	L37-			Wave Equation in Two	T1,T2,T3	5		Board,	
2,13	L39			Dimensions, General				Computers	
				Hyperbolic Equations, Elliptic					
				Equations					
14	L40-			Successive Over-Relaxation	T1,T2,T3	5		Board,	
	L42			Method, Alternating Direction				Computers	
				Method, Fourier Transform					
1.7	T 10			Method	T 1 T 2 T 2	-			
15	L43-			Finite Element Methods,	11,12,13	5		Board,	
1	L45			Algorithms for Vector and	1			Computers	1

Parallel Computers			

Course code: PH 505 Course title: Theory of Solids Pre-requisite(s): Condensed Matter Physics Co- requisite(s): Credits: 4L: 4 T: 0 P: 0 Class schedule per week: Class: I.M.Sc. Semester / Level: PE V Branch: PHYSICS Name of Teacher:

Group A

Option 3

Code:	Title: Theory of Solids					
PH 505						
Course Ob	jectives : This course enables the students					
<u>A.</u>	A. To become familiar with classification of solids using band theory.					
В.	B. To be familiarized with the change in density of states as a function of physical dimension of sol					
C. To become familiar with the electrical behaviour of dielectric materials and understand the field induced by dielectrics						
D	To become familiar with the theory behind the magnetic properties of materials					
E D.	To become familiar with the theory benind the magnetic properties of materials.					
L.	To understand the unrefent optical processes and photophysical properties of solids.					
Course Ou	tcomes : After the completion of this course, students will be					
1.	Able to classify materials as metals, insulators and semiconductors and sketch the band diagram	for each.				
2.	Able to classify material as 0D, 1D, 2D and 3D on the basis of density of states and correlate the	physical				
	properties with physical dimensions.					
3.	Able to describe the different dielectric properties and be familiar with the experimental methods	s for				
	investigation of dielectrics.					
4.	Able to apply the theories to estimate the magnetic properties of materials.					
5.	Able to correlate the results of different optical experiments with the theory.					
Module-1	Band Theory	[8]				
	Review of Concepts: (Bloch theorem and Bloch function, Kronig Pennev model),	[0]				
	Construction of Brillouin zones (1 and 2 dimensions), Extended, reduced and periodic zone					
	scheme, Effective mass of an electron, Nearly free electron model, Tight binding					
	approximation, Orthogonalized plane wave method, Pseudo-potential method,					
	Classification of conductor, semiconductor and insulators.					
Module-2	Electron Statistics	[6]				
	Fermi-Dirac distribution, Fermi energy, Density of States, Classification of solids (0D, 1D,					
	2D, 3D) on the basis of density of states and k-space, effect of temperature on Fermi					
	distribution function.					
Module-3	Dielectrics	[10]				
	Matter in a.c. field, Propagation of e.m. wave in matter on the basis of Maxwell's equation,					
	Relaxations and resonances, Kramer's-Kronig relation, Mechanical analogue of relaxation,					
	Debye relation, Argand diagram, Influence of local field and d.c. conductivity and multiple					
	relaxation times, Special diagram (cole-cole arc), Heterogeneous dielectrics (Maxwell-					
	Wagner effect), Dipole relaxation of defects in crystal lattices, Space charge polarization					
	and relaxation, Resonances: Linear oscillator model and one dimensional polar lattices,					
	Ferroelectricity, Microscopic theory of Ferroelectricity, Phase transition of ferroelectrics					
	(1 st , 2 st and relaxor kind), Hysteresis loop, Recoverable energy, Piezoelectricity and					
	transducers.	[0]				
woulde-4	Magnetis interactions. Evolutions distance interaction Direct evolutions. Indirect evolutions Devolution	[8]				
	avalance Helicol order Emutration Spin classes London theory of formers and					
	Heisenberg and Ising models. Excitations, Magnons, Bloch T ^{3/2} law Measurement of spin					
	waves Magnetism of the electron gas Spin density waves Kondo effect					
	waves, magnetism of the election gas, spin defisity waves, Kondo enect.					

Module-5	Optical properties	[8]
	Classification of optical process, optical coefficient, complex refractive index, propagation	
	of light in a dense optical medium, atomic oscillator, vibrational oscillator, free electron	
	oscillator, dipole oscillator model, inter band absorptions, excitons, concept of excitons,	
	free excitons, free excitons in external field, luminescence, light emission from solids,	
	interband luminescence, photoluminescence, electroluminescence, luminescence centres,	
	phonons, optical properties of metals.	
Text book		

Text book

- 1. Introduction to Solid State Physics 8thEdition, Charles Kittel, John Wiley and Sons, 2005.
- 2. Solid State Physics, Neil W. Ashcroft, N. David Mermin, Saunders College Publishing, 1976

References:

- 1. Optical properties of Solids: Anthony Mark Fox, Oxford Master Series in Physics, Oxford University Press (2001).
- 2. Magnetism in Condensed Matter, Oxford Master Series in Condensed Matter Physics 4, Stephen Blundell, Oxford University Press (2001).

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP	Yes
projectors	
Tutorials/Assignments	Yes
Seminars	Yes
Mini projects/Projects	No
Laboratory experiments/teaching aids	No
Industrial/guest lectures	No
Industrial visits/in-plant training	No
Self- learning such as use of NPTEL materials and	Yes
internets	
Simulation	No

Course Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizzes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	Yes	Yes	Yes	No	No
End Sem Examination Marks	Yes	Yes	Yes	Yes	Yes
Assignment	Yes	Yes	Yes	Yes	Yes

Indirect Assessment -

- 1. Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	а	b	c	d	e	f
---	---	---	---	---	---	---
1	Н	М	М	L	М	L
2	Н	М	М	L	L	L
3	М	Н	Н	L	М	М
4	Н	Н	Н	L	М	М
5	М	Н	Н	L	М	М

Course Outcome #	Course Objectives							
	a	b	с	d	e			
1	Н	М	L	L	М			
2	М	Н	L	L	L			
3	L	L	Н	L	М			
4	L	L	L	Н	L			
5	M	L	М	М	Н			

	Mapping Between COs and Course Delivery (CD) methods								
			C	Comme Delineer					
CD	Course Delivery methods		Course	Course Denvery					
CD	Course Delivery methods		Outcome	Method					
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1, CD2 and CD8					
CD2	Tutorials/Assignments		CO2	CD1, CD2 and CD8					
CD3	Seminars		CO3	CD1, CD2 and CD8					
CD4	Mini projects/Projects		CO4	CD1, CD2 and CD8					
CD5	Laboratory experiments/teaching aids		CO5	CD1, CD2 and CD8					
CD6	Industrial/guest lectures								
CD7	Industrial visits/in-plant training								
CD8	Self- learning such as use of NPTEL materials and internets								
CD9	Simulation								

Week	Lect.	Tent	Modul	Topics to be covered	Text	COs	Actual	Methodology	Remarks
No.	No.	ative Date	e No.		Book / Refere	mappe d	Content	used	by faculty if
		Dutt			nces	u	coverea		any
1	L1-L2		Ι	Review of Concepts: (Bloch theorem and Bloch function,	T1, T2	1, 2		PPT Digi Class/Chalk -Board	
1	L3			KronigPenneymodel)ConstructionofBrillouinzones(1and2dimensions)	T1, T2			PPT Digi Class/Chalk -Board	
1	L4-L5			Extended, reduced and periodic zone scheme Effective mass of an electron,	T1, T2			PPT Digi Class/Chalk -Board	
2	L6			Nearly free electron model	T1, T2			PPT Digi Class/Chalk -Board	

2	L7		Tight binding approximation	T1, T2	PPT Digi
					Class/Chalk
					-Board
2	L8-L9		Orthogonalized plane wave	T1, T2	PPT Digi
			method,Pseudo-potential		Class/Chalk
			method		-Board
3	L10		Classification of conductor,	T1, T2	PPT Digi
			semiconductor and insulators		Class/Chalk
					-Board
4	L11	II	Fermi-Dirac distribution	T1, T2	PPT Digi
					Class/Chalk
					-Board
4	L12-13		Fermi energy	T1, T2	PPT Digi
					Class/Chalk
					-Board
5	L14-16		Density of States,	T1, T2	PPT Digi
			Classification of solids (0D,		Class/Chalk
			1D, 2D, 3D) on the basis of		-Board
			density of states		
5	L17		k-space	T1, T2	PPT Digi
					Class/Chalk
					-Board
6-7	L18-20		Effect of temperature on	T1, T2	PPT Digi
			Fermi distribution function.		Class/Chalk
					-Board
	L21	III	Matter in a.c. field,	T1, T2	PPT Digi
			Propagation of e.m. wave in		Class/Chalk
			matter on the basis of		-Board
			Maxwell's equation		
	L22		Relaxations and resonances	T1, T2	PPT Digi
					Class/Chalk
					-Board
	L23		Kramer's-Kronig relation,	T1, T2	PPT Digi
			Mechanical analogue of		Class/Chalk
			relaxation		-Board
	L24		Debye relation, Argand	T1, T2	PPT Digi
			diagram		Class/Chalk
			-		-Board
	L25		Influence of local field and	T1, T2	PPT Digi
			d.c. conductivity and multiple		Class/Chalk
			relaxation times		-Board
	L26		Special diagram (cole-cole	T1, T2	PPT Digi
			arc), Heterogeneous		Class/Chalk
			dielectrics (Maxwell-Wagner		-Board
			effect)		
	L27	—	Ferroelectricity, Microscopic	T1, T2	PPT Digi
			theory of Ferroelectricity		Class/Chalk
					-Board
	L28		Phase transition of	T1, T2	PPT Digi
			ferroelectrics (1 st , 2 nd and		Class/Chalk
			relaxor kind),		-Board
L	1			1	

	L29		Hysteresis loop, Recoverable	T1, T2	PPT Digi
			energy,		Class/Chalk
					-Board
	L30		Piezoelectricity and	T1, T2	PPT Digi
			transducers.		Class/Chalk
					-Board
	L31	IV	Magnetic interactions,	T1, T2,	PPT Digi
			Exchange interaction	R2	Class/Chalk
			C C		-Board
	L32		Direct exchange, Indirect	T1, T2,	PPT Digi
			exchange	R2	Class/Chalk
					-Board
	L33-34		Double exchange, Helical	T1, T2,	PPT Digi
			order. Frustration. Spin	R2	Class/Chalk
			glasses		-Board
	I 35		Landau theory of	T1 T2	PPT Digi
	133		ferromagnetism	P2	Class/Chalk
			ienomagnetism,	112	-Board
	I 36-37		Heisenberg and Ising models	Т1 Т2	PPT Digi
	L30-37		Excitations	D2	Class/Chalk
			Excitations,	K2	-Board
	I 38		Magnons Bloch T ^{3/2} law	Т1 Т2	PPT Digi
	L30		Magnons, Dioen 1 law,	D2	Class/Chalk
				K 2	-Board
	I 30		Measurement of spin waves	Т1 Т2	PPT Digi
	1.57		Weasurement of spin waves	D2	Class/Chalk
				K2	-Board
	I 40		Spin density wayes Kondo	Т1 Т2	PPT Digi
	LTU		affact	D2	Class/Chalk
			chicet.	K 2	-Board
	I 41	V	Classification of optical	Т1 Т2	PPT Digi
	LTI	v	process optical coefficient	R1	Class/Chalk
			process, optical coefficient	IXI	-Board
	142		complex refractive index	T1 T2	PPT Digi
	112		propagation of light in a	R1	Class/Chalk
			danse enticel medium	IXI	-Board
	I 42			T1 T2	
	L45		atomic oscillator, vibrational	11, 12, 12, 11	Class/Challe
			oscillator		Roard
	T 44 45		fras alastrar assillator dirala	T1 T2	
	L/ 1 4-43		nee electron oscillator, dipole	[11, 12, 0]	Class/Challr
			oscillator model	KI	Board
	I 46		inter hand	T1 T2	
	L40		inter Dand	$\mathbf{P}_{1}^{11, 12, 12}$	Class/Challz
			absorptions, excitons, concept	KI .	Board
			of excitons, free excitons,		-Doald
			tree excitons in external field		
	L47		luminescence, light emission	Т1, Т2,	PPT Digi
			from solids	RI	Class/Chalk
					-Board
	L48		interband luminescence,	T1, T2,	PPT Digi
			photoluminescence	RI	Class/Chalk
1					-Board

L49		electroluminescence,luminesc ence centres	T1, T2, R1		PPT Digi Class/Chalk -Board	
L50		phonons, optical properties of metals.	T1, T2, R1		PPT Digi Class/Chalk -Board	

Group B- Condensed Matter Physics:

1. Theory of Solids

2. Functional Materials

COURSE INFORMATION SHEET

Course code: PH 505 Course title: Theory of Solids Pre-requisite(s): Condensed Matter Physics Co- requisite(s): Credits: 4 L: 4 T: 0 P: 0 Class schedule per week: Class: I.M.Sc. Semester / Level: PE V Branch: PHYSICS Name of Teacher:

Group B

Option 1

Same given As above(in Group A)

COURSE INFORMATION SHEET

Course code: PH 506 Course title: Functional Materials Pre-requisite(s): Condensed Matter Physics Co- requisite(s): Credits: 4L: 4 T: 0 P: 0 Class schedule per week: Class: I.M.Sc. Semester / Level: PE V Branch: PHYSICS Name of Teacher:

Option 2

Group :	В	
Code:	Title: Functional Materials	L-T-P-C
PH 506		[4-0-0-4]
Module-1	Introduction to Metals, Alloys, Ceramics, Polymers and Composites, Phase rules Fe-C phase	[8]
	diagram, Steels, cold, hot working of metals, recovery, recrystallization and grain growth,	
	Structure, properties.	
Module-2	Processing and applications of ceramics. Classification of polymers, polymerization,	[12]
	structure, properties, additives, products, processing and applications. Quasicrystals,	
	Conducting Polymers; Properties and applications composites.	
Module-3	Advanced Materials: Smart materials, ferroelectric, piezoelectric, biomaterials (some basic	[10]
	information), superalloys, aerospace materials, shape memory alloys, optoelectronic	
	materials, Materials for photodiode, light emitting diode (LED), Photovoltaic/Solar cell and	
	meta materials	
Module-4	Nanostructured Materials: Nanomaterials classification (Gleiter's Classification)-property	[8]
	changes done to size effects, Quantum dot, wire and well, synthesis of nanomaterials, ball	
	milling.	
Module-5	Liquid state processing -Sol-gel process, Vapour state processing -CVD, MBE, Aerosol	[12]
	processing, fullerene and tubules, formation and characterization of fullerenes and tubules,	
	single wall and multiwall carbon tubules, electronic properties of tubules, applications:	
	optical lithography, MOCVD, super hard coating.	
Text boo	oks:	
1. T1: S	Structure and properties of engineering materials, fifth edition, Henkel and Pense, McGraw Hill, 2	2002

2. T2: Biomaterials Science, An Introduction to Materials in Medicine , Edited by B.D. Ratner, A.S.

Hoffman, F.J. Sckoen, and J.E.L Emons, Academic Press, second edition, 2004

_Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Yes
Tutorials/Assignments	Yes
Seminars	Yes
Mini projects/Projects	No
Laboratory experiments/teaching aids	No
Industrial/guest lectures	No
Industrial visits/in-plant training	No
Self- learning such as use of NPTEL materials and internets	Yes
Simulation	No

Course Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizzes	30 (10+10+10)
End Sem Examination Marks	50

Indirect Assessment –

- **1.** Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

Assessment Components	CO1	CO2	CO3	CO4	CO5
Quizes	Yes	Yes	Yes	Yes	Yes
End Sem Examination Marks	Yes	Yes	Yes	Yes	Yes
Assignment					

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes							
	а	b	с	d	e	f		
1	Н	Н	Н	L	М	L		
2	М	Н	Н	L	L	L		
3	Н	М	М	М	М	М		
4	М	Н	М	М	Н	М		
5	Н	Н	Н	L	Н	L		

Course Outcome #	Course Objectives								
	А	В	С	D	E				
1	Н	М	М	М	М				
2	L	Н	L	L	М				
3	L	М	Н	М	М				
4	Н	L	Н	Н	L				
5	Н	М	M	L	Н				

	Mapping Between COs and Course Delivery (CD) methods								
CD	Course Delivery methods		Course	Course Delivery Method					
			Outcome						
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1, CD2 and CD8					
CD2	Tutorials/Assignments		CO2	CD1, CD2 and CD8					
CD3	Seminars		CO3	CD1, CD2 and CD8					
CD4	Mini projects/Projects		CO4	CD1, CD2 and CD8					
CD5	Laboratory experiments/teaching aids		CO5	CD1, CD2 and CD8					
CD6	Industrial/guest lectures								
CD7	Industrial visits/in-plant training								
CD8	Self- learning such as use of NPTEL materials and internets								
CD9	Simulation								

Week	Lect.	Fentativ	Modu	Fopics to be covered	Гext	COs	Actual	Methodology	Remarks
No.	No.	e	le.		Book /	mapped	Content	used	by
		Date	No.		Refere		covered		faculty if
					nces				any

1	L1	Ι	Introduction to Metals, Alloys	T1		PPT Digi	
						Class/Chal	
						k-Board	
1	L2		Ceramics	T1, T2		PPT Digi	
						Class/Chal	
						k-Board	
1	L3-		Polymers and Composites, Phase	T1. T2		PPT Digi	
_	14		rules	,		Class/Chal	
						k-Board	
2	L5	-	Fe-C phase diagram	T1		PPT Digi	
-	20					Class/Chal	
						k-Board	
2	L6-	-	Steels, cold, hot working of metals.	T1		PPT Digi	
-	18		recovery recrystallization and grain	11		Class/Chal	
			growth Structure properties			k-Board	
2	IO		Broassing and applications of	T1			
2	L9-		Processing and applications of	11		Class/Chal	
	L10		ceramics.			Lass/Chai	
2	T 1 1		Classification of nolumons	TT 1		K-Board	
3	LII-		Classification of polymers,	11		PPT Digi	
	L13		polymerization, structure,			Class/Chai	
		II	properties			K-Board	
3	L14-		additives, products, processing and	T1		PPT Digi	
	L16		applications.			Class/Chal	
		 _				k-Board	
3	L17-		Quasicrystals	T1		PPT Digi	
	L18					Class/Chal	
						k-Board	
4	L19-		Conducting Polymers; Properties	T1		PPT Digi	
	L20		and applications composites.			Class/Chal	
						k-Board	
4	L21-		Advanced Materials: Smart	T1		PPT Digi	
	22		materials,			Class/Chal	
						k-Board	
5	L23-		Ferroelectric, piezoelectric,	T1		PPT Digi	
	24					Class/Chal	
						k-Board	
5	L25-		Biomaterials (some basic	T2		PPT Digi	
	L26	ш	information), superalloys,			Class/Chal	
		111				k-Board	
6	L27-		Aerospace materials, shape memory	T1		PPT Digi	
	L28		alloys,			Class/Chal	
						k-Board	
6-7	L29-		Optoelectronic materials, Materials	T1		PPT Digi	
	L30		for photodiode, light emitting diode			Class/Chal	
			(LED), Photovoltaic/Solar cell and			k-Board	
			meta materials				
	L31-	 IV	Nanostructured Materials:	T1		PPT Digi	
	L32		Nanomaterials classification			Class/Chal	
			(Gleiter's Classification)			k-Board	
	L33-	 1	Property changes done to size	T1		PPT Digi	
	1.35		effects.			Class/Chal	
						k-Board	
	L36-	 1	Ouantum dot, wire and well.	T1		PPT Digi	
1		1			1 1		1

L38				Class/Chal	
				k-Board	
L39-		synthesis of nanomaterials, ball	T2	PPT Digi	
L40		milling.		Class/Chal	
				k-Board	
L41-		Liquid state processing -Sol-gel	T1, T2	PPT Digi	
L43		process, electronic properties of		Class/Chal	
		tubules, applications		k-Board	
L44-		Vapour state processing -CVD,	T1	PPT Digi	
L46	V	MBE		Class/Chal	
				k-Board	
L47-		Aerosol processing, fullerene and	T1	PPT Digi	
L48		tubules,		Class/Chal	
				k-Board	
L49-		Formation and characterization of	T1	PPT Digi	
L50		fullerenes and tubules, single wall		Class/Chal	
		and multiwall carbon tubules		k-Board	

- Group C <u>Photonics:</u> 1. Fiber and Integrated Optics 2. Quantum & Nonlinear Optics

			COURSE INFORMATION SHEET				
Cour	se cod	le: P	PH 507				
Cour	se titl	e: F	iber and Integrated Optics				
Pre-r	requisi	te(s): Waves and Optics				
Co-r	requisi	te(s)					
	its:		4L:4 1:0 P:0				
Class	sched		per week:				
Class	5: 1.IVI.	SC.					
Seme	ester /	Leve	el: PE V				
Bran	ch: Pl	115					
Nam	e of 1	each	ier:				
			Group C Option : 1				
C	ode:		Title: Fiber and Integrated Optics	L-T-P-C			
F	PH 507	7		[4-0-0-4]			
Cour	se Ob	jecti	ives : This course enables the students:				
	Α.	T	o understand the light propagation phenomenon through fiber optic cable				
	В.	Т	o understand various loss mechanism of signal while travelling through an optical	fiber.			
	C.	Т	o understand the basic working principle of waveguides and its design parameters.				
	D.	Т	o identify waveguides for applications in fiber optics communication systems				
	Е	Т	o understand the principle of working of fiber based sensors for various application	purposes.			
Com	rse Oi	itcoi	mes: After the completion of this course, students will be				
cou	1	A	ble to illustrate the principle of fiber optics communications				
	2 Able to distinguish between various loss mechanism in fiber optics communication system						
	3	A	ble to utilize the idea of waveguide for different application purpose	jetenn			
	4.	A	ble to categorise different waveguides for the utilization in optics communication	system			
	5.	A	ble to interpret different fiber sensors and their respective application and ca	n recommen	d this		
		te	chnique for other new application.				
Modu	ıle-1	Prir	nciple of light propagation in fibers, step-index and graded index fibers; sir	ngle mode,	5		
		mu	ltimode and W-profile fibers. Ray optics representation, meridional and skew rays.	Numerical			
		ape	rture and acceptance angle.				
Modu	ıle-2	Dis	persion, combined effects of material and other dispersions - RMS pulse v	widths and	10		
		free	quency response, birefringence. Attenuation in optical fibers. Material disp	ersion and			
		way	veguide dispersion in single-mode fibers, Inter and intramodal dispersion in gr	aded-index			
		fibe	ers				
Modu	ıle-3	The	eory of optical waveguides, planar, rectangular, symmetric and asymmetric w	vaveguides,	12		
		cha	nnel and strip loaded waveguides. Anisotropic and segmented waveguides. Step	-index and			
		gra	ded index waveguides, guided and radiation modes. Arrayed waveguide devices.	Fabrication			
	of integrated optical waveguides and devices.						
Modu	ıle-4	Wa	ave guide couplers, transverse couplers, grating couplers, tapered couplers, prisr	n couplers,	13		
		fibe	er to waveguide couplers. Multilayer planar waveguide couplers, dual channel	directional			
		cou	plers, Butt coupled ridge waveguides, Branching waveguide couplers. Directiona	d couplers,			
		opt	ical switch; phase and amplitude modulators, filters, etc. Y-junction, power splitter	s			
Modu	ıle-5	Fib	er optics sensors, intensity modulation, phase modulation sensors, fiber Bra	gg grating	12		
		sen	sors. Measurement of current, pressure, strain, temperature, refractive index, liqui	d level etc.			
		Tin	ne domain and frequency domain dispersion measurement, fibre lasers and fibre gy	roscone			

Text books:

- T1: Introduction to Fiber Optics: A.K. Ghatak and K. Thayagarajan, Cambridge University press
- T2: Integrated Optics: Theory and Technology; R. G. Hunsperger; Springer
- T3: Optical Fiber Sensors, John Dakin and Brain Culshaw, Arctech House Inc Reference books: R1:

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	Ν
Laboratory experiments/teaching aids	Ν
Industrial/guest lectures	Ν
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and internets	Y
Simulation	N

Course Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizzes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	\checkmark	\checkmark	\checkmark		
End Sem Examination Marks	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Quiz I			\checkmark	\checkmark	
Quiz II				\checkmark	\checkmark

Indirect Assessment -

- **1.** Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4	5			
Α	Н	М	М	Μ	L			
В	М	Н	М	Μ				
С	М	М	Н	Μ	L			
D	L	М	Н	Н	М			
Е	М	М	Н	Н	Н			

Mapping of Course Outcomes onto Program Outcomes					
Course	Program Outcomes				

Outcome #	а	b	С	d	e	f
1	М	Н	Н		L	Н
2	М	Н	М		М	Н
3	М	Н	Н	L	L	М
4	М	М	Н	L	М	М
5	М	М	М	L	Н	Н

	Mapping Between COs and Course Delivery (CD) methods								
		Course	Course Delivery						
CD	Course Delivery methods	Outcome	Method						
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1 and CD2						
CD2	Tutorials/Assignments	CO2	CD1 and CD2						
CD3	Seminars	CO3	CD1 and CD2						
CD4	Mini projects/Projects	CO4	CD1 and CD2						
CD5	Laboratory experiments/teaching aids	CO5	CD1 and CD2						
CD6	Industrial/guest lectures								
CD7	Industrial visits/in-plant training								
CD8	Self- learning such as use of NPTEL materials and internets								
CD9	Simulation								

Week	Lect.	Fentativ	Ch.	Fopics to be covered	Гext	Cos	Actual	Methodolog	Remark
No.	No.	e	No.		Book/	mapped	Content	y used	s by
		Date			References		covered		aculty if
									any
	L1-L2			Principle of light	T1, T2	CO1		PPT Digi	
				propagation in fibers,				Class/Choc	
				step-index and graded				k-oard	
				index fibers; single mode,					
				multimode and W-profile					
				fibers					
	L3-L5			Ray optics representation,	T1, T2	CO1		PPT Digi	
				meridional and skew rays.				Class/Choc	
				Numerical aperture and				k-Board	
				acceptance angle.					
	L6-L7			Dispersion, combined	T1, T2	CO2		PPT Digi	
				effects of material and				Class/Choc	
				other dispersions				k-Board	
	L8-			RMS pulse widths and	T1, T2	CO2		PPT Digi	
	L11			frequency response,				Class/Choc	
				birefringence. Attenuation				k-oard	
				in optical fibers.					
	L12-			Material dispersion and	T1, T2	CO2		PPT Digi	
	L15			waveguide dispersion in				Class/Choc	
				single-mode fibers, Inter				k-Board	
				and intramodal dispersion					
				in graded-index fibers					
	L16-			Theory of optical	T1, T2	CO3		PPT Digi	

L19	waveguides, planar,			Class/Choc
	rectangular, symmetric			K-Board
	and asymmetric			
	waveguides, channel and			
	strip loaded waveguides		~~~	
L20-	Anisotropic and	T1, T2	CO3	PPT Digi
L23	segmented waveguides.			Class/Choc
	Step-index and graded			K-Board
	index waveguides, guided			
	and radiation modes		~~~	
L24-	Arrayed waveguide	T1, T2	CO3	PPT Digi
L27	devices. Fabrication of			Class/Choc
	integrated optical			K-DOald
	waveguides and devices.		~~	
L28-	Wave guide couplers,	11, 12	CO4	PPT Digi
L31	transverse couplers,			k Board
	grating couplers, tapered			K-Doald
	couplers, prism couplers,			
	fiber to waveguide			
1.22	Couplers	T1 T2	<u>CO4</u>	
L32-	Multilayer planar	11, 12	04	PPT Digi
L33	waveguide couplers, dual			k-Board
	channel directional			K Doard
	couplers, Butt coupled			
	Regenerating waveguides ,			
	Branching waveguide			
1.36	Directional couplers	T1 T2	<u>CO4</u>	
1 30	optical switch: phase and	11, 12	04	Class/Choc
	amplitude modulators			k-Board
 I 40	filters Y-iunction power	T1 T2	CO4	PPT Digi
	splitters	11, 12		Class/Choc
	spinters			k-Board
L41-	Fiber optics sensors,	Т3	CO5	PPT Digi
L44	intensity modulation,			Class/Choc
	phase modulation sensors,			k-Board
	fiber Bragg grating			
	sensors			
L45-	Measurement of current,	T3	CO5	PPT Digi
L48	pressure, strain,			Class/Choc
	temperature, refractive			k-Board
	index, liquid level etc.			
L49-	Time domain and	T3	CO5	PPT Digi
L52	frequency domain			Class/Choc
	dispersion measurement,			k-Board
	fibre lasers and fibre			
	gyroscope.			

COURSE INFORMATION SHEET

Course code: PH 508 **Course title: Quantum and Nonlinear Optics Pre-requisite**(s): Waves and Optics **Co- requisite(s):** Credits: **4**L: 4 T: 0 P: 0 **Class schedule per week:** Class: I.M.Sc. Semester / Level: PE V **Branch: PHYSICS** Name of Teacher Group C

Option 2

C	ourse	Delivery	methods]			
Co PH	de: [508		Titles: Quantum and Nonlinear Optics I	L-T-P-C [4-0-0-4]				
This c	ourse	enables the	e students:					
	A.	To identif	y the phenomenon of the nonlinear optical interaction of light with	matter				
	B.	To examine higher harmonic generations, two-photon absorption and stimulated s						
		phenomer	ion					
	C.	To formul	ate nonlinear optics in two-level approximations					
	D.	To analys	e intensity dependent phenomenon					
	E	To identif	y nonlinear optical phenomenon for applications in optical devices					
Cours	se Out	comes Aft	er the completion of this course, students will be:					
Γ	1.	Able to ju	dge non-linear optical phenomenon					
	2.	Apply kn	owledge of nonlinear optical phenomena in higher harmonic	generations,	two-photoi			
		absorption	n and stimulated scattering phenomenon					
	3.	To solve	nonlinear optical interaction problem in two-level system					
	4.	To evalua	te intensity dependent material properties like refractive indices and	l self-focussing				
	5.	To design	non-linear optical devices					
Modul	e-1	Non	linear Optical Phenomena: Introduction to nonlinear optics, d	escription of	10			
		nonl	inear optical interaction, phenomenological theory of nonlineari	ty, nonlinear				
		optio	cal susceptibilities. Sum and difference frequency generation, second	ond harmonic				
		gene	eration, coupled wave equation					
Modul	e-2	Man	ley-Rowe relations, phase matching of SHG, quasi phase matching	hing, electric	10			
		field	induced SHG (EIFISH), optical parametric amplification, th	ird harmonic				
		gene	ration, two-photon absorption. Stimulated Raman scattering an	nd stimulated				
		Brill	ouin scattering.					
Modul	e-3	Two	level atoms: nonlinear optics in two level approximations, de	ensity matrix	10			
		equa	ition, closed and open two-level atoms, steady state response in mo	onochromatic				
		field	, Rabi oscillations, dressedatomic state, optical wave mixing	in two level				
		syste	ems, photon echo, sen-induced transparency, optical nutation, in	ree induction				
Modul	a 1	tonsit	y. y dapandant phanomana: intansity dapandant rafractiva inday	alf focusing	12			
Modul	6-4	solf	phase modulation spectral broadening optical continuum general	tion by short	14			
		onti	phase modulation, spectral broadening, optical continuum general	l processing				
		Self.	induced transparency spatial and temporal solitons, solitons in	Kerr media				
		phot	orefractive and quadratic solitons. Soliton pulses optical vo	rtices Pulse				
		com	pression.	ruces. ruise				
Modul	e-5	Non	linear guided wave optical devices: nonlinear planar waveguid	le, nonlinear	8			
		chan	inel waveguide, nonlinear directional coupler, nonlinear mode sor	ter, nonlinear	-			
		Mac	h-Zehnder interferometer and logic gate, Nonlinear loop mirror					
Bo	ok:			I				
T1	. Fund	amentals of	Nonlinear Optics; P.E.Powers, CRC Press Francis and Taylor (201	1)				
T2	. Princ	iples of No	nlinear Optics; Y.R.Shen					
Т3	. Nonli	inear Optics	s: Robert Boyd, Academic press					
R1	. Physi	ics of Nonli	nar Optics: Guang- Sheng –He and §9 ng-Hao Lin; World scientifi	с.				

R2. Two Level Resonances in Atoms; Allen and J.H. Emberly, John Wiley.

Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	N
Mini projects/Projects	N
Laboratory experiments/teaching aids	Ν
Industrial/guest lectures	Ν
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and internets	Y
Simulation	N

Course Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizzes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks			\checkmark		
End Sem Examination Marks					
Quiz I			\checkmark		
Quiz II					

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4	<u>5</u>
Α	Н	Μ	Μ	L	М
В	Μ	Η	Μ	L	L
С	L	L	Н	L	L
D	-	L	L	Η	L
Е	L	М	L	L	Н

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes						
	а	b	с	d	e	f	
1	Н	Н	Н	Н	L	Н	
2	Н	Н	Н	Н	М	Н	
3	Н	Н	Н	М	L	М	
4	Н	М	Н	Н	L	Μ	
5	М	Н	Н	Н	Н	Н	

Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
	Lecture by use of boards/LCD projectors/OHP		
CD1	projectors	CO1	CD1 and CD2
CD2	Tutorials/Assignments	CO2	CD1 and CD2
CD3	Seminars	CO3	CD1 and CD2
CD4	Mini projects/Projects	CO4	CD1 and CD2
CD5	Laboratory experiments/teaching aids	CO5	CD1 and CD2
CD6	Industrial/guest lectures	-	-
CD7	Industrial visits/in-plant training	-	-
	Self- learning such as use of NPTEL materials and		
CD8	internets	-	-
CD9	Simulation	-	-

Week No.	Lect. No.	Tentativ e Date	Ch. No	Topics to be covered	Text Book / Refere Nces	COs mappe d	Actual Conte nt cover ed	Methodolog y used	Remark s by faculty if any
1	L1-L10		1	Nonlinear Optical Phenomena: Introduction to nonlinear optics, description of nonlinear optical interaction, phenomenological theory of nonlinearity, nonlinear optical susceptibilities. Sum and difference frequency generation, second harmonic generation, coupled wave equation	T1, T2,	1,2		PPT Digi Class/Chock -Board	
	L11- L20			Manley-Rowe relations, phase matching of SHG, quasi phase matching, electric field induced		2		Digi Class/Chock -Board	

	SHG (EIFISH), optical parametric amplification, third harmonic generation, two-photon absorption. Stimulated Raman scattering and stimulated Brillouin scattering.			
L21- L30	Two level atoms: nonlinear optics in two level approximations, density matrix equation, closed and open two- level atoms, steady state response in monochromatic field, Rabi oscillations, dressed atomic state, optical wave mixing in two level systems, photon echo, self-induced transparency, optical nutation, free induction decay	3	Digi Class/Chock -Board	
L31- L42	Intensity dependent phenomena: intensity dependent refractive index, self-focusing, self-phase modulation, spectral broadening, optical continuum generation by short optical pulse. Optical phase conjugation, application of OPC in signal processing. Self- induced transparency, spatial and temporal solitons, solitons in Kerr media, photorefractive and quadratic solitons, Soliton pulses, optical vortices. Pulse compression	4	Digi Class/Chock -Board	
L43- L50	Nonlinear guided wave optical devices: nonlinear planar waveguide, nonlinear channel waveguide, nonlinear directional coupler, nonlinear mode sorter, nonlinear Mach- Zehnder interferometer and logic gate, Nonlinear loop mirror	5	Digi Class/Chock -Board	

Group D – <u>Electronics:</u>

1. Instrumentation and Control

Option 1

2. Physics of Low dimensional Semiconductors

COURSE INFORMATION SHEET

Course code: PH 509 Course title: Instrumentation and Control Pre-requisite(s): Co- requisite(s): Credits: 4 L: 4 T:0 P: 0 Class schedule per week: Class: I.M.Sc. Semester / Level: PE V Branch: PHYSICS Name of Teacher: Dr. Dilip Kumar Singh

Group : D

Code: **Title: Instrumentation and Control** L-T-P-C PH 509 4-0-0-4 **Course Objectives** This course enables the students: Course on Instrumentation and control intends to impart knowledge of A. measurement, data acquisition and control for experiments. The first module of the course addresses basics of measurements like range, Β. resolution, reproducibility, accuracy and precision. C. Module-2 of the course introduces various types of sensors and their working to record changes in the different physical parameters. The techniques of signal conditioning and noise reductions for acquired data D. are subject of Module-3. Last two units covers working and theory of different types of correction and E. regulating elements used in control systems. **Course Outcomes** After the completion of this course, students will be: Learners would develop understanding of various experimental parameters of 1. measurements like range, resolution, reproducibility and precision. 2. Through this course, students would develop an insight into fundamentals of sensors / transducers, data acquisition and processing, noise minimization and control systems for automation. 3. This course is expected to enable students to design and understand hardwares used for developing equipment for data acquisition, data conditioning and control. 4. Course would enable students to grasp understanding of instrumentation for automation of various physical process monitoring and control. Module-1 **Measurement basics:** 5 Range, resolution, linearity, hysteresis, reproducibility and drift, calibration, accuracy and precision. 10 Module-2 Sensors Sensor Systems, characteristics, Instrument Selection, Measurement Issues and Criteria, Acceleration, Shock and Vibration Sensors,

	Interfacing and Designs, Capacitive and Inductive Displacement Sensors, Magnetic Field Sensors, Flow and Level Sensors, Load	
	Sensors, Strain gauges, Humidity Sensors, Accelerometers,	
	Photosensors, Thermal Infrared Detectors, Contact and Non-contact	
	Position sensors, Motion Sensors, Piezoresistive and Piezoelectric	
	Pressure Sensors, Sensors for Mechanical Shock, Temperature Sensors	
	(contact and non-contact)	
Module-3	Signal conditioning	15
	Types of signal conditioning, Amplification, Isolation, Filtering,	
	Linearization, Classes of signal conditioning, Sensor Signal	
	Conditioning, Conditioning Bridge Circuits, D/A and A/D converters	
	for signal conditioning, Signal Conditioning for high impedance sensors	
	Grounded and floating signal sources, single-ended and differential	
	measurement, measuring grounded signal sources, ground loops, signal	
	circuit isolation, measuring ungrounded signal sources, system isolation	
	techniques, errors, noise and interference in measurements, types of	
	noise, noise minimization techniques	
Module-4	Actuators	4
	Correction and regulating elements used in control systems, pneumatic,	
	hydraulic and electric correction elements.	
Module-5	Control System	16
	Open loop and closed loop (feedback) systems and stability analysis of	
	these systems, Signal flow graphs and their use in determining transfer	
	functions of systems; transient and steady state analysis of linear time	
	invariant (LTI) control systems and frequency response. Tools and	
	techniques for LTI control system analysis: root loci, Routh-Hurwitz	
	criterion, Bode and Nyquist plots. Control system compensators:	
	elements of lead and lag compensation, elements of Proportional-	
	Integral-Derivative (PID) control. State variable representation and	
	solution of state equation of LTI control systems.	
Text books	:	
T1. Electron	nic Instrumentation -H. S. Kalsi, Tata McGraw-Hill Education, 2010	
T2. Electron	nic Instrumentation -W. Bolton	
T3. Instrum	nentation: Electrical and Electronic Measurements and Instrumentation	-A. K.
Sawhney,		

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	Y
Laboratory experiments/teaching aids	Ν
Industrial/guest lectures	N
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and internets	Y
Simulation	N

Course Assessment tools & Evaluation procedure

Direct Assessment	
Assessment Tool	% Contribution during CO Assessment

Assignment	10
Seminar before a commitee	10
Three Quizzes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	\checkmark		\checkmark		
End Sem Examination Marks	\checkmark		\checkmark		
Quiz I	\checkmark		\checkmark		
Quiz II					

Indirect Assessment -

- **1.** Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4
А	Н	Н	Н	Н
В	Н	Н	L	L
С	Н	Н	Н	L
D	Н	L	Н	L
Е	Н	Н	Н	L
F	Н	L	L	Н

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	а	b	с	d	e	f
1	Н	Н	Н	L	Н	Н
2	Н	Н	Н	L	Н	Н
3	Н	Н	Н	L	Н	Н
4	Н	Н	Н	L	Н	М

Mapping Between COs and Course Delivery (CD) methods

PI	The pring Detriven Cost and Course Denvery (CD) methods					
CD	Course Delivery methods	Course Outcome	Course Delivery			
			Method			
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1 and CD2			
CD2	Tutorials/Assignments	CO2	CD1 and CD2			
CD3	Seminars	CO3	CD1 and CD2			
CD4	Mini projects/Projects	CO4	CD1 and CD2			
CD5	Laboratory experiments/teaching aids	CO5	CD1 and CD2			
CD6	Industrial/guest lectures	CO6	CD1 and CD2			
CD7	Industrial visits/in-plant training	-	-			
CD8	Self- learning such as use of NPTEL materials and	-	-			
	internets					
CD9	Simulation	-	-			

Week	Lect.	Tentative	Ch	Topics to be covered	Text	Cos	Actual	Method	Remarks
	No.	Date	No		Book /	mapped	Content	ology	by faculty
No.					Refere		covered	used	if any
					nces				
1	L1			Measurement basics: Range,	,T1, T4				
	1.2			resolution, linearity,	T1, T4				
	L2 L3		-	hysteresis, reproducibility	Т1. Т4				
	I.4			drift calibration	T1 T4				
	1.5			accuracy and precision	Т1, Т4 Т1 Т4				
	16			Sensors Sensor Systems	Т1, Т4 Т1 Т4				
	20			characteristics.	, ,				
	L7			Instrument Selection.	T1, T4				
				Measurement Issues and					
				Criteria,					
	L8			Acceleration, Shock and	T1, T4				
				Vibration Sensors, Interfacing	r S				
				and Designs,					
	L9			Capacitive and Inductive	T1, T4				
				Displacement Sensors,	,				
				Magnetic Field Sensors,					
	L10			Flow and Level Sensors, Load	T1, T4				
				Sensors, Strain gauges,	,				
				Humidity Sensors,	,				
				Accelerometers,					
	L11			Photosensors, Thermal Infrared	T1, T4				
				Detectors,					
	L12			Contact and Non-contact	T1, T4				
				Position sensors, Motion					
				Sensors,					
	L13			Piezoresistive and Piezoelectric	T1, T4				
	L14			Pressure Sensors, Sensors for	T1, T4				
				Mechanical Shock,					
	L15			Temperature Sensors (contact	T1, T4				
				and non-contact)					
	L16			Signal conditioning Types of	T1, T4				
	L17			signal conditioning,	T1, T4				
	L18			Amplification, Isolation,	T1, T4				
	L19				T1, T4				
	L20			Filtering, Linearization,	T1, T4				
	L21			Classes of signal conditioning,	T1, T4				
				Sensor Signal Conditioning,					
	L22]	Conditioning Bridge Circuits,	T1, T4				
	L23			D/A converters	T1, T4				
	L24		1	and A/D converters for signal	T1, T4				
	1.05		-	conditioning,					
	L25			Signal Conditioning for high	11, 14				
				and floating signal sources	L				
	1.26		-	and mouning signal sources,	Т1 Т 4				
	L20			single choca and anticicilital	1 · · · · · ·				

		measurement,			
L27		measuring grounded signal	T1, T4		
		sources, ground loops, signal			
		circuit isolation,			
L28		measuring ungrounded signal	T1, T4		
		sources,			
L29		system isolation techniques.	T1, T4		
		errors, noise and interference in			
		measurements,			
L30		types of noise, noise	T1, T4		
		minimization techniques	,		
L31		Actuators	T1, T4		
		Correction and regulating			
L32		elements used in control	T1, T4		
1.22		systems,	T1 T4		
		electric correction elements	11, 14 T1 T4		
L34			11, 14		
L35		Control System	T1, T4		
		(feedback) systems			
L 36		stability analysis of these	Т1 Т4		
150		systems.	11, 11		
L37		Signal flow graphs and their use	T1, T4		
		in determining transfer			
		functions of systems;			
L38		transient and steady state	T1, T4		
		analysis of linear time invariant	T1, T4		
L39		(L11) control systems and			
1.40		Tools and techniques for LT	Т1 Т4		
		control system analysis: root	T1, T4		
L42	<u>├</u> ────┤	loci, Routh-Hurwitz criterion	T1, T4 T1 T4		
I / 2	<u> </u>	Bode and Nyquist plots	ті, т і Ті т <i>і</i>		
		Bode and hyquist piots.	11, 14 T1 T4		
	<u> </u>	Control avetom commencet	11, 14 T1 T4		
		elements of lead and lag	11, 14 T1 T4		
		compensation	11, 14 T1 T4		
	<u> </u>		11, 14		
		elements of Proportional-	11, 14		
		control.	11, 14		
L50		State variable representation	T1, T4		
		and solution of state equation of	Í		
		LTI control systems.			

COURSE INFORMATION SHEET

Course code: PH 510 Course title: Physics of Low dimensional Semiconductors Devices Pre-requisite(s): Co- requisite(s): Credits: 4L: 4 T: 0 P: 0 Class schedule per week: Class: I.M.Sc. Semester / Level: PE V Branch: PHYSICS Name of Teacher: Group : D

0	ption	2

Code:	Title: Physics of Low dimensional Semiconductors Devices	L-T-P-C
PH 510		4-0-0-4
Course Object	ives	

This course enables the students:

Course on "Physics of Low dimensional Semiconductors" contains information about functionality and working of devices with miniaturized size.
The first module includes introduction to various types of semiconductor nanostructures and effect of dimension on their properties.
The properties, growth and band-engineering of heterostrcutres is planned to be covered in Unit-2.
Unit-3 contains Quantum wells and Low-dimensional systems, while Unit-4 addresses physics of Tunneling transport and Low-dimensional systems.
The electronic and optical properties of Two-dimensional electron gas (2DEG) and their applications is subject of Unit-5.

Course Outcomes

After the completion of this course, students will be:

	1.	Learners would gain knowledge about working and application Semiconductors	of various Low-dimensional							
	2.	An understanding about Heterostructures, Quantum wells: Low-dimensional systems, Tunneling transport, Quantum-Hall effect and their electronic and optical applications would update learners with recent electronic and optical technologies in use.								
	3.	Knowledge about Physics and applications of Two-dimensional electron them to grasp the pace of advancing field of 2D-Semiconductors and devices.	ron gas (2-DEG) would enable their applications for ultrathin							
Modu	le-1	Introduction to Semiconductor Nanostructures Introduction, Semiconductor quantum dot and quantum wire, Density of states for 0-D, 1D and 2D nanostructures. Two- dimensional semiconductors.	6							
Module-2		Hetrostructures General properties and growth of hetrostructures, Band engineering, Layered structures, Quantum wells and barriers, Doped hetrostructures, Wires and dots, Optical confinement, Effective mass approximation and Effective mass theory in hetrostructures.	8							

Module-3	Quantum wells and Low-Dimensional Systems	12
	Infinite deep square well, square well of finite depth, parabolic	
	well, triangular well, Low-dimensional systems, Occupation of	
	subbands, Quantum wells in hetrostructures.	
Module-4	Tunneling transport and Quantum Hall effect	12
	Potential step, T-Matrices, Resonant tunneling, Superlattices and	
	minibands, Coherent transport in many channels, Tunneling in	
	hetrostructures, Schrodinger equation with electric and magnetic	
	fields, Quantum hall effect	
Module-5	Two-Dimensional electron gas (2DEG)	12
	Revision of approximate methods, scattering rates: the golden	
	rule, Absorption in a quantum well, Electronic structure of a	
	2DEG, Optical properties of quantum wells: Kane model, bands in	
	a quantum well, Interband and intersubband transitions in a	
	quantum well, Optical gain and lasers, Excitons	
Text Book		
[T1] John H. I	Davies, The Physics of Low-Dimensional Semiconductors an Introduc	ction, Cambridge University
Press.		
[T2] Thomas	Heinzel, Mesoscopic electronics in solid state nanostructures, Wiley-V	VCH
[T3] Jan G. H Engineers.	Korvink, Andreas Greiner, Semiconductors for micro and Nanotechne Wiley-VCH	ology – An Introduction for

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	N
Mini projects/Projects	Y
Laboratory experiments/teaching aids	N
Industrial/guest lectures	Ν
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and internets	Y
Simulation	Ν

Course Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizzes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Quiz1	\checkmark	\checkmark	\checkmark		
Quiz II				\checkmark	
Assignment	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
End Sem Examination	\checkmark	\checkmark		\checkmark	

Indirect Assessment –

- 1. Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

<u>Mapping between Objectives and Outcomes</u> Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4	5
Α	Η	Η	Η	Η	Н
В	Н	Η	Η	L	L
С	Н	Η	L	Η	Н

Mapping of Course Outcomes onto Program Outcomes

Course	Program Outcomes						
Outcome #	a	b	с	d	e	f	
1	Н	Н	Н	Μ	Н	Н	
2	Η	Н	Н	Μ	Н	Н	
3	Η	Н	Η	М	Н	Η	

	Mapping Between COs and Course Delivery (CD) methods							
CD	Course Delivery methods	Course Outcome	Course Delivery Method					
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1 and CD2					
CD2	Tutorials/Assignments	CO2	CD1 and CD2					
CD3	Seminars	CO3	CD1 and CD2					
CD4	Mini projects/Projects	CO4	CD1 and CD2					
CD5	Laboratory experiments/teaching aids	CO5	CD1 and CD2					
CD6	Industrial/guest lectures	-	-					
CD7	Industrial visits/in-plant training	-	-					
CD8	Self- learning such as use of NPTEL materials and internets	-	-					
CD9	Simulation	-	-					

Week	Lect.	Fentative	Ch.	Fopics to be covered	Гext	Cos	Actual	Method	Remarks
	No.	Date	No.		Book /	mapped	Content	ology	by faculty
No.					Refere		covered	used	f any
					nces				
1	L1		Ch1	Introduction to					
				Semiconductor	T1, T2,				
	L2			Nanostructures	T3				
				Introduction, Semiconductor					
				quantum dot and quantum wire,					
	L3			Density of states for 0-D, 1D	T1, T2,				
				and 2D nanostructures.	T3				
	L4								
	L5		1	Two-dimensional	T1, T2,				
				semiconductors.	Т3				

		7					
	L6						
	L7	Ch2	Hetrostructures	T1. T2.			
				T3			
			General properties and growth	10			
			of hetrostructures				
	L8		Band engineering	T1. T2.			
	20			T3			
-	IO	-	Lovered structures	т <u>л</u> т2			
	L9		Layered structures	11, 12,			
		_		13			
	L10		Quantum wells and barriers	T1, T2,			
				T3			
	L11		Doped	T1, T2,			
				T3			
			hetrostructures, Wires and dots				
	L12		Optical confinement,	T1, T2,			
				Т3			
	L13		Effective mass approximation	T1, T2.			
	┨ ┣━━━━	-	and Effective mass theory in	T3			
	L14		hetrostructures.	10			
	L15	Ch3	Quantum wells and Low-				
			Dimensional Systems	Т1 Т2			
	I 16		Dimensional Systems	T1, 12,			
	210		Infinite deep square well	15			
	L17		square well of finite depth	Т1 Т2			
	217		square wen of finite depui,	T3			
				15			
	I 18	-	parabolic well	Т1 Т2			
		-	parabone wen,	T1, 12,			
	T 10			15			
		-	trion gulor yuall	T1 T2			
	L20	-	ulangulai well,	11, 12,			
	1.01			13			
	L21	-		T 1 T 2			
	L22	_	T 1 T	11, 12,			
	L23	_	Low-dimensional systems,	13			
	1.24		Occupation of subbands,				
	L24	_					
	L25		Quantum wells in	T1, T2,			
			hetrostructures.	T3			
	L26						
	L27	Ch4	Tunneling transport and	T1, T2,			
			Quantum Hall effect Potential	T3			
			step				
	L28		T-Matrices	T1, T2,			
				T3			
	L29	1	Resonant tunneling	T1, T2.			
				T3			
	1.30	-	Superlattices and minibands	Т1 Т2	1		
	1.50		Superfactices and minibalius	$\mathbf{T}_{2}^{11, 12},$			
				13			

	L31		Coherent transport in many channels	T1, T2,		
	L32		chamiers	15		
	L33		Tunneling in hetrostructures	T1, T2,		
				T3		
	L34					
	L35		Schrodinger equation with	T1, T2,		
	L36		electric and magnetic fields	13		
	L37		Quantum hall effect	T1, T2,		
	1 38			T3		
	130	Ch5	Two Dimonsional electron gas			
	L39	CIIJ	(2DEG)			
			Revision of approximate			
	- 10		methods			
	L40		scattering rates: the golden rule	T1, T2,		
	L41			13		
	L42		Absorption in a quantum well	T1, T2,		
				Т3		
	L43					
	L44		Electronic structure of a 2DEG,	T1, T2,		
	T 45		Optical properties of quantum	T3		
	L4J		wells: Kane model			
	L46		bands in a quantum well	T1, T2,		
				Т3		
	L47		Interband and intersubband	T1, T2,		
	T 40		transitions in a quantum well	T3		
	L48			T 1 T 2		
	L49		Optical gain and lasers,	T1, T2,		
	C		Excitons	13		
	0					

Group E- Plasma Sciences:

- 1. Introduction to Plasma Physics
- 2. Plasma Processing of Materials

COURSE INFORMATION SHEET

Course code: PH 511 **Course title: Introduction to Plasma Physics Pre-requisite**(s): **Co- requisite(s):** Credits: **4** L:4 T: 0 P: 0 **Class schedule per week:** Class: I.M.Sc. Semester / Level:PE V **Branch: PHYSICS** Name of Teacher:

Group : **E Option 1**

Code: PH 511	ode: Title: Introduction to Plasma Physics H 511					
Module	Course Objective:	-				
1.	To impart the knowledge about the fundamental and basics of Plasma Physics.	1				
2.	To learn about the charged particle motion in electric and magnetic field.	1				
3.	To provide the knowledge about the ionization process and diffusion.	1				
4.	To learn about the basic Plasma Diagnostic Methods.	1				
5.	To learn how to use plasma for various application.	-				
Module	Course Outcome	-				
1.	Will have an idea about the basis of Plasma (Fourth State of Matter).	1				
2.	Will be able to visualize the motion of charged particles in electric and magnetic field.					
3.	3. Will have knowledge about the ionization and diffusion of Plasma.					
4.	4. Will be able to measure the different plasma parameters.					
5.	5. Will be familiar with different applications of Plasma.					
Module-1	Module-1 The fourth state of matter, collective behavior, charge neutrality, space and time so concept of plasma temperature, Classification of Plasma, Debye shielding, Debye len plasma frequency plasma parameters and criteria for plasma state					
Module-2	e-2 Single particle dynamics, charged particle motion in electric field, magnetic field and in combined electric and magnetic field, Basics of E × B drift, Drift of guiding centre, gradient drift, curvature drift and magnetic mirror.					
Module-3	3 Ionization by collision, Townsends theory of collision ionization, The breakdown potential, Thermal ionization and excitation, concepts of diffusion, mobility and electrical conductivity, Ambipolar diffusion.					
Module-4	odule-4 Basic plasma diagnostics, Single probe method, Double probe method, Optical emission spectroscopy (basic idea), Abel inversion.					
Module-5	Module-5Controlled Thermonuclear fusion, Tokamak, Laser Fusion, MHD Generator, Industrial applications of plasma.[8]					
Referen1. Introd2. Funda	Ices: uction to Plasma Physics and Controlled Fusion, Francis, F. Chen, Plenum Press, 1984 mental of Plasma Physics, L.A. Bittencourt, Springer, Verlag, New York Inc. 2004					

attencourt, Springer-V erlag New Y

3. The Fourth State of Matter- Introduction to Plasma Science, S. Eliezer and Y. Eliezer, IoP Publishing Ltd., 2001.

4. Elementary Plasma Physics, L. A. Arzimovich, Blaisdell Publishing Company, 1965

5. Plasmas- The Fourth State of Matter, D. A. Frank- Kamenetskii, Macmillan Press, 1972

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	Ν
Laboratory experiments/teaching aids	N
Industrial/guest lectures	N
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and internets	Y
Simulation	N

Course Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	\checkmark	\checkmark			
End Sem Examination Marks	\checkmark	\checkmark		\checkmark	\checkmark
Quiz I				\checkmark	
Quiz II					

Indirect Assessment -

- **1.** Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4	<u>5</u>
Α	Н	М	L	Μ	L
В	М	Н	L	L	L
С	М	L	Н	L	L
D	М	L	L	Η	L
Е	L	L	L	L	Н

Mapping of Course Outcomes onto Program Outcomes

Course		Program Outcomes										
Outcome #	a	В	С	d	e	f	g	h	Ι	j	k	1
1	Μ	Н	Μ	Μ	Μ	Η						
2	М	Н	Μ	Μ	Μ	Η						
3	Μ	Н	Μ	Μ	Μ	Η						
4	Μ	Н	Μ	Μ	Μ	Η						
5	M	Н	L	Μ	Μ	Н						

Mapping Between COs and Course Delivery (CD) methods							
			Course	Course Delivery			
CD	Course Delivery methods		Outcome	Method			

CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1 CD2
CD2	Tutorials/Assignments	CO2	CD1 CD2
CD3	Seminars	CO3	CD1 CD2
CD4	Mini projects/Projects	CO4	CD1 CD2
CD5	Laboratory experiments/teaching aids	CO5	CD1 CD2
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

Week	Lect.	Tentat	Ch.	Topics to be covered	Text	COs	Actual	Methodolo	Remarks
No.	No.	ive	No.	_	Book /	mapped	Content	gy used	by
		Date			Refere		covered		faculty
					nces				if any
1	L1-			The fourth state of matter,	T1 R1				
	L2			collective behavior, charge					
				neutrality,					
	L3-			space and time scale, concept	T1 R1				
	L4			of plasma temperature,					
	L5-			Classification of Plasma,	T1 R1				
	L6			Debye shielding, Debye					
				length,					
	L7-			plasma frequency, plasma	T1 R1				
	L8			parameters and criteria for					
				plasma state.					
	L9-			Single particle dynamics,	T1T2				
	L10			charged particle motion in	R1				
				electric field,					
	L11-			magnetic field and in	T1T2				
	L12			combined electric and	R1				
				magnetic field,					
	L13-			Basics of $E \times B$ drift, Drift of	T1T2				
	L14			guiding centre,	R1				
	L15-			Basics of $E \times B$ drift, Drift of	T1T2				
	L16			guiding centre,	R1				
	L17-			Ionization by collision,	T2 R1				
	L20			Townsends theory of collision					
				ionization, The breakdown					
				potential,					
	L21-			Thermal ionization and	T2 R1				
	L24			excitation, concepts of					
				diffusion, mobility and					
				electrical conductivity,					
				Ambipolar diffusion					
	L25-			Basic plasma diagnostics,	T2 R1				
	L28			Single probe method, Double					
				probe method,					
	L29-			Optical emission spectroscopy	T2 R1				
	L32			(basic idea), Abel inversion					
	L33-			Controlled Thermonuclear	T1 R1				
	L36			fusion, Tokamak,					

L37-	Laser Fusio	n, MHD Genera	ator,	T1 R1		
L40	Industrial	applications	of			
	plasma.					

COURSE INFORMATION SHEET

Course code: PH 512 Course title: Plasma Processing of Materials Course code: SAP Course title: Plasma Processing of Materials Pre-requisite(s): Co- requisite(s): Credits: 4 L: 4 T: 0 P: 0 Class schedule per week: 0x Class: I.M.Sc. / M.Sc. Semester / Level: Branch: Physics Name of Teacher: Dr. Sanat Kr. Mukherjee

Group : E Option 2

Code: PH 512	Title: Plasma Processing of Materials					
Course (bjectives					
This cour	e enables the students to:					
A	Defineplasma and its parameters					
В	Outline the design principles of high and low-pressure plasma torches.					
C	Identify the processes of measurement of plasma parameters.					
D	Outline the industrial applications of low temperature plasma					
E.	Explain arc plasma-based systems and illustrate their industrial applications					
Course (utcomes					
After the	completion of this course, students will be able to:					
1.	Define plasma, classify it into various types in terms of the plasma parameters and explain the v types of reactions involved in a plasma.	arious				
2.	Demonstrate the construction and working of high and low-pressure plasma torches.					
3.	Illustrate the various processes of measurement of plasma parameters.					
4	Outlinevarious plasma processes, such as, plasma etching, plasma ashing, plasma polymerization and their associated techniques such as, sputtering, nitriding, etc.	on, etc.,				
5.	5. Illustrate arc plasma based applications like, plasma spraying, plasma waste processing, plasma cutting,					
	etc.					
Module-	Plasma-the fourth state of matter, Plasma Parameters, Debye length, Plasma oscillations &	[8]				
	frequency, Plasma Sheath, Interaction of electromagnetic wave with plasma, Concept about					
	plasma equilibrium, Industrial Plasmas, Cold and thermal plasma, Plasma Chemistry,					
	Homogeneous and Heterogeneous reaction, Reaction rate coefficients, Plasma Surface interaction.					
Module-	Design principles and construction of plasma torches and thermal plasma reactors, Efficiency	[8]				
	of plasma torches in converting electrical energy in to thermal energy, Designing aspects of low pressure plasma reactors					
Module-	Measurements of Plasma parameters. Electrical probes. Single and double I anomuir probe	[8]				
module	Magnetic probe, Calorimetric measurements, Enthalpy Probes, Spectroscopic techniques.	[U]				
Module-	Plasma Etching Anisotropic etching plasma cleaning surfactants removal plasma ashing	[15]				
mouule	plasma polymerization. Plasma sputtering and PECVD Thin film coatings, magnetron					
	sputtering, RF PECVD, MW PECVD, plasma nitriding.					
Module-	Module 5: Plasma Spraving Non-transferred plasma torches powder feeder optimization of	[6]				
iniouulo .	spraying processes spherodization Arc plasmas Plasma torches plasma waste processing	[0]				
	Synthesis of materials and metallurgy in arc plasmas, Plasma cutting and Welding.					
Text	books:					

- 1. Introduction to Plasma Physics and Controlled Fusion, Francis, F. Chen, Plenum Press, 1984
- 2. Fundamental of Plasma Physics, J, A. Bittencourt, Springer-Verlag New York Inc., 2004
- 3. The Fourth State of Matter- Introduction to Plasma Science, S. Eliezer and Y. Eliezer, IoP Publishing Ltd.,, 2001.

Reference books:

- 1. Elementary Plasma Physics, L. A. Arzimovich, Blaisdell Publishing Company, 1965
- 2. Plasmas- The Fourth State of Matter, D. A. Frank- Kamenetskii, Macmillan Press, 1972

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Yes
Tutorials/Assignments	Yes
Seminars	No
Mini projects/Projects	No
Laboratory experiments/teaching aids	No
Industrial/guest lectures	No
Industrial visits/in-plant training	No
Self- learning such as use of NPTEL materials and internets	Yes
Simulation	No

Course Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

AssessmentCompoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	Yes	Yes	Yes	No	No
End Sem Examination Marks	Yes	Yes	Yes	Yes	Yes
Assignment	Yes	Yes	Yes	Yes	Yes

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course	Program Outcomes							
Outcome #	a	b	с	d	e	f		
1	Н	Н	Н	L	М	L		
2	Н	Н	М	L	L	L		
3	Н	М	М	L	L	L		
4	Н	М	М	L	L	L		
5	Н	Н	Н	L	Н	L		

Course	Course Objectives						
Outcome #	а	b	с	d	e		

1	Н	М	М	М	L
2	М	Н	М	М	L
3	М	М	Н	L	L
4	М	М	Н	L	L
5	М	М	L	L	Н

	Mapping Between COs and Course Delivery (CD) methods									
CD	Course Delivery methods	Course	Course Delivery							
		Outcome	Method							
	Lecture by use of boards/LCD projectors/OHP									
CD1	projectors	CO1	CD1, CD2 and CD8							
CD2	Tutorials/Assignments	CO2	CD1, CD2 and CD8							
CD3	Seminars	CO3	CD1, CD2 and CD8							
CD4	Mini projects/Projects	CO4	CD1, CD2 and CD8							
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2 and CD8							
CD6	Industrial/guest lectures									
CD7	Industrial visits/in-plant training									
	Self- learning such as use of NPTEL materials and									
CD8	internets									
CD9	Simulation									

Week No.	Lect.	Fentat	ModuleNo.	Fopics to be covered	Гext	Cos	Actual	Methodology	Remarks
	No.	ive			Book /	mapped	Content	used	byfaculty
		Date			Refere		covered		f any
					nces				
1-2	L1-2		Ι	Plasma-the fourth state of	T2	CO-1		PPT Digi	
				matter, Plasma				Class/Chal	
				Parameters, Debye length				k-Board	
	L3-4			Plasma oscillations &	T2	CO-1		PPT Digi	
				frequency, Plasma Sheath,				Class/Chal	
				Interaction of				k-Board	
				electromagnetic wave with					
				plasma, Concept about					
				plasma equilibrium					
2	L5			Industrial Plasmas, Cold	T1	CO-1		PPT Digi	
				and thermal plasma,				Class/Chal	
				_				k-Board	
2-3	L6			Plasma Chemistry,	T1	CO-1		PPT Digi	
				Homogeneous and				Class/Chal	
				Heterogeneous reaction				k-Board	
3	L7-8			Reaction rate coefficients,		CO-1		PPT Digi	
				Plasma Surface interaction				Class/Chal	
								k-Board	
4	L9-12		II	Design principles and	T3	CO-2		PPT Digi	
				construction of plasma				Class/Chal	
				torches and thermal				k-Board	
				plasma reactors					
5	L13-			Efficiency of plasma	T1	CO-2		PPT Digi	

	14		torches in converting			Class/Chal
			electrical energy in to			k-Board
			thermal energy			
5.6	I 15	ш	Massuraments of Dissma	Т1	CO_{2}	DDT Digi
5-0	L15-	111	Weasurements of Flasma	11	0-5	Class/Chal
	10		parameters			
7	I 17					K-Board
/	LI/-		Electrical probes, Single		CO-3	PPT Digi
	18		and double Langmuir			Class/Chal
			probe			k-Board
8	L19-		Magnetic probe,	T2	CO-3	PPT Digi
	20		Calorimetric			Class/Chal
	_		measurements Enthalny			k-Board
			Drohas			
0.0	1.01			T 1		
8-9	L21-		Spectroscopic techniques.	11,	CO-3	PPT Digi
	22			Τ2,		Class/Chal
						k-Board
9-10	L23-	IV	Plasma Etching	T1,	CO-4	PPT Digi
	25		Anisotropic etching	Τ2,		Class/Chal
						k-Board
10-11	L26-		plasma cleaning,	T1,	CO-4	PPT Digi
	28		surfactants removal	Τ2,		Class/Chal
						k-Board
11-12	L29-		plasma ashing, plasma	T1,	CO-4	PPT Digi
	31		polymerization	Τ2,		Class/Chal
						k
						-Board
12	L32-		Plasma sputtering and	T1	CO-4	PPT Digi
	33		PECVD Thin film	T2		Class/Chal
	55			12,		k-Board
10	1.24		coatings	T 1		
13	L34-		magnetron sputtering	Π,	CO-4	PPT Digi
	35			Τ2,		Class/Chal
						k-Board
13	L36		, RF PECVD, MW	T1,	CO-4	PPT Digi
			PECVD	Τ2,		Class/Chal
						k-Board
14	L37		plasma nitriding	T1,	CO-4	PPT Digi
				Τ2,		Class/Chal
						k-Board
14	L40	V	Plasma Spraying Non-	T1,	CO-5	PPT Digi
			transferred plasma torches	Τ2,		Class/Chal
						k-Board
14	L41		powder feeder,	T2	CO-5	PPT Digi
			optimization of spraying			Class/Chal
			processes			k-Board
15	142		spherodization Are	T1	CO-5	PPT Digi
1.5			plasma Diama tarahas	т <u>э</u>		Class/Chal
			piasilias, Piasma torcnes	12,		k Roard
15	I 42		plaama waata areeeei	T)	CO 5	
13	L43-		plasma waste processing,	12	0-5	
	44		Synthesis of materials and			
			metallurgy in arc plasmas			K-Board
16	L45		Plasma cutting and	T2	CO-5	PPT Digi

	Welding		Class/Chal	
			k-Board	
PE-VI to VII

Group A- Theoretical and Computational Physics:

- 1. Theoretical and Computational Fluid Dynamics
- 2. Theoretical and Computational Condensed Matter Physics
- 3. Nonlinear Dynamics and Chaos

COURSE INFORMATION SHEET

Course code: PH 514
Course title: Theoretical and Computational Fluid Dynamics
Pre-requisite(s):
Co- requisite(s):
Credits: 4 L: 2 T: 0 P: 4
Class schedule per week:
Class: I.M.Sc.
Semester / Level: PE VI//VII
Branch: PHYSICS
Name of Teacher:
Group : A Option 1

01000		
Code:	Title: Theoretical and Computational Fluid Dynamics	L-T-P-C
PH 514	Theory & Programming using C for solving problems on following topics:	
		[2- 0-4- 4]
Course (Dbjectives	

This cour	se enables the students:
А.	To learn the techniques of model atomic and molecular systems.
B.	To receive explanation of methods to deal with the different ensembles used in Statistical Mechanics.
C.	To obtain training on numerical methods used for integrations in Fluid Dynamics.
D.	To discuss ways to analyze the accuracy of correlation functions and equilibrium averages.

Course Outcomes

After the completion of this course, students will be:

	······					
1.	Learning about common models used to describe atoms and molecules					
2.	Able to prepare codes for transforming between different ensembles.					
3.	Develop a good handle on relevant numerical integrations.					
4.	Achieve competence in the estimation of errors involved in computing correlation functions equilibrium averages.	s and				
Module-1	Model systems and interaction potentials: Atomic systems, Molecular systems, Lattice	[11]				
	systems, Calculating the potential, Constructing an intermolecular potential, Studying small					
	systems: periodic and spherical boundary conditions.					
Module-2	Statistical Mechanics: Statistical ensembles, Transformation between ensembles,	[9]				
	Fluctuations, Time correlations, Transport coefficients.					
Module-3	Molecular dynamics: Finite difference methods, Verlet algorithm, Linear and nonlinear [7]					
	molecules, Checks on accuracy.					
Module-4	Monte Carlo methods: Monte Carlo integration, Importance sampling, Metropolis method,	[9]				
	Molecular liquids.					
Module-5	Analyzing results: Time correlation functions, Fast Fourier transform, Estimation of errors in	[9]				
	equilibrium averages and fluctuations, Errors in time correlation functions.					
Referen	<u>ces:</u>					
1. "Comp	uter Simulation of Liquids" by Allen and Tildesley, Oxford Science Publications .					
2. "The A	rt of Molecular Dynamics Simulation" by D. C. Rappaport, Cambridge University Press.					

Direct Assessment							
Assessment Tool	% Contribution during CO Assessment						
Assignment	10						
Seminar before a commitee	10						
Three Quizes	30 (10+10+10)						
End Sem Examination Marks	50						

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination					
Marks					
End Sem Examination					
Marks					
Quiz I					
Quiz II					

Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4
А	Н	М	М	М
В	М	Н	М	М
С	М	L	Н	М
D	L	М	Н	Н

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes						
	а	b	с	d	e	f	
1	Н	Н	М	М	Н	М	
2	L	Н	М	М	Н	М	
3	L	Н	Н	М	Н	М	
4	L	Н	Н	М	Н	М	

Week No	Lect. No.	Tent ative Date	Ch. No	Topics to be covered	Text Book / Referen ces	Cos map ped	Actual Content covered	Met hodo logy used	Remark s by faculty if any
1	L1-L3			Model systems and interaction potentials: Atomic systems, Molecular systems	T1,T2	1			
2	L4-L6			Lattice systems, Calculating the potential, Constructing an intermolecular potential,	T1,T2	1			
3	L7-L9			Studying small systems: periodic and spherical boundary conditions	T1,T2	1			
4	L10- L12			Statistical Mechanics: Statistical ensembles	T1,T2	2			
5	L13-			Transformation between ensembles,	T1,T2	2			

	L15	Fluctuations				
6	L16-	Time correlations, Transport	T1,T2	2		
	L18	coefficients.				
7	L19-	Molecular dynamics: Finite	T1,T2	3		
	L21	difference methods, Verlet				
		algorithm				
8	L22-	Linear and nonlinear molecules,	T1,T2	3		
	L24	Checks on accuracy.				
9	L25-	Monte Carlo methods: Monte Carlo	T1,T2	4		
	L27	integration				
10	L28-	Importance sampling, Metropolis	T1,T2	4		
	L30	method				
11	L31-	Molecular liquids.	T1,T2	4		
	L33					
12	L34-	Analyzing results: Time correlation	T1,T2	5		
	L36	functions, Fast Fourier transform				
13	L37-	Estimation of errors in equilibrium	T1,T2	5		
	L39	averages and fluctuations				
14	L40L42	Errors in time correlation functions.	T1,T2	5		

Course code: PH 515 Course title: Theoretical and Computational Condensed Matter Physics Pre-requisite(s): Co- requisite(s): Credits: 4L: 2 T: 0 P:4 Class schedule per week: Class: I.M.Sc. Semester / Level: PE VI / VII Branch: PHYSICS Name of Teacher:

Group : A Option 2

Code:Title: Theoretical and Computational Condensed Matter PhysicsPH 515Theory & Programming using C for solving problems on following topics:								
Course	e Obje	ctives:						
The co	The course aims to give students the basic concepts of condensed matter physics and to prepare them to formulate the							
probler	ms in c	condensed matter physics so that these can be solved on a computer. The main objectives of the co	ourse are					
1.	To te	ach how Monte-Carlo techniques can be used to solve various physical systems.						
2.	To gi mode	ve concepts of first order phase transitions, second order phase transitions and mean field theory el.	using Ising					
3.	To te	ach the equilibrium properties and time evolution of simple fluids.						
4.	To p	ovide the concept on computation of free energies of solids and how to obtain them numerically.	,					
5.	To in	troduce the method of dissipative particle dynamics.						
Progra	am Ou	tcomes:						
After ta	aking t	he course the student should be able to						
1.	Use I	Monte-Carlo simulation to obtain the equilibrium configuration of a physical system.						
2.	Diffe	rentiate between first order and second order phase transitions and appreciate the efficiency of m	ean field					
	theor	y.						
3.	Calcu	alate transport coefficients and space-time correlation function of simple fluids.						
4.	Com	pute the free energy of perfect or imperfect solids numerically.						
5.	Unde	erstand the fundamentals of dissipative particle dynamics technique.						
Modul	e-1	Random Systems	[10]					
		Generation of Random Numbers, Introduction to Monte Carlo Methods: Integration, Random Walks, Self-Avoiding Walks, Random Walks and Diffusion, Diffusion, Entropy, and the Arrow of Time, Cluster Growth Models, Fractal Dimensionalities of Curves, Percolation						
Modul	e-2	Statistical Mechanics, Phase Transitions, and the Ising Model	[10]					
		The Ising Model and Statistical Mechanics, Mean-Field Theory, The Monte Carlo Method,						
		The Ising Model and Second-Order Phase Transitions, First-Order Phase Transitions						
Modul	e-3	Equilibrium and Dynamical properties of simple fluids	[10]					
		Thermodynamic measurements, Structure, Packing studies, Cluster analysis, Transport						
M - 11	- 4	coefficients Measuring transport coefficients, Space-time correlation functions	[10]					
Modul	e-4	Free Energies of Solids	[10]					
		Vacancies and Interstitials, Numerical Calculations						
Module 5		Dissinative Particle Dynamics	[10]					
Wiodule-5		Justification of the Method, Implementation of the Method, DPD and Energy Conservation						
Text h	ooks							
T1:	: "Con	nputation Physics" by Nicholas J. Giordano, Pearson Addison-Wesley						
T2:	: "The	Art of Molecular Dynamics Simulation" by D. C. Rappaport, Cambridge University Press.						
Refere	ence b	ooks:						

R1: "Understanding Molecular Simulation" by Daan Frenkel, Academic Press.

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	Ν
Laboratory experiments/teaching aids	Ν
Industrial/guest lectures	Ν
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and internets	Y
Simulation	Y

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	C05
End Sem Examination Marks					
Quiz 1					
Quiz 2					
Quiz 3					

Indirect Assessment –

- 1. Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Objectives onto Course Outcomes

Course Outcome #	Program Outcomes						
	а	b	с	d	e		
1	Η	L	L	L	L		
2	L	Н	L	L	L		
3	L	L	Н	L	L		
4	L	L	L	Н	L		
5	L	L	L	L	Н		

Course Outcome #	Program Outcomes					
	а	b	с	d	e	f
1	Η	Η	Η	М	Н	Н
2	Η	Η	Η	М	Н	Н
3	Η	Η	Η	М	Н	Н
4	Η	Η	Η	М	Н	Н
5	Н	Н	Н	М	Н	Н

Mapping Between COs and Course Delivery (CD) methods							
		Comme	Corres Dalianes				
CD	Course Delivery methods	Course Outcome	Course Denvery Method				
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2 and CD9				
CD2	Tutorials/Assignments	CO2	CD1, CD2and CD9				
CD3	Seminars	CO3	CD1, CD2 and CD9				
CD4	Mini projects/Projects	CO4	CD1, CD2 and CD9				
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2 and CD9				
CD6	Industrial/guest lectures						
CD7	Industrial visits/in-plant training						
CD8	Self- learning such as use of NPTEL materials and internets						
CD9	Simulation						

Week	Lect	Tenta	Ch.	Topics to be covered	Text	COs	Actual	Methodology	Remar
No.		tive	No.		Book /	mapp	Content	used	ks by
	No.	Date			Refere	ed	covered		faculty
					nces				if any
1-3	L1-			Generation of Random	T1, T2	1		PPT Digi	
	L10			Numbers, Introduction to Monte				Class/Chock	
				Carlo Methods: Integration,				-Board	
				Random Walks, Self-Avoiding					
				Walks, Random Walks and					
				Diffusion, Diffusion, Entropy,					
				Growth Models Erected					
				Dimensionalities of Curves					
				Percolation					
3-5	L11-			The Ising Model and Statistical	T1, R1	2			
	L20			Mechanics, Mean-Field Theory,					
				The Monte Carlo Method, The					
				Ising Model and Second-Order					
				Phase Transitions, First-Order					
				Phase Transitions					
6-8	L21-			Thermodynamic measurements,	T1, T2,	3			
	L30			Structure, Packing studies,	R1				
				Cluster analysis, Transport					
				coefficients Measuring transport					

		coefficients, Space-time correlation functions				
8-10	L31- L40	Thermodynamic Integration, Free Energies of Solids, Free Energies of Molecular Solids, Vacancies and Interstitials, Numerical Calculations	T1, T2	4		
11-14	L41- L50	Justification of the Method, Implementation of the Method, DPD and Energy Conservation	T1, T2, R1	5		

Course code: PH 516 Course title: Nonlinear Dynamics and Chaos Pre-requisite(s): Classical Dynamics Co- requisite(s): Credits: 4L: 2 T: 0 P: 4 Class schedule per week: Class: I.M.Sc. Semester / Level: PE V Branch: PHYSICS Name of Teacher:

Code: PH 516		Title: Nonlinear Dynamics and Chaos	L-T-P-C 2- 0-4- 4]
Course	e Objo	ectives: The objective of the course is to	<u> </u>
1.	Traiı	students to calculate fixed points and do stability analysis of various systems motivated from	
	phys	ics/biology.	
2.	Give	a clear concept of bifurcation and some examples of the phenomenon.	
3.	Teac	h them to plot limit cycles of various differential equations on computer using C language.	
4.	Teac	h properties of limit cycles taking examples from physics.	
5.	Trair	students to solve problems on coevolution and the impact of environment on population growth	using
	conc	epts from physics.	
Course	e Outo	comes: The student should be able to	
1.	Mod	el physical or biological systems computationally and obtain their fixed points, saddle points, attr	ractors, etc.
2.	Com	pute the evolution of phase space as various parameters are changed.	
3.	Visu	alize limit cycles of various nonlinear systems graphically.	
4.	Solv	e problems related to oscillators, viz., relaxation oscillators, weakly nonlinear oscillators, etc.	
5.	Solv	e simple models of population growth of multiple-species on computer.	
Modul	e-1	Flows on the Line & Circle	[12]
		Fixed Points and Stability, Population Growth, Linear Stability Analysis, Existence and Uniqueness, Impossibility of Oscillations, Potentials, Solving Equations on the Computer, Uniform Oscillator, Nonuniform Oscillator, Overdamped Pendulum, Fireflies, Superconducting Josephson Junctions	
Modul	e-2	Bifurcations	[10]
		Saddle-Node Bifurcation, Transcritical Bifurcation, Laser Threshold, Pitchfork Bifurcation,	
		Overdamped Bead on a Rotating Hoop, Imperfect Bifurcations and Catastrophes, Insect Outbreak, Chaos	
Modul	e-3	Phase Plane	[10]
		Phase Portraits, Existence, Uniqueness, and Topological Consequences, Fixed Points and Linearization, Rabbits versus Sheep, Conservative Systems, Reversible Systems, Pendulum,	
		Index Theory	503
Modul	e-4	Limit Cycles	[8]
		Oscillators Weakly Nonlinear Oscillators	
Modul	e-5	Population Dynamics	[10]
Wiodul	05	Multispecies model: limit cycles and time delays Randomly Fluctuating Environment Niche	
		Overlap and Limiting Similarity	
Text b	ooks		<u>I</u>
T1: No	onlinea	ar dynamics and Chaos: with applications to physics, biology, chemistry, and engineering by	Steven H.
Strogat	tz, CR	C Press.	

T2: "Stability and Complexity in Model Ecosystems" by Robert M May, Princeton University Press.

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	Ν
Laboratory experiments/teaching aids	Ν
Industrial/guest lectures	Ν
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and	
internets	Y
Simulation	Y

Direct Assessment							
Assessment Tool	% Contribution during CO Assessment						
Assignment	10						
Seminar before a commitee	10						
Three Quizes	30 (10+10+10)						
End Sem Examination Marks	50						

Assessment Compoents	CO1	CO2	CO3	CO4	C05
End Sem Examination Marks					
Quiz 1					
Quiz 2					
Quiz 3					

Indirect Assessment -

- **1.** Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Objectives onto Course Outcomes

Course Outcome #	Program Outcomes						
	а	b	с	d	e		
1	Н	L	L	L	L		
2	L	Н	L	L	L		
3	L	L	Н	L	L		
4	L	L	L	Н	L		
5	L	L	L	L	Н		

Course Outcome #	Program Outcomes					
	а	b	с	d	e	f
1	Η	Η	Η	М	Н	Н
2	Η	Η	Η	М	Н	Н
3	Η	Η	Η	М	Н	Н
4	Η	Η	Η	М	Н	Н
5	Н	Η	Н	М	Η	Н

Mapping Between COs and Course Delivery (CD) methods							
		Course	Course Delivery				
CD	Course Delivery methods	Outcome	Method				
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2 and CD9				
CD2	Tutorials/Assignments	CO2	CD1, CD2and CD9				
CD3	Seminars	CO3	CD1, CD2 and CD9				
CD4	Mini projects/Projects	CO4	CD1, CD2 and CD9				
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2 and CD9				
CD6	Industrial/guest lectures						
CD7	Industrial visits/in-plant training						
CD8	Self- learning such as use of NPTEL materials and internets						
CD9	Simulation						

Week	Lect.	Tent	C	Topics to be covered	Text	COs	Actual	Methodol	Remarks
No.	No.	ative	h.		Book /	map	Content	ogy	by faculty
		Date	Ν		Refere	ped	covered	used	if any
			0		nces				
1-3	L1-			Fixed Points and Stability,	T1, T2	1		PPT Digi	
	L12			Population Growth, Linear				Class/Cho	
				Stability Analysis, Existence				ck	
				and Uniqueness, Impossibility				-Board	
				of Oscillations, Potentials,					
				Solving Equations on the					
				Computer, Uniform Oscillator,					
				Nonuniform Oscillator,					
				Overdamped Pendulum,					
				Fireflies, Superconducting					
				Josephson Junctions					
4-6	L13-			Saddle-Node Bifurcation,	T1, T2	2			
	L22			Transcritical Bifurcation, Laser					
				Threshold, Pitchfork					
				Bifurcation, Overdamped Bead					
				on a Rotating Hoop, Imperfect					
				Bifurcations and Catastrophes,					
				Insect Outbreak, Chaos					
6-8	L23-			Phase Portraits, Existence,	T1,T2	3			
				Uniqueness, and Topological					

	LL3 2	Consequences, Fixed Points and Linearization, Rabbits versus Sheep, Conservative Systems, Reversible Systems, Pendulum, Index Theory				
9-10	L33- L40	Ruling Out Closed Orbits, Poincare-Bendixson Theorem, Lienard Systems, Relaxation Oscillators, Weakly Nonlinear Oscillators	T1,T2	4		
11-14	L41- L50	Multispecies model: limit cycles and time delays, Randomly Fluctuating Environment, Niche Overlap and Limiting Similarity	T1, T2	5		

Course code: PH 517

Course title: Nonconventional Energy Materials

Pre-requisite(s):Student should qualify 'Solid State Physics' or similar paper

Co- requisite(s):Knowledge of Mathematical Physics, Quantum Mechanics, and Statistical Mechanics

Credits: 4L: 4 T: 0 P: 0 Class schedule per week:4 Class: I.M.Sc./ M.Sc. Semester / Level: X/IV Branch:Physics Name of Teacher:

G	roup	: B <u>Option 1</u>	
Code:	נ	Title: Nonconventional Energy Materials	L-T-P-C
PH 51	17		[4-0-0-4]
Cours	se Ob	jectives	
		•	
This c	ourse	enables the students:	
	A.	Todefine the current scenario of the conventional sources of energy and importance of	
		sustainable energy sources.	
	В.	To explain the basic of PN Junction solar cell.	
	С.	To define the solar cell characterization.	
	D.	To illustrate the various solar cell technologies.	
	E.	To explain the other nonconventional energy sources	
Cours	se Ou	itcomes	
	.1		
After	the co	ompletion of this course, students will be able to:	
	1.	Explain the current status of conventional sources of energy and list the various sustainable	
	~	energy sources.	
	2.	Define various properties of the semiconducting materials, formation of PN junction and	
	2	Demonstrate the measurement of solar cell peremeters and solar cell.	
	э.	design for high Voc. design for high FE	
	4	Explain the fabrication of wafer based solar calls, thin film solar call, organic solar calls, dva	
	4.	sensitized solar cell. GaAs solar cells. Thermo-photovoltaics and multijunction solar cells.	
	5	Discuss the concepts of wind energy bio energy tidal power fuel cells, and solar thermal	
Modu	J.	Energy sources and their availability conventional sources of energy. Fossil fuel Hydraulic	[5]
Wiodu	10-1	energy Nuclear energy: nuclear fission nuclear fusion Environmental impact of conventional	[5]
		sources of energy Need for sustainable energy sources Nonconventional energy sources	
		Current status of renewable energy sources	
Modu	le-2	Structure of solar cell materials direct and indirect hand gap semiconductor carrier	[10]
Modu	10 2	concentration and distribution drift and diffusion current densities P-N Junction: space charge	[10]
		region energy hand diagram carrier movements and current densities carrier concentration	
		profile: P-N junction in non-equilibrium condition I-V Relation P-N Junction under	
		Illumination. Generation of photovoltage. Light generated current. I-V equation of solar cells.	
Modu	le-3	Solar Cell Characteristics and Cell parameters: Short circuit current open circuit voltage fill	[10]
111044		factor, efficiency: losses in solar cells. Solar Cell Design: design for high Isc. design for high	[10]
		Voc. design for high FF: Solar spectrum at the Earth's surface, solar simulator: I-V	
		measurement, quantum efficiency measurement, minority carrier lifetime and diffusion length	
		measurement.	
Modu	le-4	Wafer-based Si solar cell fabrication: saw damage removal and surface texturing P-N Junction	[15]
		formation, ARC and surface passivation, metal contacts—pattern defining and deposition. High	[-•]
		efficiency solar cells, Thin Film Solar Cell Technologies: advantages of thin film technologies.	
		thin films solar cell structures, thin film crystalline, microcrystalline, polycrystalline, and	
		amorphous Si solar cells. Emerging solar cell technologies: working principle of organic solar	

	cells, material properties and structure of organic solar cells; Dye-sensitized Solar Cell: working	
	principle, materials and their Properties; GaAs solar cells, Thermo-photovoltaics, multijunction	
	solar cells.	
Module-5	Other nonconventional Energy Sources: Wind Energy: Classification of wind mills, advantages	[10]
	and disadvantage of wind energy; Bio Energy: Bio gas and its compositions, process of bio gas,	
	generation - wet process, dry process, utilization and benefits of biogas technology. Tidal	
	Power: Introduction, classification of tidal power plants, factors affecting the suitability of the	
	site for tidal power plant, advantages and disadvantages of tidal power plants. Fuel Cells:	
	Introduction, working of fuel cell, types of fuel cells, advantages of fuel cell technology. Solar	
	Thermal: Solar collectors, solar cookers, solar water heater.	
Text/Ref	erence Books:	

- 1. Solar cells: Operating principles, technology and system applications by Martin A Green, Prentice Hall Inc, Englewood Cliffs, NJ, USA, 1981.
- 2. Semiconductor for solar cells, H J Moller, Artech House Inc, MA, USA, 1993.
- 3. Solis state electronic device, Ben G Streetman, Prentice Hall of India Pvt Ltd., New Delhi 1995.
- 4. Direct energy conversion, M.A. Kettani, Addision Wesley Reading, 1970.
- 5. Hand book of Batteries and fuel cells, Linden, Mc Graw Hill, 1984.

Course Delivery methods		
Lecture by use of boards/LCD projectors/OHP projectors	Y	
Tutorials/Assignments	Y	
Seminars	N	
Mini projects/Projects	N	
Laboratory experiments/teaching aids	N	
Industrial/guest lectures	N	
Industrial visits/in-plant training	N	
Self- learning such as use of NPTEL materials and internets	Y	
Simulation	N	

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	\checkmark	\checkmark	\checkmark		
End Sem Examination Marks	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Quiz I	\checkmark	\checkmark	\checkmark		
Quiz II				\checkmark	\checkmark

Indirect Assessment -

- **1.** Student Feedback on Faculty
- 2. Student Feedback on Course Outcome
- **3.** Teacher's assessment

Mapping between Objectives and Outcomes

Mapping between Course Objectives and Course Outcomes

Course	1	2	3	4	5	

Objectives					
А	Н	L	L	L	L
В	Μ	Н	М	М	L
С	М	Μ	Н	L	L
D	М	L	L	Η	L
Е	М	L	L	L	Н

Course	Program Outcomes								
Outcome #	а	b	с	d	e	f			
1	L	L	М	Н	L	Н			
2	М	Н	М	Н	Н	Н			
3	М	Н	М	Н	Н	Н			
4	М	Н	М	Н	Н	Н			
5	М	Н	М	Н	Н	Н			

	Mapping Between COs and Course Delivery (CD) methods								
	Course Delivery methods		Course	Course Delivery					
CD			Outcome	Method					
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1 and CD2					
CD2	Tutorials/Assignments		CO2	CD1 and CD2					
CD3	Seminars		CO3	CD1 and CD2					
CD4	Mini projects/Projects		CO4	CD1 and CD2					
CD5	Laboratory experiments/teaching aids		CO5	CD1 and CD2					
CD6	Industrial/guest lectures		-	-					
CD7	Industrial visits/in-plant training		-	-					
CD8	Self- learning such as use of NPTEL materials and internets		-	-					
CD9	Simulation		-	-					

Week	Lect.	Tentativ	Ch.	Topics to be covered	Text	Cos	Actual	Method	Remarks by
No.	No.	e Date	No.		Book /	mapped	Content	ology	faculty if
					Referenc		covered	used	any
					es				
	L1			World energy status, current	R1				
				energy scenario in India,					
				environmental aspects of					
				energy utilization,					
				Classification of energy,					
				Energy Resources, need of					
				renewable energy, non-					
				conventional energy					
				sources.					
	L2,			An overview of	R1				
	L3			developments in Offshore					
				Wind Energy, Tidal Energy,					
				Wave energy systems,					
				Ocean energy,					

I.A.	Thermal Energy Conversion.	R1		
1.5	solar energy biomass			
1.5	biochemical conversion			
	biogas generation			
	goothermal energy tidal			
	geotiletinal energy tidal			
	Energy, Hydroelectricity.			
	Energy conservation and			
	storage.			
L6-	Solar energy, its importance,	R1, R2		
L10	storage of solar energy,	T1		
	solar pond, non-convective			
	solar pond, applications of			
	solar pond and solar energy,			
	solar water heater, flat plate			
	collector, solar distillation,			
	solar cooker, solar green			
	houses, solar cell			
L11-	absorption air conditioning.	R1, R2		
L15	Need and characteristics of	T1		
	photovoltaic (PV) systems.			
	PV models and equivalent			
	circuits and sun tracking			
	systems			
I 16	Wind Energy: Fundamentals	R1 R2		
L10- L 10	of Wind energy Wind	$\mathbf{K}_{1},\mathbf{K}_{2}$		
L19	Turbinos and different			
	interest mashings in wind			
	electrical machines in wind			
	turbines, Power electronic			
	interfaces, and grid			
1.20	interconnection topologies.	D1 D0		
L20-	Ocean Energy, Potential	R1, R2		
L22	against Wind and Solar,			
	Wave Characteristics, Wave			
	Energy Devices.			
L23-	Tide characteristics and	R1, R2		
L25	Statistics, Tide Energy			
	Technologies, Ocean			
	Thermal Energy, Osmotic			
	Power, Ocean Bio-mass.			
L26-	Biomass energy, resources,	R1, R2		
L30	conversion, gasification,			
	liquefaction, production,			
	energy farming,			
L31-	Geothermal Energy:	R1, R2		
L33	Geothermal Resources,			
	Geothermal Technologies.			
L34.	small hydro resources.	R1, R2		
L35	Lavout, water turbines.	,		
	classifications, generators,			
	status.			
L36-	Direct Energy conversion:	R1. R2		
1.38	Thermoelectric effects			
	generators Thermionic			
	generators magneto hydro			
	generators, magneto nyuro	1	1	

		dynamics generators, Fuel cells	
]	L39, L40	photovoltaic generators, R1, R2 electrostatic mechanical generators, Thin film solar cells, nuclear batteries.	

Course code: PH 518 **Course title: Cryogenic Physics** Pre-requisite(s): **Co- requisite(s):** Credits: **4**L: 4 T: 0 P: 0 **Class schedule per week:** Class: I.M.Sc. Semester / Level:PE VI / VII **Branch: PHYSICS** Name of Teacher: Group : B

Option 2

Code:		Title: Cryogenic Physics				
	0 60 ()]	iactives • This course enables the students	[4-0-0-4]			
Cour	A.	To become familiar with low temperature and the principles and methods to produce low temperature	ture.			
	В.	To acquire basic understanding of the macroscopic manifestations of quantum phenomenon at low temperatures like superfluidity of He ⁴ , He ³ and superconductivity.	v			
	C. To acquire basic knowledge of the behaviour of various physical properties at low temperature.					
	 D. To become aware of various special phenomena observed at low temperature and their manifestation i physical properties. 					
	E	Become conversant with the principles and methods to produce low temperature.				
Cour	se Oi	ter the completion of this course, students will be				
	1.	Able to explain the physics and production of low temperature.				
	2.	Able to describe and analyze the macroscopic manifestations of quantum phenomenon at low temp	peratures.			
	3.	Able to summarize and apply the knowledge of the behaviour of various physical properties at low temperature.	7			
	4.	Able to discuss and compare various special phenomena observed at low temperatures.				
	5.	Compare different methods of producing low temperature.				
Modu	ule-1	Quantum Fluids: Introduction to low temperature physics; cryo-liquids; helium-general properties; superfluid ⁴ He, experimental observation, two-fluid model and Bose-Einstein condensation; normal-fluid and superfluid ³ He; mixtures of ³ He and ⁴ He.	[8]			
Modu	ıle-2	Solids at Low Temperature (Phonons and Electrons):				
		Specific heat of phonons-Debye model, significance of the Debye temperature; specific heat of conduction electrons in simple metals; electrical conductivity, relaxation-time approximation, Matthiessen's rule, electron-phonon scattering, electron-magnon scattering; thermal conductivity of metals; Kondo effect; Heavy Fermion Systems.				
Modu	ıle-3	Solids at Low Temperature (Magnetic Moments, Spins): Paramagnetic systems-isolated	[8]			
		spins, magnetic contribution to specific heat, Schottky anomaly; spin waves-magnons, ferromagnets, anti-ferromagnets.				
Modu	ıle-4	Solids at Low Temperature (Introduction to Superconductivity, Shubnikov-de Haas	[8]			
		Oscillations, Colossal Magnetoresistance): Transition temperature, Meissner effect, type-I and type-II superconductors; phenomenological description, London equations; microscopic theory of superconductors; flux quantization; Shubnikov-de Haas (SdH) oscillations, quantization of Bloch electrons in a uniform magnetic field; colossal magnetoresistance (CMR).				
Modu	ule-5	Refrigeration: Liquefaction of gases, expansion engines, Joule-Thomson expansion; closed cycle refrigerators, Gifford Mc-Mahon coolers; simple-helium bath cryostats; ³ He- ⁴ He dilution refrigerator; Pomeranchuk cooling; refrigeration by adiabatic demagnetization of a paramagnetic salt and adiabatic nuclear demagnetization.	[8]			
<u>T</u> 1. 2.	<u>extba</u> . Lo . Ma	<u>oks:</u> w-Temperature Physics, Christian Enss and Siegfried Hunklinger, Springer 2005. atter and Methods at Low Temperatures, Frank Pobell, Springer 2007.				

References:

- 1. Introduction to Solid State Physics, Charles Kittel, 8th edition, John Wiley and Sons, 2005. (For SdH oscillations)
- 2. Solid State Physics, Neil W. Ashcroft and N. David Mermin, Harcourt College Publishers, 1976. (For SdH oscillations)

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Yes
Tutorials/Assignments	Yes
Seminars	No
Mini projects/Projects	Yes
Laboratory experiments/teaching aids	Yes
Industrial/guest lectures	No
Industrial visits/in-plant training	No
Self- learning such as use of NPTEL materials and internets	Yes
Simulation	No

Course Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

AssessmentCompoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	Yes	Yes	Yes	No	No
End Sem Examination Marks	Yes	Yes	Yes	Yes	Yes
Assignment	Yes	Yes	Yes	Yes	Yes

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course	Program Outcomes						
Outcome #	a	b	С	d	e	f	
1	L	Н	Н	L	Н	М	
2	М	Н	Н	L	Н	М	
3	М	Н	Н	L	Н	М	
4	L	Н	Н	L	Н	Μ	
5	L	Н	Н	L	Н	М	

Course	Course Objectives							
Outcome #	a b		С	d	e			
1	Н	Н	Н	L	L			
2	Μ	Н	Μ	Μ	L			

3	М	М	Н	М	L
4	М	М	Н	Н	L
5	М	L	L	L	Н

	Mapping Between COs and Course Delivery (CD) methods								
				Course	Delivery				
CD	Course Delivery methods		Course Outcome	Method					
	Lecture by use of boards/LCD projectors/OHP			CD1, CD2,	CD4,CD5				
CD1	projectors		CO1	and CD8					
				CD1, CD2,	CD4,CD5				
CD2	Tutorials/Assignments		CO2	and CD8					
				CD1, CD2,	CD4,CD5				
CD3	Seminars		CO3	and CD8					
				CD1, CD2,	CD4,CD5				
CD4	Mini projects/Projects		CO4	and CD8					
				CD1, CD2,	CD4,CD5				
CD5	Laboratory experiments/teaching aids		CO5	and CD8					
CD6	Industrial/guest lectures								
CD7	Industrial visits/in-plant training								
	Self- learning such as use of NPTEL materials								
CD8	and internets								
CD9	Simulation								

Week	Lect.	Tentative	Module	Topics to be covered	Text	COs	Actual	Methodolo	Remarks
No.	No.	Date	No.		Book /	mapped	Content	gyused	byfacult
					Refere		covered		y if any
					nces				
1-2	L1		Ι	Introduction to low	T1-T2	CO-1		PPT Digi	
				temperature physics,				Class/Chal	
				course objectives,				k-Board	
				grading scheme					
	L2-			Cryoliquids, general	T1-T2	CO-1		PPT Digi	
	L5			properties of He,				Class/Chal	
				Superfluid ⁴ He,				k-Board	
				Experimental					
				Observation, Two					
				fluid model, Bose					
				Einstein Condensation					
2	L6-7			Superfluid and Normal	T1-T2	CO-1		PPT Digi	
				Fluid ³ He.				Class/Chal	
								k-Board	
2	L8			Mixtures of ³ He and	T1-T2	CO-1		PPT Digi	
				⁴ He.				Class/Chal	
								k-Board	
3	L9-		II	Solids at Low	T1-T2	CO-2		PPT Digi	
	L10			Temperature: Phonons				Class/Chal	
				and electrons, specific				k-Board	
				heat of Phonons,					
				Debye model					
3	L11			Specific heat of	T1-T2	CO-2		PPT Digi	
				conduction electrons in				Class/Chal	

			simple metals			1	k-Board	
3-4	L11- L13		Electrical conductivity, relaxation-time approximation, Matthiessen's rule, electron-phonon scattering, electron- magnon scattering	T1-T2	CO-2		PT Digi Class/Chal c-Board	
4	16		of metals; Kondo effect; Heavy Fermion Systems	11-12	CO-2]	Class/Chal k-Board	
5	L17- 20	III	Solids at Low Temperature (Magnetic Moments, Spins) Paramagnetic systems-isolated spins, magnetic contribution to specific heat, Schottky anomaly	T1-T2	CO-3		PT Digi Class/Chal c-Board	
6	L21- 24		Spin waves-magnons, ferromagnets, anti- ferromagnets	T1-T2	CO-3]	PPT Digi Class/Chal k-Board	
7	L25- 28	IV	Solids at Low Temperature (Introduction to Superconductivity, Shubnikov-de Haas Oscillations , Colossal Magnetoresistance) Transition temperature, Meissner effect, type-I and type- II superconductors; phenomenological description, London equations; microscopic theory of superconductors; flux quantization;	T1-T2	CO-4		PT Digi Class/Chal c-Board	
8	L29- 32		Shubnikov-de Haas (SdH) oscillations, quantization of Bloch electrons in a uniform magnetic field; colossal magnetoresistance (CMR).	T1- T2, R1-R2	CO-4		2PT Digi Class/Chal c-Board	
9	L33- 34	V	Refrigeration: Liquefaction of gases, expansion engines, Joule-Thomson expansion	T1-T2	CO-5		PPT Digi Class/Chal s-Board	

9	L35-	Closed	cycle	T1-T2	CO-5	PPT Digi	
	36	refrigerators,	Gifford			Class/Chal	
		Mc-Mahon	coolers;			k-Board	
		simple-helium	h bath				
		cryostats					
10	L37-	³ He- ⁴ He	dilution	T1-T2	CO-5	PPT Digi	
	40	refrigerator;				Class/Chal	
		Pomeranchuk	cooling;			k-Board	
		refrigeration	by				
		adiabatic					
		demagnetizati	on of a				
		paramagnetic	salt and				
		adiabatic	nuclear				
		demagnetizati	on.				

Course code: PH 519 Course title: Physics of Thin Films Pre-requisite(s): Co- requisite(s): Credits: 4L: 4 T: 0 P: 00 Class schedule per week: 0x Class: I.M.Sc. / M.Sc. Semester / Level:X / IV Branch: Physics Name of Teacher:

Group: B

Option 3

Code		Title: Physics of Thin Films	L-T-P-C
PH 51	19		[4004]
Cours	se Obj	ectives	
This c	ourse e	enables the students to:	
	А.	Definevacuum and compare various vacuum pumps and gauges.	
	В.	Outline the thermodynamics of thin films.	
	C.	Illustrate the mechanism of thin film formation.	
	D.	Explain various techniques of thin film formation.	
	E.	Summarize various properties of thin films.	
Cours	so Out	comes	
After	the cor	npletion of this course, students will be able to:	
	1.	Demonstrate various types of pumps and gauges, inspect leak in vacuum and can design a	
		vacuum system.	
	2.	Define the thermodynamical parameters of thin films and can outline interdiffusion in thin	
		films.	
	3.	Demonstrate the stages of thin film formation and can outline the conditions for the	
		formation of amorphous, crystalline and epitaxial films.	
	4	Illustrate and compare physical vapour deposition (PVD) and chemical vapour deposition	
	_	(CVD) techniques.	
	5.	Define various thin film properties and outline the techniques of their determination.	
Modu	ıle-1	Vacuum Science & Technology:	[8]
		Classification of vacuum ranges, Kinetic theory of gases, gas transport and pumping,	
		Conductance and Throughput, Classification of vacuum pumps, single stage and double stage	
		rotary pump, diffusion pump, turbomolecular pump, cryopump and Classification of gauges,	
		Mechanical gauges: McLeod gauge, Thermal conductivity gauges: Pirani gauge and	
		thermocouple gauge, Ionization gauges: Bayard-Alpert gauge, Penning gauge, leak detection.	
Modu	ıle-2	Basic Thermodynamics of Thin Films	[8]
		Solid surface, interphase surface, Surface energies: Binding energy and Interatomic Potential	
		energy, latent heat, surface tension, Liquid surface energy measurement by capillary effect,	
		by zero creep, magnitude of surface energy, General concept, jump frequency and diffusion	
		flux, Fick's First law, Nonlinear diffusion, Fick's second law, calculation of diffusion	
		coefficient, interdiffusion and diffusion in	
	1 0	thin films	
Modu	ile-3	Mechanisms of Film Formation	[8]
		Stages of thin film formation: Nucleation, Adsorption, Surface diffusion, capillarity theory of	
		nucleation, statistical theory of nucleation, growth and coalescence of islands, grain structure	
		and microstructure of thin films, diffusion during film growth, polycrystalline and amorphous	
		tims, i neories of epitaxy, role of interfacial layer, epitaxial film growth, super lattice	
	1 4		F4 = 3
Modu	ıle-4	Methods of Preparation of Thin Films:	15

	Physical vapour deposition: Vacuum evaporation-Hertz- Knudsen equation, evaporation from a source and film thickness uniformity, Glow discharge and plasmas-Plasma structure, DC, RF and microwave excitation; Sputtering processes-Mechanism and sputtering yield, Sputtering of alloys; magnetron sputtering, Reactive sputtering; vacuum arc: cathodic and anodic vacuum arc deposition. Chemical vapour deposition: Thermodynamics of CVD, gas transport, growth kinetics, Plasma chemistry, plasma etching mechanisms; etch rate and selectivity, orientation dependent etching; PECVD.	
Module-5	Characterization of thin films:	[6]
	Deposition rate, Film thickness and uniformity, Structural properties: Crystallographic	
	properties, defects, residual stresses, adhesion, hardness, ductility, electrical properties,	
	magnetic properties; optical properties.	
Text book		
1. Th	e Material Science of Thin Films by Milton Ohring, Academic Press, Inc., 1992.	
2. Ha	ndbook of Thin Films by Maissel and Glang	
3. Th	in Film Phenomena by K. L. Chopra (McGraw Hill, 1969)	
Reference	books:	
1. Th	in Film Deposition: Principles & Practice by Donald L. Smith (McGraw Hill, 1995)	
2. Co	ating Technology Handbook by D. Satas, A. A. Tracton, Marcel Dekkar Inc. USA.	
3. Ar 19	e Plasma Technology in Material Science, P. A. Gerdeman and N. L. Hecht, Spring 72.	er Verlag,

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP	Yes
projectors	
Tutorials/Assignments	Yes
Seminars	No
Mini projects/Projects	No
Laboratory experiments/teaching aids	No
Industrial/guest lectures	No
Industrial visits/in-plant training	No
Self- learning such as use of NPTEL materials and	Yes
internets	
Simulation	No

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

AssessmentCompoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	Yes	Yes	Yes	No	No
End Sem Examination Marks	Yes	Yes	Yes	Yes	Yes
Assignment	Yes	Yes	Yes	Yes	Yes

Indirect Assessment -

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Course		Program Outcomes								
Outcome #	a	b	с	d	e	f				
1	Н	Н	Н	L	М	L				
2	Н	Н	М	L	L	L				
3	Н	М	М	L	L	L				
4	Н	М	М	L	L	L				
5	Н	Н	Н	L	Н	L				

Course	Course Objectives								
Outcome #	a	b	с	d	e				
1	Н	М	М	М	L				
2	М	Н	М	М	L				
3	М	М	Н	L	L				
4	М	М	Н	L	L				
5	М	М	L	L	Н				

	Mapping Between COs and Course De	eli	very (CD) n	nethods
CD	Course Delivery methods		Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1, CD2 and CD8
CD2	Tutorials/Assignments		CO2	CD1, CD2 and CD8
CD3	Seminars		CO3	CD1, CD2 and CD8
CD4	Mini projects/Projects		CO4	CD1, CD2 and CD8
CD5	Laboratory experiments/teaching aids		CO5	CD1, CD2 and CD8
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

Week	Lect.	Tent	Module	Topics	to	be	Text	Cos	Actual	Methodology	Remarks
	No.	ative	No.	covered			Book /	mapped	Content	used	by
No.		Date					Refere		covered		faculty if
							nces				any
1-2	L1-2		Ι	Classifica	ation	of	T2	CO-1		PPT Digi	
				vacuum	rang	ges,				Class/Chalk-	
				Kinetic t	theory	of				Board	
				gases							
	L3-4			gas trans	sport	and	T2	CO-1		PPT Digi	
				pumping,	,					Class/Chalk	
				Conducta	ince	and				-Board	
				Throughr	nit						
				Inough) al						
2	L5			Classifica	ation	of	T1	CO-1		PPT Digi	
				vacuum	pun	nps,				Class/Chalk-	
				single st	tage	and				Board	

2-3	L6		doublestagerotarypump,diffusionpump,turbomolecularpump,cryopumpandClassificationofgauges,Mechanicalgauges:McLeod	T1	CO-1	PPT Digi Class/Chalk- Board	
3	L7		gauge Thermal conductivity gauges: Pirani gauge and thermocouple gauge.		CO-1	PPT Digi Class/Chalk- Board	
3	L8		Ionization gauges: Bayard-Alpert gauge, Penning gauge, leak detection.	Τ3	CO-2	PPT Digi Class/Chalk- Board	
4	L9	Π	Solid surface, interphase surface	Т3	CO-2	PPT Digi Class/Chalk- Board	
4	L10		Surface energies: Binding energy and Interatomic Potential energy	T1	CO-2	PPT Digi Class/Chalk- Board	
5	L11-12		latent heat, surface tension, Liquid surface energy measurement by capillary effect, by zero creep	T1	CO-2	PPT Digi Class/Chalk- Board	
5	L13		magnitude of surface energy, General concept, jump frequency and diffusion flux		CO-2	PPT Digi Class/Chalk- Board	
6	L14-16		Fick's First law, Nonlinear diffusion, Fick's second law,	T1, T2, T3	CO-2	PPT Digi Class/Chalk- Board	

			calculation of				
			diffusion				
			coefficient,				
			interdiffusion and				
			diffusion in				
			thin films				
7	L17-18	III	Stages of thin film	T1	CO-3	PPT Digi	
			formation.			Class/Chalk-	
			Nucleation			Board	
			Adsorption				
			Surface diffusion				
7 8	I 10 20		conjillarity theory		CO 3		
7-0	L19-20		of pupiloption		0-5	Class/Chalk-	
						Board	
			statistical theory			20000	
			of nucleation,				
			growth and				
			coalescence of				
			1slands				
8	L21-22		grain structure and	T2	CO-3	PPT Digi	
			microstructure of			Class/Chalk-	
			thin films,			Doard	
			diffusion during				
			film growth				
9	L23		polycrystalline and	T1,	CO-3	PPT Digi	
			amorphous films,	Т2,		Class/Chalk-	
			Theories of			Board	
			epitaxy				
9	L24		role of interfacial	T2, T3	CO-3	PPT Digi	
			layer, epitaxial			Class/Chalk-	
			film growth, super			Board	
			lattice structures				
9-10	L25-26	IV	Vacuum	T1	CO-4	PPT Digi	
			evaporation-Hertz-			Class/Chalk-	
			Knudsen equation,			Board	
			evaporation from a				
			source and film				
			thickness				
			uniformity				
10	L27-28		Glow discharge	T1	CO-4	PPT Digi	
			and plasmas-			Class/Chalk-	
			Plasma structure			Board	
			DC. RF and				
			microwave				
			excitation				
11	L29-30		Sputtering	T2	CO-4	ΡΡΤ Πισί	
**			nrocesses-	1		Class/Chalk-	
			Mechanism and			Board	
			ivicchanisin and				

			sputtering yield,				
			Sputtering of				
			allovs				
11-12	L31-32		magnetron	Т2	CO-4	PPT Digi	
11 12	201 02		sputtering		001	Class/Chalk-	
			Ponotivo			Board	
			Reactive				
10	1.00.04		sputtering		00.4		
12	L33-34		vacuum arc:	12	CO-4	PPT Digi	
			cathodic and			Class/Chalk-	
			anodic vacuum arc			Doald	
			deposition.				
			Chemical vapour				
			deposition				
13	L35-36		Thermodynamics	T2	CO-4	PPT Digi	
			of CVD, gas			Class/Chalk-	
			transport, growth			Board	
			kinetics. Plasma				
			chemistry				
14	L37-39		plasma etching	Т2	CO-4	PPT Digi	
1	201 05		mechanisms, etch		001	Class/Chalk-	
			rate and			Board	
			solootivity				
			sciectivity,				
			demondent etching:				
			dependent etcning;				
1.4	I. 40	X 7	PECVD		00.5		
14	L40	V	Deposition rate,	12	CO-5	PPT Digi	
			Film thickness and			Class/Chaik-	
			uniformity			Board	
15	L41		Structural	T2	CO-5	PPT Digi	
			properties:			Class/Chalk-	
			Crystallographic			Board	
			properties, defects				
15	L42		residual stresses,	T2	CO-5	PPT Digi	
			adhesion,			Class/Chalk-	
			hardness, ductility			Board	
15	L43		electrical	T2	CO-5	PPT Digi	
			properties			Class/Chalk-	
			1 · I · · · · ~			Board	
16	L44		magnetic	T2	CO-5	PPT Digi	
			properties;			Class/Chalk-	
						Board	
16	L45		optical properties	T2	CO-5	PPT Digi	
						Class/Chalk-	
			1	1		ьoard	

 Course code: PH 520

 Course title: Theory of Dielectrics and Ferroics

 Pre-requisite(s):

 Co- requisite(s):

 Credits:
 4L: 3 T: 1 P: 0

 Class schedule per week:

 Class: I.M.Sc.

 Semester / Level:PE VI / VII

 Branch: PHYSICS

 Name of Teacher:

 Group : B
 Option 4

			L T C P					
Code PH 52	e: 20	Title: Theory of dielectrics and ferroics	3-1-0-4					
Cours	se Obj	ectives						
This c	ourse	enables the students:						
	A.	To become familiar with the concept of polarisation in ideal and non-ideal dielectrics.						
	В.	To be familiarized with electrochemical impedance spectroscopy.						
	C.	Γο become familiar with the theory of ferroelectricity using domain theory and understand different type of phase transition in ferroelectric materials.						
	D.	To acquire an understanding of the theory of ferromagnetism and know about the different magnetic ordering.	t types of					
	E.	To become familiar with the concept of multiferroics and different types of mechanisms by multiferroics can be formed.	y which					
Cours	se Out	comes unletion of this course, students will be:						
1 11001	1.	Able to differentiate between different type of dielectrics, ferroelectrics and able to interpresent experimental results with different theoretical models.	et the					
	2.	Able to apply the concept of relaxation, resonance and dispersion in dielectrics using frequencies time domain method.	uency and					
	 Able to differentiate between different types of ferroelectric materials and able to calculate the recoverable energy efficiency from the hysteresis loop 							
	4.	Able to identify and compare different kinds of magnetic ordering.						
	5.	Able to categorize different types of multiferroics based on the different mechanisms of the origin.	eir					
Modu	le-1	Macroscopic theory of dielectrics: Polarisation in dielectrics, Clausius Mosotti relation for ideal dielectrics, Lorentz field, Debye correction to Clausius Mosotti equation, frequency and temperature dependency of dielectrics, Temperature coefficient of dielectrics, dielectric losses. The double well potential model for polarization and determination of depth of potential wells.	[10]					
Modu	le-2	Dielectric spectroscopy: introduction to impedance spectroscopy, physical models for equivalent circuit elements, dielectric relaxation in materials with single time constant, distribution of relaxation time, interface and boundary conditions, grain boundary effects. Elementary idea of measurement technique in frequency and time domain methods.						
Module-3 Ferroelectricity: Ferroelectricity, Microscopic theory of Ferroelectricity, Land of ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor k optical phonons, hysteresis loop, Recoverable energy, Piezoelectricity ar harvesting, transducer.,		Ferroelectricity: Ferroelectricity, Microscopic theory of Ferroelectricity, Landau primer of ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop, Recoverable energy, Piezoelectricity and energy harvesting, transducer.,	[10]					
Modu	le-4	Ferromagnetism: Weiss model of a ferromagnet, magnetic susceptibility, effect of a magnetic field, origin of the molecular field, Weiss model of antiferromagnet, magnetic susceptibility, effect of a strong magnetic field, types of antiferromagnetic order, ferrimagnetism, helical order, spin glasses, frustration.	[10]					

Module-5	Multiferroics: Ferroic, magnetoelectric, multiferroic, magnetodielectric, magnetoelectric coupling, Type I and Type II Multiferroics, charge-order driven multiferroicity, examples of charge-ordered driven multiferroicity, lone-pair electron multiferroic systems, geometric ferroelectricity, frustrated magnetism triggered ferroelectricity, applications of multiferroics: magnetoelectric switching, multiferroics for spintronics.	[10]
Textbo	ooks:	
1. App	blied Electromagnetism and Materials by Andre Moliton, Springer, 2007	
2. Mag	gnetism in Condensed Matter, Oxford Master Series in Condensed Matter Physics 4.	, Stephen
Blu	ndell, Oxford University Press, 2001.	
3. Mu	ltiferroic Materials: Properties, Techniques and Applications, Junling Wang, CRC Pres	s, Taylor
and	Francis group, 2017.	

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Yes
Tutorials/Assignments	Yes
Seminars	Yes
Mini projects/Projects	No
Laboratory experiments/teaching aids	No
Industrial/guest lectures	No
Industrial visits/in-plant training	No
Self- learning such as use of NPTEL materials and	Yes
internets	
Simulation	No

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

AssessmentCompoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	Yes	Yes	Yes	No	No
End Sem Examination Marks	Yes	Yes	Yes	Yes	Yes
Assignment	Yes	Yes	Yes	Yes	Yes

Indirect Assessment -

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Thupping of course once a regram outcomes										
Course Outcome #		Program Outcomes								
	а	b	с	d	e	f				
1	М	Н	Н	L	L	М				
2	L	Н	Н	L	L	М				
3	М	Н	Н	L	L	L				
4	Н	М	М	L	L	L				
5	Μ	Н	Н	Н	L	L				

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Course Objective							
	a	b	с	d	e			
1	Н	М	М	L	М			
2	М	Н	М	L	М			
3	M	М	Н	L	М			
4	L	L	L	Н	Н			
5	M	M	Μ	Н	Н			

	Mapping Between COs and Course Delivery (CD) methods								
CD	Course Delivery methods	Course Outcom	Course Delivery e Method						
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2 and CD8						
CD2	Tutorials/Assignments	CO2	CD1, CD2 and CD8						
CD3	Seminars	CO3	CD1, CD2 and CD8						
CD4	Mini projects/Projects	CO4	CD1, CD2 and CD8						
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2 and CD8						
CD6	Industrial/guest lectures								
CD7	Industrial visits/in-plant training								
CD8	Self- learning such as use of NPTEL materials and internets								
CD9	Simulation								

Week	Lect.	Tentative	Mod	Topics to be covered	Text	COs	Actual	Methodolog	Remarks
No.	No.	Date	ule		Book /	map	Content	у	by
			No.		Refere	ped	covered	used	faculty
					nces				if any
1	L1-2		Ι	Macroscopic theory of	T1	1, 2		PPT Digi	
				dielectrics: Polarisation				Class/Chalk	
				in dielectrics,				-Board	
				ClausiusMosotti relation					
				for ideal dielectrics,					
1	L3			Lorentz field, Debye	T1			PPT Digi	
				correction to				Class/Chalk	
				ClausiusMosotti				-Board	
				equation,					
1	L4-			frequency and	T1			PPT Digi	
	L5			temperature dependency				Class/Chalk	
				of dielectrics,				-Board	

2	L6		Temperature coefficient	T1	PPT Digi
			of dielectrics, dielectric		Class/Chalk
			losses.		-Board
2	L7-8		The double well	T1	PPT Digi
			potential model for		Class/Chalk
			polarization and		-Board
			determination of depth		
			of potential wells.		
4	L9-	II	Dielectric spectroscopy:	T1	PPT Digi
	10		introduction to		Class/Chalk
			impedance		-Board
			spectroscopy		
4	L11		physical models for	T1	PPT Digi
			equivalent circuit		Class/Chalk
			alamenta		Doord
5	L 10	_	dialactoria malamatian in	T1	
5	L12-		dielectric relaxation in	11	PPT Digi
	13		materials with single		Class/Chalk
			time constant,		-Board
			distribution of relaxation		
			time,		
5	L14-		interface and boundary	T1	PPT Digi
	15		conditions, grain		Class/Chalk
			boundary effects.		-Board
6	L16		Elementary idea of	T1	PPT Digi
			measurement technique		Class/Chalk
			in frequency and time		-Board
			domain methods		2000
	L17	Ш	Ferroelectricity:	T1	PPT Digi
		111	Ferroelectricity		Class/Chalk
			Microscopic theory of		Board
			Earroalastrisity		-Doard
	I 10	-	Landau primar of	T1	
			Landau primer of		PPI Digi
			C 1 4 · · ·		(1) (01) (1)
			ferroelectricity,		Class/Chalk
	X 10	_	ferroelectricity,	m1	Class/Chalk -Board
	L19		ferroelectricity, Phase transition of	T1	Class/Chalk -Board PPT Digi
	L19		ferroelectricity,Phase transition of ferroelectrics (1st, 2nd	T1	Class/Chalk -Board PPT Digi Class/Chalk
	L19	-	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind),	T1	Class/Chalk -Board PPT Digi Class/Chalk -Board
	L19 L20	-	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons,	T1 T1	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi
	L19 L20	-	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop,	T1 T1 T1	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk
	L19 L20	-	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop,	T1 T1 T1	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board
	L19 L20 L21-	-	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop, Recoverable energy,	T1 T1 T1 T1	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi
	L19 L20 L21- 24	-	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop, Recoverable energy, Piezoelectricity and	T1 T1 T1 T1	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk
	L19 L20 L21- 24	-	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop, Recoverable energy, Piezoelectricity and energy harvesting,	T1 T1 T1 T1	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board
	L19 L20 L21- 24	-	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop, Recoverable energy, Piezoelectricity and energy harvesting, transducer	T1 T1 T1 T1	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board
	L19 L20 L21- 24 L25		ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop, Recoverable energy, Piezoelectricity and energy harvesting, transducer Ferromagnetism: Weiss	T1 T1 T1 T1 T1 T2	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi
	L19 L20 L21- 24 L25	IV	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop, Recoverable energy, Piezoelectricity and energy harvesting, transducer Ferromagnetism: Weiss model of a ferromagnet	T1 T1 T1 T1 T2	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk
	L19 L20 L21- 24 L25	IV	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop, Recoverable energy, Piezoelectricity and energy harvesting, transducer Ferromagnetism: Weiss model of a ferromagnet,	T1 T1 T1 T1 T1 T2	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board
	L19 L20 L21- 24 L25	IV	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop, Recoverable energy, Piezoelectricity and energy harvesting, transducer Ferromagnetism: Weiss model of a ferromagnet,	T1 T1 T1 T1 T1 T2	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi
	L19 L20 L21- 24 L25 L26	IV	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop, Recoverable energy, Piezoelectricity and energy harvesting, transducer Ferromagnetism: Weiss model of a ferromagnet, magnetic suscentibility affect of a	T1 T1 T1 T1 T1 T2 T2	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk
	L19 L20 L21- 24 L25 L26	IV	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop, Recoverable energy, Piezoelectricity and energy harvesting, transducer Ferromagnetism: Weiss model of a ferromagnet, magnetic susceptibility,effect of a magnetic field	T1 T1 T1 T1 T2 T2	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board
	L19 L20 L21- 24 L25 L26	IV	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop, Recoverable energy, Piezoelectricity and energy harvesting, transducer Ferromagnetism: Weiss model of a ferromagnet, magnetic susceptibility,effect of a magnetic field,	T1 T1 T1 T1 T1 T2 T2	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi
	L19 L20 L21- 24 L25 L25 L26 L27	IV	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop, Recoverable energy, Piezoelectricity and energy harvesting, transducer Ferromagnetism: Weiss model of a ferromagnet, magnetic susceptibility,effect of a magnetic field, origin of the molecular	T1 T1 T1 T1 T1 T2 T2 T2	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi
	L19 L20 L21- 24 L25 L26 L27	IV	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop, Recoverable energy, Piezoelectricity and energy harvesting, transducer Ferromagnetism: Weiss model of a ferromagnet, magnetic susceptibility,effect of a magnetic field, origin of the molecular field, Weiss model of	T1	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi
	L19 L20 L21- 24 L25 L26 L27	IV	ferroelectricity, Phase transition of ferroelectrics (1 st , 2 nd and relaxor kind), soft optical phonons, hysteresis loop, Recoverable energy, Piezoelectricity and energy harvesting, transducer Ferromagnetism: Weiss model of a ferromagnet, magnetic susceptibility,effect of a magnetic field, origin of the molecular field, Weiss model of antiferromagnet,	T1 T1 T1 T1 T1 T2 T2 T2	Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board PPT Digi Class/Chalk -Board

28	effect of a magnetic field,	strong T2	PPT Digi Class/Chalk Board	
29- 30	types antiferromagneti	of T2 c order	PPT Digi Class/Chalk -Board	
L31- 32	ferrimagnetism, order, spin frustration.	helical T2 glasses,	PPT Digi Class/Chalk -Board	
L33	V Multiferroic, magnetoelectric, multiferroic,	T3	PPT Digi Class/Chalk -Board	
L34	magnetodielectri magnetoelectric coupling, Type Type II Multifer	I and roics,	PPT Digi Class/Chalk -Board	
L35	charge-order multiferroicity, examples of ordered multiferroicity,	driven T3 charge- driven	PPT Digi Class/Chalk -Board	
L36	lone-pair multiferroic syst	electron T3 ems,	PPT Digi Class/Chalk -Board	
L37- 38	geometric ferroelectricity, frustrated ma triggered ferroelectricity,	agnetism T3	PPT Digi Class/Chalk -Board	
L39- 40	applications multiferroics: magnetoelectric switching, mult for spintronics	of T3 iferroics	PPT Digi Class/Chalk -Board	

 Course code: PH 515

 Course title: Theoretical and Computational Condensed Matter Physics

 Pre-requisite(s):

 Co- requisite(s):

 Credits:
 4L: 2

 T: 0
 P:4

 Class schedule per week:

 Class: I.M.Sc.

 Semester / Level: PE VI / VII

 Branch: PHYSICS

 Name of Teacher:

 Group : B
 Option 5

Same Given As above(in Group A)

Group C-	- Photonics:						
1. Pl	'hotonic and Optoelectronic Devices 4. Introduction to Nanophotonics						
2. H	Iolography and Applications						
3. Q	Quantum photonics and applications						
COURSE INFORMATION SHEET							
Course code: PH 521							
Course ti	itle: Photonics and Ontoelectronic Devices						
Pre-reau	uisite(s):						
Co- requ	uisite(s):						
Credits:	4 L: 3 T:1 P: 0						
Class sch	nedule per week:						
Class: I.N	M.Sc.						
Semester	r / Level: VI / VII						
Branch:	PHYSICS						
Name of	Teacher:						
Grou	ip : C Option 1	I					
Code: PH	H 521 Title: Photonics and Optoelectronic Devices	L-T-P-	·C				
		[3 1	0 4]				
Course O	D bjectives This course enables the students:						
T	o explain the properties of optoelectronic material and optical processes in semiconductor						
B. To	o understand underlying principle & working of liquid crystal displays, optical modulator,	and switches.					
C. To	o understand principle & working of light sources and photodetectors.						
D To	o know the working of optical nonlinear devices and understand its significance for optical	l computing.					
E To	o acquire the knowledge of the function and working of photonic switches and interconne	cts					
Course C	Outcomes After the completion of this course, students will be:						
1. A	ble to identify suitable optoelectronic materials and explain optical phenomena occurring	in semiconductor					
2. A	ble to recognize parameters for optimizing the performance of liquid crystal displays,	optical modulator	, and				
sv	witches & solve related numerical problems.						
3. A	ble to identify the parameters for optimizing the performance of light sources and detector	. .					
4. To	o define the role of different nonlinear optical devices in optical computing.						
5. To	o select appropriate photonic switch and interconnect for different operations under different	ent working condi	tion.				
Module-	Optical processes in semiconductors: Electron-hole pair formation and recombination	tion, Direct and	10				
1	indirect bandgap semiconductors, structural property of crystalline, polycrystal	line, amorphous					
	materials, optoelectronic materials, Liquid crystals, compound semiconductors	, absorption in					
	semiconductors, Stark effects in quantum well structures, Absorption and emission s	pectra, excitonic					
	effects.						
Module-	Displays, optical modulators, and switches: Liquid crystal cells (principle), Passive a	nd Active matrix	8				
2	liquid crystal displays, Electro-optic modulator, Magneto-optic modulator, Acousto-	optic modulator.					
	Electro-absorption modulators, Mach-Zehnder Electrorefraction (Electro-optic) mod	ulators, optical					
	switches.						
Module-	Optical sources and detectors: Light emitting diodes, surface- and edge- emitting	ng configuration.	12				
3	Injection laser diodes, gain and index guided lasers, PIN and avalanche photodiodes, I	Photoconductors,					
	Phototransistors, noise in photodetector. Solar cells (spectral response, conversion effi	ciency), Charge-					
	coupled devices, Characteristics and applications.						
Module-	Optical computing: Digital optical computing: Nonlinear devices, optical bistable	devices, SEED	10				
4	devices, Optical phase conjugate devices, integrated devices, spatial light modulators	(SLM), Optical					
	Memory: Holographic data storage						
Module-	Iodule-Photonic switching and interconnects:Kerr gates, Nonlinear Directional couplers, Nonlinear optical10						

5	5	loop mirror (NOLM), Soliton logic gates, Free-space optical interconnects, wave-guide interconnects, holographic interconnections.	
1	Refer	ences ences	

- Introduction to Fiber Optics, Ghatak & Thyagarajan, Cambridge University press.
- 2.
- Optoelectronics: An Introduction to Materials and Devices, Jasprit Singh, The McGraw-Hill Companies. 3.
- 4. Semiconductor Optoelectronics Devices, P. Bhattacharya, PHI.
- 5. Optoelectronics and Photonics, principles and practices S. O. Kasap, Prentice Hall
- Photonic switching and Interconnects; Abdellatif Marrakchi, Marcel Dekker, Inc. 6.
- Optical Computing, an Introduction, Mohammad A. Karim and Abdul A. S Awwal, John Wiley & Sons Inc 7.

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	N
Laboratory experiments/teaching aids	N
Industrial/guest lectures	Ν
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and internets	Y
Simulation	Ν

Direct Assessment

Assessment Tool	% Contribution during CO Assessment				
Assignment	10				
Seminar before a commitee	10				
Three Quizes	30 (10+10+10)				
End Sem Examination Marks	50				

AssessmentCompoents	CO1	CO2	CO3	CO4	<u>CO5</u>
Quiz 1	\checkmark	\checkmark			
Quiz 2			\checkmark	\checkmark	
Mid Sem Examination Marks	\checkmark	\checkmark	\checkmark		
End Sem Examination Marks	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Assignment	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark

Indirect Assessment -

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping between Course Objectives and Course Outcomes

Course		Co	urse Ou	itcomes	
Objective	1	2	3	4	5
А	Н	Н	Н	Н	Н
В	L	Н	Μ	Μ	L
С	Μ	Н	Н	Μ	Н
D	Μ	Μ	Н	Н	Н
Е	Μ	Н	Н	Н	Н

Course Outcome	Program Outcomes						
	а	b	с	d	e	f	
1	Н	Η	Η	-	Н	М	
2	Н	Н	Η	-	Н	Н	
3	М	Η	Η	-	Н	Н	
4	М	Н	М	-	Н	Н	
5	L	Н	М	-	Н	Н	

	Mapping Between COs and Course Deliv	very (CD) metho	ds
CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2
CD2	Tutorials/Assignments	CO2	CD1
CD3	Seminars	CO3	CD1, CD2
CD4	Mini projects/Projects	CO4	CD1, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

Wee	Lect	Tentativ	Ĉh	Topics to be covered	Text	COs	Actual	Method	Remarks
1.	Leet		CII.	Toples to be covered		003	Contont	alagu	h
K	•	e	INO		BOOK /	mappe	Content	ology	by
No.	No.	Date	•		Refere	d	covered	used	faculty if
					nces				any
1	L1		1	Electron-hole pair	R3, R4,	1, 2		CD1,	
				formation and	R5			CD2	
				recombination					
	L2			Direct and indirect	R3, R4,	1		CD1,	
				bandgap	R5			CD2	
				semiconductors					
	L3			structural property of	R3, R4	1		CD1,	
				crystalline,				CD2	
				polycrystalline.					
				amorphous materials					
	I A			anto al actuaria matariala	D2 D4	1		CD1	
	L/4			optoelectronic materials	K3, K4,	1		CD1,	
					K5			CD2	
2	L5			Liquid crystals,	R3	1		CD1,	
								CD2	
	L6			compound	R4	1		CD1,	
				semiconductors				CD2	
	L7			absorption in	R3, R4,	1		CD1,	
				semiconductors	R5			CD2	
	L8			Stark effects in quantum	R3, R4,	1		CD1,	
				well structures	R5			CD2	
3	L9			Absorption and	R3, R4,	1		CD1,	
			emission spectra	R5		CD2			
---	-----	---	--------------------------	---------	------	------	--		
	L10		excitonic effects	R4	1	CD1,			
						CD2			
	L11	2	Liquid crystal cells	R3	2	CD1,			
			(principle)			CD2			
-	L12		Passive and Active	R3	2	CD1,			
			matrix liquid crystal			CD2			
			displays						
4	L13		Electro-optic modulator	R3, R4,	1,2	CD1,			
			1	R5	-	CD2			
	L4		Magneto-optic	R3, R4,	1,2	CD1,			
			modulator	R5		CD2			
	L15		Acousto-optic	R3, R4,	1,2	CD1,			
			modulator	R5		CD2			
	L16		Electro-absorption	R3, R4,	1,2	CD1,			
	_		modulators	R5	,	CD2			
5	L17		Mach-Zehnder	R3. R4.	1.2	CD1.			
C			Electrorefraction	R5	-,-	CD2			
			(Electro-optic)	-					
			modulators						
-	L18	-	ontical switches	R4	1.2	CD1			
	210		optical switches		-,-	CD2			
	L19	3	Light emitting diodes	R3. R4.	1.3	CD1.			
		-	Light entitting aroues	R5	- ,-	CD2			
	L20		Surface- emitting	R3, R4,	1,3	CD1,			
			configuration	R5	,	CD2			
6	L21		edge- emitting	R3, R4,	1,3	CD1,			
			configuration	R5		CD2			
	L22		Injection laser diodes	R3, R4,	1.3	CD1,			
			5	R5	,	CD2			
	L23		gain and index guided	R3, R4,	1,3	CD1,			
			lasers	R5		CD2			
	L24		PIN photodiodes	R3, R4,	1,3	CD1,			
			1	R5		CD2			
7	L25		Avalanche photodiodes	R3, R4,	1,3	CD1,			
				R5		CD2			
	L26		Photoconductors	R3, R4,	1,3	CD1,			
				R5		CD2			
	L27		Phototransistors	R3, R4,	1,3	CD1,			
				R5		CD2			
	L28		Noise in photodetector	R3, R4,	1,3	CD1,			
				R5		CD2			
8	L29		Solar cells (spectral	R3, R4,	1,3	CD1,			
			response, conversion	R5		CD2			
	ļ		efficiency)						
	L30		Charge-coupled	R3, R4,	1,3	CD1,			
			devices, Characteristics	R5		CD2			
			and applications						
	L31	4	Digital optical	R6, R7	3,4	CD1,			
			computing			CD8			
9	L32		Nonlinear devices	R4, R6	3,4	CD1,			
						CD8			

	L33		optical bistable devices	R4	3,4	CD1, CD8
	L34		SEED devices	R4	3,4	CD1, CD8
	L35		Optical phase conjugate devices	R6, R7	3,4	CD1, CD8
10	L36 - L37		integrated devices	R6, R7	3,4	CD1, CD8
	L38 - L39		spatial light modulators (SLM)	R6, R7	3,4	CD1, CD8
	L40		Optical Memory: Holographic data storage	R6, R7	4,5	CD1, CD8
11	L41	5	Kerr gates	R4, R6, R7	4,5	CD1, CD8
	L42 - L43		Nonlinear Directional couplers	R6, R7	4,5	CD1, CD8
	L44		Nonlinear optical loop mirror (NOLM)	R6, R7	4,5	CD1, CD8
12	L45		Soliton logic gates	R6, R7	4,5	CD1, CD8
	L46 - L47		Free-space optical interconnects	R6, R7	4,5	CD1, CD8
13	L48 - L49		wave-guide interconnects	R6, R7	4,5	CD1, CD8
	L50		holographic inteconnections	R6, R7	4,5	CD1, CD8

Course code: PH 522 Course title: Holography and Applications Pre-requisite(s): Co- requisite(s): Credits: 4 L: 3 T:1 P: 0 Class schedule per week: Class: I.M.Sc. Semester / Level: VI / VII Branch: PHYSICS Name of Teacher: Group : C Option 2

Code:		Title: Holography and Applications	L-T-J	P-C
PH 52	2		[0] 1	0 41
			[3] [0 4]
Cour	se Ob	jectives This course enables the students:		
			1	
	A.	To understand the basics of holograms and able to differentiate between holography and		
	D	photography The service the largest largest for the largest field and the largest field	-	
	B.	To acquire the knowledge of different types of holograms.	-	
	C.	To understand different materials used for hologram recordings and its merits and demerits.	-	
	D.	To have an idea of using holographic technique in varieties of diverse applications	-	
	E	To acquire knowledge in holographic optical elements and to estimate how these optical		
C		elements can be utilized.]	
Cour		Attest the completion of this course, students will be:	1	
	1.	Able to identify the parameters which differentiate holograms from photographs	-	
	2.	Able to distinguish between various types of holograms.	-	
	3.	Able to analyze the different parameters of holographic recording materials.	-	
	4.	Able to utilize holographic interferometric technique in various new applications	-	
	5.	Able to experiment with holographic elements for various applications.		
Modu	ıle-1	Basics of Holography: Principle of Holography. Recording and Reconstruction Method. Theo	ry of	[10]
		Holography as Interference between two Plane Waves. Point source holograms, In line Holog	gram,	
		off axis hologram, Fourier Hologram, Lenses Fourier Hologram, Image Hologram, Fraunl	hofer	
		Hologram. Holographic interferometer, double exposure hologram, real-time holography, d	igital	
		holography, holographic camera.	C	
Modu	ıle-2	Theory of Hologram: Coupled wave theory, Thin Hologram, Volume Hologram, Transmi	ssion	[8]
		Hologram, Reflection Hologram, Anomalous Effect.		
Modu	ıle-3	Recording Medium: Microscopic Characteristics, Modulation transfer function, Diffra	ction	[13]
		efficiencies, Image Resolution, Nonlinearities, S/N ratio, Silver halide emulsion, Dichron	nated	
		gelatin, Photoresist, Photochrometics, Photothermoplastics, photorefractive crystals.		
Modu	ıle-4	Applications: Microscopy, interferometry, NDT of engineering objects, particle sizing, hologra	aphic	[13]
		particle image velocimetry; imaging through aberrated media, phase amplification by hologra	aphy:	
		Optical testing; Information storage.	1 .	
Modi	ıle-5	Holographic Optical Elements (HOE): multifunction, holographic lenses, holographic m	irror.	[8]
		holographic beam splitters, polarizing, diffuser, interconnects, couplers, scanners; Optical	data	[-]
		processing, holographic solar connectors; antireflection coating, holophotoelasticity;		
Т	ext b	poks:	I	
T	1: Op	ical Holography. Principle Techniques and applications: P. Hariharan, Cambridge University	v Press	3
Т	2:	Holographic Recording materials: H M Smith Springer Verlag		-
I		notographie recording materials, rationnal, opiniger vehag		
R	efere	nce books: R1: Lasers and Holography P C Mehta and V V Rampal, World Scientific		

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP	Y
projectors	
Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	Ν
Laboratory experiments/teaching aids	Ν
Industrial/guest lectures	Ν
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and	Y
internets	
Simulation	Ν

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks					
End Sem Examination Marks					
Quiz I					
Quiz II			\checkmark	\checkmark	

Indirect Assessment -

- 1. Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

<u>Mapping between Objectives and Outcomes</u> Mapping between Course Objectives and Course Outcomes

···· 8····· 9····· 9····· 1								
Course Objectives	1	2	3	4	5			
Α	Н	Μ	L	Η				
В	Н	Η	Μ	Μ	L			
С	Н	Η	Η	Μ	Μ			
D		Μ	Μ	Н	Η			
Е	L	Μ	Μ	Н	Н			

Course		Program Outcomes								
Outcome #	а	b	с	d	e	f				
1	М	Н	Н		L	Н				

2	М	Н	М		М	Н
3	М	Н	Н	L	L	М
4	М	М	Н	L	Н	М
5	М	М	М	L	Н	Н

	Mapping Between COs and Course Delivery (CD) methods								
CD	Course Delivery methods	Course	Course Deliver						
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1 and CD2						
CD2	Tutorials/Assignments	CO2	CD1 and CD2						
CD3	Seminars	CO3	CD1 and CD2						
CD4	Mini projects/Projects	CO4	CD1 and CD2						
CD5	Laboratory experiments/teaching aids	CO5	CD1 and CD2						
CD6	Industrial/guest lectures								
CD7	Industrial visits/in-plant training								
	Self- learning such as use of NPTEL materials and								
CD8	internets								
CD9	Simulation								

Week	Lect.	Fentative	Ch.	Fopics to be covered	Гext	Cos	Actual	Methodol	Remarks	by
No.	No.	Date	No		Book /	mapped	Content	ogy used	faculty if any	
					Refere		covered			
					nces					
1	L1-			Principle of Holography.	T1, R1	CO1		PPT Digi		
	L2			Recording and				Class/Ch		
				Reconstruction Method.				ock-		
				Theory of Holography				Board		
				as Interference between						
				two Plane Waves						
	L3-			Point source holograms,	T1, R1	CO1		PPT Digi		
	L6			In line Hologram, off				Class/Ch		
				axis hologram, Fourier				ock-		
				Hologram, Lenses				Board		
				Fourier Hologram,						
				Image Hologram						
	L7-			Fraunhofer Hologram.	T1, R1	CO1		PPT Digi		
	L10			Holographic				Class/Ch		
				interferometer, double				ock-oard		
				exposure hologram,						
				real-time holography,						
				digital holography						
	L11-			Theory of Hologram:	T1, R1	CO2		PPT Digi		
	L14			Coupled wave theory,				Class/Ch		
				Thin Hologram, Volume				ock-		
				Hologram				Board		
	L15-			Transmission Hologram,	T1, R1	CO2		PPT Digi		
								Class/Ch		

	L18	Reflection Hologram,			ock-	
		Anomalous Effect.			Board	
	L19-	Recording Medium:	T2, R1	CO3	PPT Digi	
	L22	Microscopic			Class/Ch	
		Characteristics,			ock-	
		Modulation transfer			Board	
		function, Diffraction				
		efficiencies,				
	L23-	Image Resolution,	T2, R1	CO3	PPT Digi	
	L26	Nonlinearities, S/N			Class/Ch	
		ratio, Silver halide			ock-	
		emulsion			Board	
	L27-	Dichromated gelatin,	T2, R1	CO3	PPT Digi	
	L31	Photoresist,			Class/Ch	
		Photochrometics,			ock-	
		Photothermoplastics.			Board	
		photorefractive crystals.				
	L32-	Applications:	T1, R1	CO4	PPT Digi	
	L35	Microscopy.	,		Class/Ch	
		interferometry, NDT of			ock-oard	
		engineering objects.				
		particle sizing.				
	L36-	holographic particle	T1. R1	CO4	PPT Digi	
	L39	image velocimetry:	,		Class/Ch	
		imaging through			ock-	
		aberrated media			Board	
	L40-	phase amplification by	T1. R1	CO4	PPT Digi	
	L44	holography: Optical	,		Class/Ch	
		testing: Information			ock-oard	
		storage				
	L45-	Holographic Optical	T1. R1	CO5	PPT Digi	
	L46	Elements (HOE):	,		Class/Ch	
		multifunction.			ock-	
		holographic lenses.			Board	
		holographic mirror				
	I 47-	holographic beam	T1 R1	CO5	PPT Digi	
	L50	splitters polarizing	11,111	000	Class/Ch	
	250	diffuser interconnects			ock-	
		couplers scanners			Board	
<u> </u>	L51-	Ontical data processing	T1 R1	CO5	PPT Digi	
1	L51	holographic solar	11,111		Class/Ch	
	1.52	connectors:			ock-	
		antireflection coating			Board	
1		holophotoelasticity				
1		nonophotociasticity				1

Course code: PH 523 Course title: Quantum photonics and applications Pre-requisite(s): **Co- requisite(s): Credits:** P: 0 4 L: 3 T: 1 **Class schedule per week:** Class: I.M.Sc. Semester / Level: VI / VII **Branch: PHYSICS** Name of Teacher: **Group** : C

Option 3

Code: PH 523		Title: Quantum photonics and applications	L-T-P	-C		
			[3 1	0 4]		
Cours	e Obje	tives :This course enables the students:				
	А.	To assess light-matter interaction at the nanoscale (1-100 nm) in terms of photon statistics for of single photon sources.	· identif	ication		
	В.	To Identify various plasmonic nanoantenna (nanoparticles, nanorods) for enhanced el interaction	ectroma	agnetic		
	C.	C. To identify a source of single photons and discuss a method to detect the single photons efficiently.				
	D.	To design chip scale devices for propagation of single photons for quantum communications				
	E	To assess the present status and future applications of single photons in quantum technologies and the status and future applications of single photons in quantum technologies.	ogy			

Course Outcomes : After the completion of this course, students will be

	1.	Able to identify semiconducting quantum dot as a single photon source.							
:	2.	To develop skills of designing a suitable metal nanoantenna for enhanced light-matter interaction, thus making single photon source faster and brighter.							
	3.	To characterize (theoretically) whether a given source of the photon, is a single photon source.							
'	4.	To design (theoretically) photonic circuits for the propagation of single photons on semiconductor and metallic platform.							
	5.	To understand the modern and future scope of quantum communication.							
Module	e-1	Classical optical communications and their limitations, quantum optical communications, Semiconducting quantum dots, quantum dot single photon sources, classification of light states and photon statistics. Photon detection and correlation function.Single-Photon Pulses and Indistinguishability of Photons.	12						
Module	e-2	Plasmonic nanoantennas, fabrications, characterizations and applications in quantum communications devices	8						
Module	e-3	Single photon sources for quantum information: Fabrication and characterizations, Han burry Brown and Twiss measurements (single photons characterization), The Hong–Ou–Mandel effect (indistinguishability test).	12						
Module	e-4	Resonant excitation of single photon sources, Integrated quantum photonic circuits and devices, semiconductor, metallic platform, single photon filtering and multiplexing.	8						
Module-5 Principles of quantum key distribution (QKD), Implementing QKD, Fiber-based QKD, Free-space QKD, Diamond-based single-photon sources and their application in quantum key distribution, Quantum repeaters									
Ref	Reference:								
1.	1. Michler, P. (Ed.). (2009). Single semiconductor quantum dots (Vol. 28). Berlin: Springer.								
2.	2. Novotny, L. & Hecht, B., Principles of nano-optics, Cambridge university press, 2006								

- 3. Lounis, B., &Orrit, M. (2005). Single-photon sources. Reports on Progress in Physics, 68(5), 1129.
- 4. Prawer, Steven, and Igor Aharonovich, eds. Quantum information processing with diamond: Principles and applications. Elsevier, 2014.
- 5. Briegel , H.-J. , Dürr , W. , Cirac , J. I. and Zoller , P. (1998) ' Quantum repeaters: The role of imperfect local operations in quantum communication ', Phys Rev Lett, 81, 5932 - 5935,

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP	Y
projectors	

Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	Ν
Laboratory experiments/teaching aids	Ν
Industrial/guest lectures	Ν
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and	Y
internets	
Simulation	Ν

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	\checkmark	\checkmark			
End Sem Examination Marks	\checkmark	\checkmark			\checkmark
Quiz I				\checkmark	
Quiz II				\checkmark	\checkmark

Indirect Assessment -

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4	5
Α	Н	Μ	М	L	М
В	М	Н	М	L	L
С	L	L	Н	L	L
D	-	L	L	Η	L
Е	L	Μ	L	L	Н

Course Outcome #	Program Outcomes						
	а	b	с	d	e	f	
1	Н	Н	Н	Н	L	Н	
2	Н	Н	Н	Н	М	Н	
3	Н	Н	Н	М	L	М	
4	Н	М	Н	Н	L	М	
5	М	Н	Н	Н	Н	Н	

	Mapping Between COs and Course Delivery (CD) methods							
CD	Course Delivery methods		Course	Course Delivery				
			Outcome	Method				
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1 and CD2				
CD2	Tutorials/Assignments		CO2	CD1 and CD2				
CD3	Seminars		CO3	CD1 and CD2				
CD4	Mini projects/Projects		CO4	CD1 and CD2				
CD5	Laboratory experiments/teaching aids		CO5	CD1 and CD2				
CD6	Industrial/guest lectures		-	-				
CD7	Industrial visits/in-plant training		-	-				
	Self- learning such as use of NPTEL materials and							
CD8	internets		-	-				
CD9	Simulation		-	-				

Week No.	Lect. No.	Tentati ve Date	Ch. No.	Topics to be covered	Text Book / Refere	COs mapped	Actual Content covered	Methodolo gy used	Remarks by faculty if
1	L1-L2		1	Classical optical communications and their limitations, quantum optical communications	T1, T2,	1,2		PPT Digi Class/ Chock -Board	
	L3-L7			Semiconducting quantum dots, quantum dot single photon sources,		1,		Digi Class/ Chock -Board	
	L8-L10			classification of light states and photon statistics		1,2		Digi Class/Ch ock -Board	
	L11- L12			Photondetectionandcorrelationfunction.Single-PhotonPulsesandIndistinguishabilityofPhotons		1,2,3		Digi Class/Ch ock- Board	
	L13- L20			Plasmonic nanoantennas, fabrications, characterizations and applications in quantum communications devices.		1,2		DigiClass /Chock -Board	
	L21- L32			Single photon sources for quantum information: Fabrication and characterizations, Han burry Brown and Twiss measurements (single photons characterization), The Hong–Ou–Mandel effect (indistinguishability		1		Digi Class/Ch ock -Board	

	test).		
L33- L40	Resonant excitation of single photon sources, Integrated quantum photonic circuits and devices, semiconductor, metallic platform, single photon filtering and multiplexing.	2	Digi Class/Ch ock -Board
L41- L50	Principles of quantum key distribution (QKD), Implementing QKD, Fiber-based QKD, Free- space QKD, Diamond- based single-photon sources and their application in quantum key distribution, Quantum repeaters	3	Digi Class/Ch ock -Board

Course	code: PH 524	
Course	title: Introduction to Nanophotonics	
Pre-requ	uisite(s):	
Co- requ	uisite(s):	
Credits:	4 L: 3 T: 1 P: 0	
Class sc	hedule per week:	
Class: L	M.Sc.	
Semeste	r / Level· VI / VII	
Branch	PHVSICS	
Nomo of	Tanahari	
Crown (Continu 4	
Group		
Code:	L-I-P-C	
PH 524		
Course	Objective: Course enables the students:	
Α	To identify optical phenomenon and tools to understand physics at nanoscales.	
В.	To evaluate different quantum systems in zero, one, two and three-dimensional system at the nanoscale.	
C.	To discuss photonic crystals and manifestation of nonlinear optical interactions with it.	
D	To discuss different types of microstructure fibres and photonic crystal fibre devices.	
F	To identify the manifestation of optical interaction with metallic nanostructures and nanophotonic devices	
	like microcavity and waveguides	
Course	Outcomes • After the completion of this course, students will be:	
	To solve problems of optical confinement at paposcales	
1.	To solve problems of optical commence at nanoscales.	
2.	To evaluate light-matter interaction in Nano-systems (quantum dots, well etc).	
3.	To design theoretical models for photomic crystals. The line $(1 - 1)$ is the second	
4.	To design (theoretically) different types of microstructure fibres and photonic crystal fibre devices	
Э.	To assess the field enhancement in metal nanoparticles and its application in surface plasmon waveguide	s.
	Further he/she will be able to apply knowledge of light confinement in microcavity for microcavity laser	s.
Module-1	Foundations for Nanophotonics: similarities and differences of photons and electrons and their	10
	confinement. Propagation through a classically forbidden zone: tunnelling. Localization under a	
	periodic potential: Band gap. Cooperative effects for photons and electrons. Nanoscale optical	
	interactions, axial and lateral nanoscopic localization, scanning near-field optical microscopy.	
	Nanoscale confinement of electronic interactions: Quantum confinement effects, nanoscale	
	interaction dynamics, nanoscale electronic energy transfer. Cooperative emissions	
Module-2	Quantum wells, quantum wired, quantum dots, quantum rings and superlattices. Quantum	10
	confinement, density of states, optical properties. Quantum confined stark effect. Dielectric	
	confinement effect. Core-shell quantum dots and quantum-dot-quantum wells. Quantum confined	
	structures as lasing media. Organic quantum-confined structures	
Module-3	Photonic Crystals: basics concepts, features of photonic crystals, wave propagation, photonic band-	12
	gaps light guiding Theoretical modeling of photonic crystals Methods of fabrication Photonic	
	crystal ontical circuitry Nonlinear photonic crystals Applications of photonic crystals	
	Microstructure fibers: photonic crystal fiber (PCF) photonic hand gap fibers (PBG) hand gap	
	guiding single mode and multi-mode dispersion engineering nonlinearity engineering PCE devices	
	guiding, single mode and multi-mode, dispersion engineering, noninicarity engineering, i er devices.	
Module_4	Plasmonics: Metallic nanonarticles, nanorods and nanoshells, local field enhancement. Collective	8
viouuic-+	modes in papoparticle arrays, particle chains and arrays, surface plasmons, plasmon waveguides	0
	Applications of metallic Manastructures	
Modula 5	Applications of instance manosulucines	10
viouule-5	diodos Eurodomontolo of Covity OED, strong and much covity quantum well fasters and light emitting	10
	diodes, Fundamentals of Cavity QED, strong and weak coupling regime, Purceil factor, Spontaneous	
	emission control, Application of microcavities, including low threshold lasers, resonant cavity LED.	
	Microcavity-based single photon sources.	
Refe	rences:	
T1. N	vanophotonics, Paras N Prasad, John Wiley & Sons (2004)	
T2.	Fundamentals of Photonic Crystal Fibers; Fredric Zolla- Imperial College Press.	
T3. F	hotonic Crystals; John D Joannopoulos, Princeton University Press.	

T4 Photonic Crystals: Modelling Flow of Light; John D Joannopoulos, R.D. Meade and J.N.Winn, Princeton University Press (1995)

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP	Y
projectors	
Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	Ν
Laboratory experiments/teaching aids	Ν
Industrial/guest lectures	Ν
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and	Y
internets	
Simulation	Ν

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	\checkmark	\checkmark	\checkmark		
End Sem Examination Marks	\checkmark	\checkmark	\checkmark	\checkmark	
Quiz I			\checkmark	\checkmark	
Quiz II					

Indirect Assessment -

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4	5
Α	Н	Μ	Μ	L	М
В	Μ	Η	Μ	L	L
С	L	L	Н	L	L
D	-	L	L	Η	L
Е	L	Μ	L	L	Н

Course Outcome #		Program Outcomes				
	а	b	с	d	e	f
1	Н	Н	Н	Н	L	Н

2	Н	Н	Н	Н	М	Н
3	Н	Н	Н	М	L	М
4	Н	М	Н	Н	L	М
5	М	Н	Η	Н	Н	Η

	Mapping Between COs and Course Delivery (CD) methods						
CD	Course Delivery methods		Course Outcome	Course Delivery Method			
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1 and CD2			
CD2	Tutorials/Assignments		CO2	CD1 and CD2			
CD3	Seminars		CO3	CD1 and CD2			
CD4	Mini projects/Projects		CO4	CD1 and CD2			
CD5	Laboratory experiments/teaching aids		CO5	CD1 and CD2			
CD6	Industrial/guest lectures		-	-			
CD7	Industrial visits/in-plant training		-	-			
	Self- learning such as use of NPTEL materials and						
CD8	internets		-	-			
CD9	Simulation		_	-			

Week	Lect.	Tentati	Ch.	Topics to be covered	Text	COs	Actual	Methodo	Remarks
No.	No.	ve	No	-	Book /	mappe	Content	logy	by
		Date			Refere	d	covered	used	faculty if
					nces				anv
1	L1-L4		1	Foundations for	T1. T2.	1.2		PPT Digi	
				Nanophotonics:	, ,	,		Class/Ch	
				similarities and				ock	
				differences of photons				-Board	
				and electrons and their				2000	
				confinement.					
				Propagation through a					
				classically forbidden					
				zone: tunneling.					
				Localization under a					
				periodic potential:					
				Band gap.					
	L3-L7			Cooperative effects for		1,		Digi	
				photons and electrons.				Class/Ch	
				Nanoscale optical				ock	
				interactions, axial and				-Board	
				lateral nanoscopic					
				localization, scanning					
				near-field optical					
	10110			microscopy.		1.0		D' '	
	L8-L10			Nanoscale confinement		1,2		Digi	
				oi electronic				Class/Ch	
				interactions: Quantum				ock	
				commement effects,				-Board	
				nanoscale interaction					
				dynamics, nanoscale					

	electronic energy		
	transfer. Cooperative		
	emissions		
		1.0.0	D' '
LII-LI2	Quantum wens,	1,2,3	Digi
	quantum wired,		Class/Ch
	quantum dots,		ock
	quantum rings and		-Board
	superlattices Quantum		Dourd
	confinament density		
	commentent, density		
	of states, optical		
	properties		
L13-L15	Quantum confined stark	1,2	Digi
	effect. Dielectric		Class/Ch
	confinement effect		ock
	Core shell quantum		
	data and mantan dat		-Board
	dots and quantum-dot-		
	quantum wells.		
L16-L20	Quantum confined	3	Digi
	structures as lasing		Class/Ch
	media. Organic		ock
	auantum-confined		Deced
	quantum-commed		-Board
	structures		
L21-L25	Photonic Crystals:	3	Digi
	basics concepts,		Class/Ch
	features of photonic		ock
	crystals, wave		-Board
	propagation photonic		Board
	band gang light		
	band-gaps, light		
	guiding. Theoretical		
	modeling of photonic		
	crystals. Methods of		
	fabrication		
I 26-I 30	Photonic crystal ontical	3	
E20 E50	circuitry Nonlineer	5	
	cheunty. Nominear		
	photonic crystais.		
	Applications of		
	photonic crystals.		
	Microstructure fibers:		
	photonic crystal fiber		
	(PCF) photonic hand		
	(i ci); photoine band		
	gap fibers (FDO), ballu		
	gap		
	guiding, single mode		
	and multi-mode,		
	dispersion		
	engineering		
	nonlineerity		
	engineering, PCF		
	devices		
L31-L35	Plasmonics: Metallic	4	
	nanoparticles,		
	nanorods and		
	nanoshells local field		
	anhoncomont		
	ennancement.		
	Collective modes in		
	nanoparticle arrays,		
	particle chains and		
	arrays surface		
	nlaemone plaemon		
	prasmons, prasmon		

	waveguides. Applications of metallic Nanostructures		
L36-L50	Nanophotonic Devices:Quantum well lasers:resonantcavityquantum well lasersand light emittingdiodes, Fundamentalsof Cavity QED, strongand weak couplingregime, Purcell factor,Spontaneous emissioncontrol, Application ofmicrocavities,includinglowthresholdlasers,resonantcavity-basedsingle photon sources.	5	

Group D- Electronics:

1. Microprocessor and Microcontroller Applications

2. Integrated Electronics

3. Microwave Electronics

COURSE INFORMATION SHEET

Course code: I	PH 525			
Course title: M	licroprocessor	and Mic	rocontroller	Applications
Pre-requisite(s	s):			
Co- requisite(s	s):			
Credits:	4 L: 3 T: 1	P: 0		
Class schedule	per week:			
Class: I.M.Sc.	-			
Semester / Lev	el:PE VI / VII			
Branch: PHYS	SICS			
Name of Teach	ner:			
Group : D			Option 1	

Code: PH 52	Title:MicroprocessorandMicrocontrollerL-T-P-CApplications3-1-0-4					
Course Ol	ojectives					
This course	enables the students:					
А.	The first module introduces architecture of 8085 and 8086 Microprocessor.					
В.	The module-2 is compilation of information about I/O communication Interface.					
C.	Microcontrollers (8051), its architecture and working is subject of module-3					
D.	The 4 th module contains Real time control sequences and programming of 8051- microcontroller.					
E.	The AVR RISC microcontroller architecture is covered in module-5.					

Course Outcomes

After the completion of this course, students will be:

1.	e course intends to impart knowledge of Microprocessors and microcontrollers to enable learners							
	the knowledge of basics of Modern computation.							
2.	Knowledge of 8085/8086 architecture would make learners rich about working and	design of						
	microprocessors and microcontrollers.							
3.	The course also includes information about microcontrollers, real time control of 8051 and A	AVR RISC						
	microcontroller architecture. This would enable learners to understand fundam	entals of						
	microcontrollers and implement it to design / use microcontroller for new environments.							
N 1 1 1		F1 73						
Module-1	8086 Architecture [15]							
	Introduction to 8085 Microprocessor, 8086 Architecture-Functional diagram.							
	Register Organization, Memory Segmentation. Programming Mode!. Memory							
	addresses. Physical memory organization. Architecture of 8086, signal descriptions							

	-					
	of 8086-common function signals. Minimum and Maximum mode signals. Timing					
	diagrams. Interrupts of 8086. Instruction Set and Assembly Language Programming					
	of 8086: Instruction formats, addressing modes, instruction set, assembler directives,					
	macros, simple programs involving logical, branch and call instructions, sorting,					
	evaluating arithmetic expressions, string manipulations.					
Module-2	I/O and Communication Interface:	[14]				
	8255 PPI various modes of operation and interfacing to 8086. Interfacing keyboard,					
	display, stepper motor interfacing, D/A and A/D converter. Memory interfacing to					
	8086. Interrupt structure of 8086. Vector interrupt table. Interrupt service routine.					
	Introduction to DOS and BIOS interrupts. Interfacing Interrupt Controller 8259					
	DMA Controller 8257 to 8086 Communication interface: Serial communication					
	standards Serial data transfer schemes 8251 USART architecture and interfacing					
	RS-232 IFFE-4-88 Prototyping and trouble shooting					
Module-3	Introduction to Microcontrollers: Overview of 8051 microcontroller. Architecture	[6]				
Widdule-5	I/O Ports Memory organization addressing modes and instruction set of 8051	[0]				
	simple program					
Modulo 4	8051 Deal Time Control: Interrupts timer/ Counter and sorial communication	[7]				
Module-4	busin Real Time Control. Interrupts, timer Counter and serial communication,	[/]				
	programming limer interrupts, programming external hardware interrupts,					
	programming the serial communication interrupts, programming 8051 timers and					
		[7]				
Module-5	The AVR RISC microcontroller architecture: Introduction, AVR Family	[/]				
	architecture, Register File, The ALU. Memory access and Instruction execution. I/O					
	memory. EEPROM. I/O ports. Timers. UART. Interrupt Structure					
TEXT BOOKS): 					
1 D. V. H	Iall. Micro processors and Interfacing, TMGH. 2'1 edition 2006.					
2 Kennet	h. J. Ayala. The 8051 microcontroller, 3rd edition, Cengage learning, 2010					
REFERENCE	BOOKS:					
1 Advanced Microprocessors and Peripherals -A. K. Ray and K.M. Bhurchandani, TMH, 2nd edition						
2 The 80	051 Microcontrollers, Architecture and programming and Applications -K.Uma	Rao, Andhe				
Pallavi,	"Pearson, 2009.					
2 11		1 1 0 1				

3 Micro Computer System 8086/8088 Family Architecture. Programming and Design -By Liu and GA Gibson, PHI, 2nd Ed.,

4 Microcontrollers and application, Ajay. V. Deshmukh, TMGH. 2005

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	N
Mini projects/Projects	N
Laboratory experiments/teaching aids	N
Industrial/guest lectures	N
Industrial visits/in-plant training	N
Self- learning such as use of NPTEL materials and internets	Y
Simulation	N

Course Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks		\checkmark	\checkmark		
End Sem Examination Marks		\checkmark			\checkmark
Quiz I		\checkmark			
Quiz II			\checkmark	\checkmark	

Indirect Assessment –

1. Student Feedback on Faculty

Student Feedback on Course Outcome 2.

<u>Mapping between Objectives and Outcomes</u> Mapping between Course Objectives and Course Outcomes

Course Objectives	Course Outcomes				
	1	2	3	4	5
Α	Н	Μ	Μ	L	Η
В	М	Н	Μ	Μ	Η
С	L	L	Н	М	L
D	М	L	L	Η	Н
Е	Н	Μ	L	L	Η

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #		Program Outcomes					
	a	b	с	d	e	f	
1	Н	М	Н	М	М	М	
2	L	Η	Η	М	Η	Н	
3	Н	L	М	М	L	М	
4	L	М	Η	М	М	М	
5	L	Η	Н	М	Η	Η	

	Mapping Between COs and Course Delivery (CD) methods							
			Course	Course Delivery				
CD	Course Delivery methods		Outcome	Method				
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1 and CD2				
CD2	Tutorials/Assignments		CO2	CD1 and CD2				
CD3	Seminars		CO3	CD1 and CD2				
CD4	Mini projects/Projects		CO4	CD1, CD2 and CD8				
CD5	Laboratory experiments/teaching aids		CO5	CD1, CD2 and CD8				
CD6	Industrial/guest lectures		-	-				
CD7	Industrial visits/in-plant training		-	-				
CD8	Self- learning such as use of NPTEL materials and internets		-	-				
CD9	Simulation		-	-				

Week	Lect.	Fentative	Ch.	Fopics to be covered	Гext	Cos	Actual	Methodol	Remarks
	No.	Date			Book /	mappe	Content	ogy used	by
No.			No.		Refere	d	covered		faculty if

				nces			any
1	L1- L2	1	Introductionto8085Microprocessor,8086Architecture-Functionaldiagram.	T1, R3	CO1	CD1, CD2	
	L3- L5		RegisterOrganization,MemorySegmentation.Programming Model	T1,R3	CO1	CD1, CD2	
2	L6		Memory addresses. Physical memory organization.	T1,R3	CO1	CD1, CD2	
	L7-8		Architecture of 8086, signal descriptions of 8086- common function signals. Minimum and Maximum mode signals.	T1, R3	CO1	CD1, CD2	
3	L9		Timing diagrams. Interrupts of 8086.	T1, R3	CO1	CD1, CD2	
	L10- 11		Instruction Set and Assembly Language Programming of 8086: Instruction formats, addressing modes, instruction set, assembler directives,	T1, R3	CO1	CD1, CD2	
4	L12- 13		macros, simple programs involving logical, branch and call instructions, sorting,	T1, R3	CO1	CD1, CD2	
	L14- 15		evaluating arithmetic expressions, string manipulations.	T1, R3	CO1	CD1, CD2	
5	L16	2	8255 PPI various modes of operation and interfacing to 8086	T2	CO2	CD1, CD2	
	L17- 18		Interfacing keyboard, display, stepper motor interfacing, D/A and A/D converter.	T2	CO2	CD1, CD2	
6	L19- 20		Memory interfacing to 8086, Interrupt structure of 8086, Vector interrupt table, Interrupt service routine,	T2	CO2	CD1, CD2	
	L21- 22		Introduction to DOS and BIOS interrupts, Interfacing Interrupt Controller 8259 DMA Controller 8257 to 8086.	T2	CO2	CD1, CD2	
7	L23- 25		Communication interface: Serial	T2	CO2	CD1, CD2	

		 -					
			communication standards,				
			Serial data transfer schemes.				
	L26-		8251 USART architecture	T2	CO2	CD1,	
	27		and interfacing, RS-232,			CD2	
			IEEE-4-88,				
8	L28-		Prototyping and trouble	T2	CO2	CD1,	
	29		shooting			CD2	
	L30-	3	Overview of 8051	T2	CO3	CD1,	
	31		microcontroller.			CD2	
			Architecture.				
9	L32-		I/O Ports. Memory	T2	CO3	CD1,	
	33		organization,			CD2	
	L33-		addressing modes and	T2	CO3	CD1,	
	L34		instruction set of 8051,			CD2	
	L35		simple program	T2	CO3	CD1,	
						CD2	
10	L36-	4	Interrupts, timer/ Counter	T2, R2	CO4	CD1,	
	37		and serial communication,			CD2	
	L38-		programming Timer	T2, R2	CO4	CD1,	
	39		Interrupts, programming external hardware interrupts			CD2	
11	L40-		programming the serial	T2, R2	CO4	CD1.	
	41		communication interrupts			CD2	
	L42		programming 8051 timers	T2, R2	CO4	CD1,	
			and counters	, ,		CD2, and	
						CD8	
	L43	5	Introduction	R4	CO5	CD1,	
						CD2, and	
						CD8	
	L44-		AVR Family architecture,	R4	CO5	CD1,	
	45		Register File, The ALU.			CD2, and	
						CD8	
12	L46-		Memory access and	R4	CO5	CD1,	
	47		Instruction execution.			CD2, and	
						CD8	
	L48-	1	Timers. UART. Interrupt	R4	CO5	CD1,	
	49		Structure			CD2, and	
						CD8	

Course code: PH 526 Course title: Integrated Electronics Pre-requisite(s): Co- requisite(s): Credits: 4 L: 3 T:1 P: 0 Class schedule per week: Class: I.M.Sc. Semester / Level: PE VI / VII Branch: PHYSICS Name of Teacher: Group : D

Option 2

Code:	Title: Integrated Electronics	L-T-P-C						
PH 526	3-1-0-4							
Course Objec	tives							
This course ena	bles the students:							
А.	First module of the course contains information about various type of circuitry to achieve logic processing for digital devices.							
В.	The second module of the course would introduce the learners t being followed in foundry for fabrication of Integrated devices.	to the processes currently						
C.	The learners should explain different nanoscale devices.							
D.	The working and construction of nanoscale electronic devices is planned to be covered in Module-4.							
E.	The final module, module-5 contains an account of functional thin films, nanostructures and their applications. Information contained in this module bridges ongoing research with the course taught.							

Course Outcomes

After the completion of this course, students will be:

	1.	This course would introduce students about designing and making process of integrated devices.						
-	2.	The various fabrication process taught in module-II would enrich their knowledge to various foundry fabrication processes enabling them with skills of nanofabrication.						
	3.	Knowledge of functioning and construction of nanoscale electronic devices would cater the need to keep them update with recent technologies in the field.						
	4.	Knowledge of functioning and construction of nanoscale optoelectronic devices would cater the need to keep them update with recent technologies in the field.						
	5	Knowledge of various types of functional thin films, nanostructures and their applications would enable learners understand working of presently used various type of sensors and devices.	ıld					
Modul	le-1	Logic Families	5					
		Diode Transistor Logic, High Threshold Logic, Transistor-transistor Logic, Resistor-						
		transistor Logic, Direct Coupled Transistor Logic, Comparison of Logic families						
Modul	le-2	Integrated Chip Technology	20					
		Overview of semiconductor industry, Stages of Manufacturing, Process and product trends,						
		Crystal growth, Basic wafer fabrication operations, process yields, semiconductor material						
		preparation, yield measurement, contamination sources, clean room construction, substrates,						
		diffusion, oxidation and photolithography, doping and depositions, implantation, rapid						
		thermal processing, metallization. patterning process, Photoresists, physical properties of						
		photoresists, Storage and control of photoresists, photo masking process, Hard bake, develop						
	inspect, Dry etching Wet etching, resist stripping, Doping and depositions: Diffusion process							
		steps, deposition, Drive-in oxidation, Ion implantation, CVD basics, CVD process steps, Low						
	pressure CVD systems, Plasma enhanced CVD systems, Vapour phase epitoxy, molecu							
	beam epitaxy. Design rules and Scaling, BICMOS ICs: Choice of transistor types, j							
	transistors, Resistors, capacitors, Packaging: Chip characteristics, package functions, package							

	operations	
Modulo 2	Nencolostronio devices	15
Module-5	Nanoelectronic devices	15
	Effect of shrinking the p-n junction and bipolar transistor; held-effect transistors, MOSFETS,	
	Introduction, CMOS scaling, the nanoscale MOSFET, vertical MOSFETs, electrical	
	characteristics of sub-100 nm MOS transistors, limits to scaling, system integration limits	
	(interconnect issues etc.), heterostructure and heterojunction devices, ballistic transport and	
	high-electron-mobility devices, HEMT, Carbon Nanotube Transistor, single electron effects,	
	Coulomb blockade. Single Electron Transistor, Resonant Tunneling Diode, Resonant	
	Tunneling Transistor, applications in high frequency and digital electronic circuits and	
	comparison with competitive devices.	
Module-4	Nano-Optoelectronic devices	5
	Direct and indirect band gap semiconductors, QWLED, QWLaser, Quantum Cascade Laser	
	Integrated Micromachining Technologies for Transducer Fabrication	
Module-5	Applications of Functional Thin Films and Nanostructures	5
	Functional Thin Films and Nanostructures for Gas Sensing, Chemical Sensors, Applications	
	of Functional Thin Films for Mechanical sensing, Sensing Infrared signals by Functional	
	Films.	
Referen	ices	
Textbooks	s and Reference Books:	
1 Herbert	Taub, Donald L. Schilling, Digital Integrated Electronics, McGraw-Hill, 1977	
2 S.M. Sz	e, Ed, Modern Semiconductor Device Physics, Wiley, New York	
3 S.M. Sz	e and K.K. Ng, Physics of Semiconductor Devices, 3rd Ed, Wiley, Hoboken.	
4 S. Wolf	and R.N. Tauber, Silicon Processing, vol. 1, (Lattice Press)	
5 S.Wolf	and R. N. Tauber, Silicon Processing for the VLSI Era. (Lattice Press, 2000)	
6 Streetm	an, B.G. Solid State Electronic Devices, Prentice Hall, Fifth Edition, 2000	
7 R. D. D	oering and Y. Nishi, Handbook of Semiconductor Manufacturing Technology, CRC Press, Boca	Raton.
8 W. R. F	ahrner (Editor), Nanotechnology and Nanoelectronics, Materials, Devices, Measurement Technik	aues

9 Anis Zribi, Jeffrey Fortin (Editors), Functional Thin Films and Nanostructures for Sensors Synthesis, Physics, and Applications

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	N
Mini projects/Projects	N
Laboratory experiments/teaching aids	N
Industrial/guest lectures	N
Industrial visits/in-plant training	N
Self- learning such as use of NPTEL materials and internets	Y
Simulation	N

Course Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Quiz I	\checkmark	\checkmark			
Quiz II			\checkmark	\checkmark	
Assessment	\checkmark	\checkmark	\checkmark	\checkmark	
Mid Sem Examination Marks	\checkmark	\checkmark	\checkmark		
End Sem Examination Marks	\checkmark	\checkmark		\checkmark	

Indirect Assessment -

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping between Course Objectives and Course Outcomes

Course Objectives		Co	ourse Outco	me	
	1	2	3	4	5
Α	Н	L	М	Μ	М
В	Μ	Н	Н	Н	Н
С	L	М	Н	Н	М
D	L	М	М	Η	Н
Е	L	Μ	Н	Н	Н

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes							
	a	b	с	d	e	f		
1	Н	Н	Н	М	М	М		
2	М	Н	Н	М	Н	Н		
3	М	Н	М	М	Н	М		
4	М	Н	М	М	Н	М		
5	М	Н	Н	М	Н	Н		

Mapping Between COs and Course Delivery (CD) methods							
			Course	Course Delivery			
CD	Course Delivery methods		Outcome	Method			
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1 and CD2			
CD2	Tutorials/Assignments		CO2	CD1 and CD2			
CD3	Seminars		CO3	CD, CD2 and CD8			
CD4	Mini projects/Projects		CO4	CD1, CD2 and CD8			
CD5	Laboratory experiments/teaching aids		CO5	CD1, CD2 and CD8			
CD6	Industrial/guest lectures		-	-			
CD7	Industrial visits/in-plant training		-	-			
CD8	Self- learning such as use of NPTEL materials and internets		-	-			
CD9	Simulation		-	-			

Week	Lect.	Fentati	Ch.	Fopics to be covered	Гext	COs	Actual Cont	entMethodolo	gRemar
	No.	ve			Book /		covered	у	ks by
No.		Date	No.		Refere	napped			faculty
								ısed	if any
					nces				

1	L1-L2	1	Diode Transistor Logic, High	R2,	CD1,
			Threshold Logic, Transistor-	R3,	CD2
			transistor Logic	and R6	
	L3-L4		Resistor-transistor Logic.	R2.	CD1.
	_		Direct Coupled Transistor	R3.	CD2
			Logic	and R6	
	L5		Comparison of Logic	R2	CD1
	20		families	R3	CD2
				and R6	002
	I.6-7	2	Overview of semiconductor	R1 R4	CD1
		2	industry Stages of	R1,R1,	CD2
			Manufacturing Process and	KJ	CD2
			product trends		
	180		Crystal growth Pasia wafar	D1	CD1
	L0-9		fabrication	\mathbf{N} I, \mathbf{D} 4 \mathbf{D} 5	CD1, CD2
			radification operations,	к4, кэ	CD2
			process yields,		
			semiconductor material		
	T.O.		preparation,	D 1	
	L9		yield measurement,	RI,	CDI,
			contamination sources, clean	R4, R5	CD2
			room construction,		
	L10-		substrates, diffusion,	R1,	CD1,
	12		oxidation and	R4,	CD2
			photolithography, doping	R5	
			and depositions,		
			implantation, rapid thermal		
			processing, metallization.		
	L13-		patterning process,	R1,	CD1,
	14		Photoresists, physical	R4, R5	CD2
			properties of photoresists,		
	L15-		Storage and control of	R1,	CD1,
	16		photoresists, photo masking	R4, R5	CD2
			process, Hard bake, develop		
			inspect,		
	L17-		Dry etching Wet etching,	R1,	CD1,
	18		resist stripping,	R4, R5	CD2
	L19-		Doping and depositions:	R1,	CD1,
	20		Diffusion process steps.	R4, R5	CD2
			deposition, Drive-in		
			oxidation, Ion implantation.		
	L21-		CVD basics, CVD process	R1,	CD1,
	22		steps, Low pressure CVD	R4. R5	CD2
			systems, Plasma enhanced	,	
			CVD systems. Vapour phase		
			epitoxy molecular beam		
			epitaxy.		
	1.23-		Design rules and Scaling	R1	CD1
	24		BICMOS ICs. Choice of	R4 R5	CD2
	2- 1		transistor types ppp	к т , КЭ	
			transistor types, plip		

			transistors, Resistors,			
			capacitors			
	L25		Packaging: Chip	R1,	CD1,	
			characteristics, package	R4, R5	CD2	
			functions, package			
			operations			
	L26-	3	Effect of shrinking the p-n	R8, R9	CD1,	
	27		junction and bipolar		CD2, and	
			transistor; field-effect		CD8	
			transistors, MOSFETs,			
	L28-		Introduction, CMOS scaling,	R8. R9	CD1.	
	29		the nanoscale MOSFET.	,	CD2, and	
	-		vertical MOSFETs		CD8	
	L30-		electrical characteristics of	R8. R9	CD1.	
	31		sub-100 nm MOS transistors.	-) -	CD2, and	
	• -		limits to scaling system		CD8	
			integration limits			
			(interconnect issues etc.)			
	L32-		heterostructure and	R8 R9	CD1	
	33		heteroiunction devices	100,100	CD2 and	
	20		ballistic transport and high-		CD8	
			electron-mobility devices		CD0	
	I.34-		HEMT Carbon Nanotube	R8 R9	CD1	
	L35		Transistor single electron	K0, K)	CD2 and	
	200		effects Coulomb blockade		CD8	
			eneets, coulonio bioekade.		CD0	
	L36-		Single Electron Transistor,	R8, R9	CD1,	
	38		Resonant Tunneling Diode,		CD2, and	
			Resonant Tunneling		CD8	
			Transistor		 	
	L39-		applications in high	R8, R9	CD1,	
	40		frequency and digital		CD2, and	
			electronic circuits and		CD8	
			comparison with competitive			
			devices			
	L41	4	Direct and indirect band gap	R8, R9	CDI,	
			semiconductors		CD2, and	
					 CD8	
	L42-		QWLED, QWLaser,	R8, R9	CD1,	
	43		Quantum Cascade Laser		CD2, and	
					CD8	
	L44-		Integrated Micromachining	R8, R9	CD1,	
	45		Technologies for Transducer		CD2, and	
			Fabrication		CD8	
	L46-	5	Functional Thin Films and	R9	CD1,	
	48		Nanostructures for Gas		CD2, and	
			Sensing, Chemical Sensors		CD8	
	L49-		Applications of Functional	R9	CD1,	
	50		Thin Films for Mechanical		CD2, and	
			sensing, Sensing Infrared		CD8	
		[signals by Functional Films			

Course code: PH 527 Course title: Microwave Electronics Pre-requisite(s): Co- requisite(s): Credits: 4L: 3 T: 1 P: 0 Class schedule per week: Class: I.M.Sc. Semester / Level: PE VI / VII Branch: PHYSICS Name of Teacher: Group : D

Option 4

Code: PH 52	: 27	Title: Microwave Electronics	L-T-P-C [3-1-0-4]				
Cours	se O	bjectives					
This	cours	se enables the students:					
	A.	Module-1 contains information about Transmission lines and wave-guides.					
	В.	The design and working of various types of micro-wave sources is covered in module-II.					
	C.	Module-III contains information about various types of stripline, microstrip lines and l analysis.	Network				
	D.	Knowledge about Micro-wave passive components and methods to measure various mic parameters are planned to be covered in Module-IV.	crowave				
	E.	Module-V contains information about design, fabrication and working of microwave in	tegrated				
		circuit technology.	C				
Cours	se O	utcomes					
After	the o	completion of this course, students will be:					
	1.	Leaner would gain knowledge about working, design and application of microwave fre	quency				
		electronics.					
2.		The course is intended to enrich the learner about Microwave transmission lines and waveguides. Through it students would be able to understand the propagation of microwave through transmission lines and Waveguides.					
	3.	Learner would gather understanding of devices used for microwave generation, detection and microwave network analysis					
	4.	Learner would also enrich their knowledge in terms of various microwave passive components, microwave parameters and microwave integrated circuit technology					
Modu	le-1	Transmission lines and Waveguides Introduction of Microwaves and their applications. Types of Transmission lines, Characterization in terms of primary and secondary constants, Characteristic impedance, General wave equation, Loss less propagation, Propagation constant, Wave reflection at discontinuities, Voltage standing wave ratio, Transmission line of finite length, The Smith Chart, Smith Chart calculations for lossy lines, Impedance matching by Quarter wave transformer, Single and double stub matching. Rectangular Waveguides: TE and TM wave solutions, Field patterns, Wave impedance and Power flow.	12				
Module-2		Microwave Sources	7				
		Microwave Linear-Beam (O type) and Crossed-Field tubes (M type), Limitations of conventional tubes at microwave frequencies, Klystron, Multicavity Klystron Amplifiers, Reflex Klystrons, Helix Travelling-wave tubes, magnetron Oscillators. Tunnel diode, TED ¬Gunn diode, Avalanche transit time devices IMPATT (also TRAPAT) and parametric devices.					

Module-3	Stripline and microstrip lines and Network analysis	11					
	Dominant mode of propagation, Field patterns, Characteristic impedance, Basic design						
	formulas and characteristics. Parallel coupled striplines and microstrip lines-Even-and						
	odd-mode excitations. Slot lines and Coplanar lines. Advantages over waveguides.						
	Microwave Network Analysis: Impedance and Admittance matrices, Scattering matri						
	Parameters of reciprocal and Loss less networks, ABCD Matrix, Scattering matrices of						
	typical two-port, three-port and four-port networks, Conversion between two-port						
	network matrices.						
Module-4	Microwave Passive Components and measurements	14					
	Waveguide Components: E-plane and H-plane Tees, Magic Tee, Shorting plunger,						
	Directional couplers, and Attenuator. Stripline and Microstrip line Components: Open						
	and shorted ends. Half wave resonator, Lumped elements (inductors, capacitors and						
	resistors) in microstrip. Ring resonator, 3-dB branchline coupler, backward wave						
	coupler, Wilkinson power dividers and rat-race hybrid ring. Low pass and band pass						
	filters. Microwave Measurements: Detection of microwaves, Microwave power						
	measurement, Impedance measurement, Measurement of reflection loss (VSWR), and						
	transmission loss in components. Passive and active circuit measurement &						
	characterization using network analyser, spectrum analyser and noise figuremeter						
Module -5	Microwave Integrated Circuit Technology	6					
	Substrates for Microwave Integrated Circuits (MICs) and their properties. Hybrid						
	technology – Photolithographic process, deposited and discrete lumped components.						
	Microwave Monolithic Integrated Circuit (MMIC) technology-Substrates, MMIC						
	process, comparison with hybrid integrated circuit technology (MIC technology).						
RECOMME	ENDED BOOKS:						
	tromagnetic Waves and Radiating Systems – E.C. Jordan & K.G. Balmain, Prentice Hall, In	nc.					
2 Mici	rowave Devices and Circuits -S. Y. LIAO, PHI						
3 Intro	duction to Microwave Theory and Measurements – L. A. Lance, TMH						
4 Iran	Ismission lines and Networks – Walter C. Johnson, McGraw Hill, New Delhi						
5 Netv	vorks Lines and Fields – John D. Ryder	N 11 '					
6 Mici	rowave Engineering: Passive Circuits -Peter A. Razi, Prentice Hall of India Pvt. Ltd, New I	Delhi.					
7 Wav	reguldes – H.K.L. Lamont, Methuen and Company Limited, London	D 11 '					
8 Four	idations for Microwave Engineering – Robert E. Collin, McGraw Hill Book Company, New	w Delhi					
9 Micro	wave Engineering – Annapurna Das, IMH, New Delhi						

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	N
Laboratory experiments/teaching aids	N
Industrial/guest lectures	N
Industrial visits/in-plant training	N
Self- learning such as use of NPTEL materials and internets	Y
Simulation	N

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Quiz I		\checkmark			
Quiz II			\checkmark	\checkmark	
Assesment		\checkmark	\checkmark	\checkmark	
Mid Sem Examination Marks		\checkmark	\checkmark		
End Sem Examination Marks					

Indirect Assessment -

- 1. Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

<u>Mapping between Objectives and Outcomes</u> Mapping between Course Objectives and Course Outcomes

Course Objectives		Course Outcomes				
	1	2	3	4	<u>5</u>	
Α	Н	Μ	Μ	L	Н	
В	Н	Н	Μ	L	Н	
С	Μ	L	Н	L	L	
D	Н	L	L	Η	Н	
Е	L	Μ	L	L	Н	

Course Outcome	Program Outcomes					
	а	b	с	d	e	f
1	Н	М	Н	М	Н	Н
2	Н	Н	Н	М	Н	Н
3	Н	L	М	М	L	М
4	Н		Н	М	М	М
5	М	Н	Н	М	Н	Н

Mapping Between COs and Course Delivery (CD) methods								
CD	Course Delivery methods	Course Outcome	Course Delivery Method					
	Lecture by use of boards/LCD							
CD1	projectors/OHP projectors	CO1	CD1 and CD2					
CD2	Tutorials/Assignments	CO2	CD1 and CD2					
CD3	Seminars	CO3	CD1 and CD2					
CD4	Mini projects/Projects	CO4	CD1 and CD2					
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2 and CD8					
CD6	Industrial/guest lectures	-	-					
CD7	Industrial visits/in-plant training	-	-					
	Self- learning such as use of NPTEL							
CD8	materials and internets	-	-					
CD9	Simulation	-	-					

Week	Lect.	Tentati	Ch.	Topics to be covered	Text	COs	Actual	Methodology	Remarks by
No.	No.	ve	No.	L	Book /	mappe	Content	used	faculty if any
		Date			Refere	d	covered		
					nces				
1	L1-L2		1	Introduction of Microwaves	R1, R4	,CO1		CD1, CD2	
				and their applications.	and R7				
	L3-L5			Types of Transmission	R1, R4	,CO1		CD1, CD2	
				lines, Characterization in	and R7				
				terms of primary and					
				secondary constants,	,				
			_	Characteristic impedance					
2	L6			General wave equation,	,R1, R4	,CO1		CD1, CD2	
				Loss less propagation,	and R7				
				Propagation constant, Wave	•				
	17		_	reflection at discontinuities,	D1 D4	001			
	L7			Voltage standing wave	RI, R4	,COI		CD1, CD2	
				ratio, Iransmission line of	and R/				
	το		_	The Smith Chart Smith	D1 D4	CO1		CD1 CD2	
	Lð			Chart coloulations for lossy	KI, K4	,001		CD1, CD2	
				lines	allu K /				
3	TQ		-	Impedance matching by	R1 R4	CO1		CD1 CD2	
5	L9			Quarter wave transformer	and $R7$,001		CD1, CD2	
				Single and double stub					
				matching.					
	L10-12		-	Rectangular Waveguides:	R1. R4	CO1		CD1. CD2	
				TE and TM wave solutions.	and R7	,			
				Field patterns, Wave					
				impedance and Power flow.					
4	L13-14		2	Microwave Linear-Beam (O	R2	CO2		CD1, CD2	
				type) and Crossed-Field	l				
				tubes (M type), Limitations					
				of conventional tubes at					
			_	microwave frequencies,					
	L15			Klystron, Multicavity	R2	CO2		CD1, CD2	
				Klystron Amplifiers, Reflex	-				
_			_	Klystrons		~ ~ ~			
5	L16-17			Helix Travelling-wave	R2	CO2		CD1, CD2	
				tubes, magnetron	L				
	T 10		-	Uscillators.	D.2	<u> </u>		CD1 CD2	
	L18			Iunnel diode, IED ¬Gunn	R2	CO2		CDI, CD2	
	I 10		_	diode,	D1	CO2		CD1 CD2	
	L19			Avalanche transit time	κ <i>z</i>	CO_2		CD1, CD2	
				TRAPAT) and parametric					
				devices	·				
6	L20-21		3	Dominant mode of	R4 R5	CO1		CD1 CD2	
Ĭ	L2V-21		Ĩ	propagation Field natterns	μτ 1, Ι τ.	CO3			
				Characteristic impedance					
	L22		-	Basic design formulas and	R4. R5	CO1.	1	CD1, CD2	
				characteristics.	,	CO3		, _	
	L23		1	Parallel coupled striplines	R4, R5	CO1,		CD1, CD2	

			and microstrip lines-Even-	CO3		
	1.24		Slot lines and Coplanar D4 D5	CO1	CD1 CD2	
	L24		Slot lines and Copianark4, KS	CO1,	CD1, CD2	
			waveguides	05		
7	1 25 27		Microwaya Network D4 D5	CO1	CD1 CD2	
/	L23-27		Analysis Impedance and	CO1,	CD1, CD2	
			Analysis: Impedance and Admitteness matrices	05		
			Souttoring matrix			
	T DO		Demonstern of regime color dD4, D5	<u>CO1</u>		
	L20		Loss loss networks APCD	CO1,	CD1, CD2	
			LOSS IESS HELWOIKS, ADCD	05		
0	1.20		Souttoring matrices of D4 D5	CO1	CD1 CD2	
0	L29		tunical two port three port	CO1,	CD1, CD2	
			and four port notworks	05		
	I 20		Conversion between two P4 P5	CO1	CD1 CD2	
	L30		conversion between two-K4, K5	CO1,	CD1, CD2	
	I 21 22	1	Wayaguida Components: E D6 D8	CO3	CD1 CD2	
	L31-32	4	plane and H plane Tees	C04	CD1, CD2	
			Magic Tee Shorting			
			nlunger Directional			
			couplers and Attenuator			
9	I 33-34		Stripline and Microstrip lineR6 R8	CO4	CD1 CD2	
	L33-3-		Components: Open and	0.04	CD1, CD2	
			shorted ends			
	L35-36		Half wave resonator R6 R8	CO4	CD1 CD2	
			Lumped elements			
			(inductors, capacitors and			
			resistors) in microstrip.			
10	L37-38		Ring resonator, 3-dBR6, R8	CO4	CD1, CD2	
			branchline coupler,			
			backward wave coupler,			
			Wilkinson power dividers			
			and rat-race hybrid ring.			
	L39		Low pass and band passR6, R8	CO4	CD1, CD2	
			filters.			
11	L40-42		Microwave Measurements: R6, R8	CO4	CD1, CD2	
			Detection of microwaves,			
			Microwave power			
			measurement, Impedance			
			measurement, Measurement			
			of reflection loss (VSWR),			
			and transmission loss in			
			components.			
	L43-44		Passive and active circuitR6, R8	CO4	CD1, CD2	
			measurement &			
			characterization using			
			network analyser, spectrum			
			analyser and noise			
10	T 47		riguremeter	005		
12	L43	Э	Substrates for MicrowaveR9	COS	CD1, CD2	
			and their properties			
	I 16 17		Hybrid technology D0	CO5		
		I	riyona acimology – Ry		CD1, CD2,	

	Photolithographic process, deposited and discrete lumped components.		and CD8
L48	Microwave MonolithicR9 Integrated Circuit (MMIC) technology-Substrates	CO5	CD1, CD2, and CD8
L49-50	MMIC process, comparisonR9 with hybrid integrated circuit technology (MIC technology).	CO5	CD1, CD2, and CD8

Group E- Plasma Sciences:

1. Theory of Plasmas

2. Plasma Confinement

3. Waves and Instabilities in Plasma

4. Physics of Thin Films

COURSE INFORMATION SHEET

Course code: PH 528 Course title: Theory of Plasmas Pre-requisite(s): Co- requisite(s): Credits: 4L:3 T: 1 P: 0 Class schedule per week: Class: I.M.Sc. Semester / Level: PE VI/ VII Branch: PHYSICS Name of Teacher: Group : E Option 1

Code:	Title: Theory of Plasmas	L-T-P-C					
PH 528		[3-1-0-4]					
Plasma Tł	ieory						
Course Ol	ojective						
1. To lea	rn about the similarity of plasma with fluid.						
2. To lea	rn about the diffusion and mobility of plasma.						
3. To lea	rn about the resistivity and single fluid MHD equation of plasma.						
4. To lea	rn about the Boltzmann and the Vlasov equation.						
5. To lea	rn about the different type of discharges.						
Course Ou	itcome						
1. Be fan	niliar about the method by which plasma can be treated as a fluid.						
2. Be fan	niliar with the diffusion and mobility process.						
3. Be abl	e to derive the set of single fluid MHD equation.						
4. Be abl	e to describe plasma with Boltzmann and Vlasov equation.						
5. Be fan	niliar with the different type of electrical discharges.						
Module-1	Relation of plasma physics to ordinary electromagnetic field, Fluid equation of	[8]					
	motion, Fluid drifts perpendicular to B, Fluids drifts parallel to B, Plasma						
	approximation.						
Module-2	Diffusion and mobility in weakly ionized gases, Decay of a plasma by diffusion,	[8]					
	steady state solution, Recombination, diffusion across a magnetic field, collision						
	in fully ionized plasma.						
Module-3	Mechanics of coulomb collisions, Physical meaning of resistivity, Numerical	[8]					
	value of resistivity, Single fluid MHD equations, Diffusion in fully ionized						
Module-4	Concepts of elementary kinetic theory of plasmas, The meaning of distribution	[8]					
Module-5 Electrical discharges, Electrical breakdown in gases, glow disch		[8]					
	sustained discharges, Paschen curve, High frequency electrical discharge in						
	gases, electrode less discharge, capacitively and Inductively coupled plasmas,						
	ECR Plasmas, Electrical arcs.						
Reference	S						
1. Ga	1. Gas Discharge Physics, Y P Raizer, Springer, 1997						

- 2. Introduction to Plasma Physics and Controlled Fusion, Francis, F. Chen, Plenum Press, 1984
- 3. Fundamental of Plasma Physics, J, A. Bittencourt, Springer-Verlag New York Inc., 2004
- 4. Plasma Physics (Plasma State of Matter) S. N. Sen, Pragati Prakashan, 1999

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	Ν
Laboratory experiments/teaching aids	N
Industrial/guest lectures	Ν
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and internets	Y
Simulation	N

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	\checkmark		\checkmark		
End Sem Examination Marks	\checkmark		\checkmark	\checkmark	\checkmark
Quiz I			\checkmark	\checkmark	
Quiz II					

Indirect Assessment -

- 1. Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

<u>Mapping between Objectives and Outcomes</u> Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4	<u>5</u>					
Α	Н	L	L	L	L					
В	М	Н	L	L	L					
С	М	Μ	Η	L	L					
D	М	L	L	Η	L					
Е	L	L	L	L	Н					

Course		Program Outcomes										
Outcome #	a	В	С	d	E	f	g	Н	i	j	K	1
1	Μ	Н	Μ	Μ	Μ	H						
2	М	Н	L	Μ	Μ	H						
3	Μ	Н	Н	Μ	Μ	H						
4	Μ	Н	Н	Μ	Μ	H						
5	Μ	Н	L	Μ	Μ	H						

Mapping Between COs and Course Delivery (CD) methods								
CD	Course Delivery methods	Course	Course Delivery Method					
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1 CD2					

CD2	Tutorials/Assignments	CO2	CD1 CD2
CD3	Seminars	CO3	CD1 CD2
CD4	Mini projects/Projects	CO4	CD1 CD2
CD5	Laboratory experiments/teaching aids	CO5	CD1 CD2
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

Week	Lect	Fentative	Ch	Topics to be covered	Text	COs	Actual	Methodo	Remark	s
No.	No.	Date	No.		Book /	mapped	Content	logy	by	
					Refere		covered	used	Faculty	if
					Nces				any	
1	L1-			Relation of plasma	T2 T3					
	L5			physics to ordinary	R 1					
				electromagnetic field,						
				Fluid equation of motion,						
	L6-			Fluid drifts perpendicular	T2 T3					
	L10			to B, Fluids drifts parallel	R1					
				to B, Plasma						
				approximation						
	L11-			Diffusion and mobility in	T2 T3					
	L15			weakly ionized gases,	R1					
				Decay of a plasma by						
				diffusion,	—					
	L16-			steady state solution,	T2 T3					
	L20			Recombination, diffusion	R1					
				across a magnetic field,						
				collision in fully ionized						
	1.01			plasma.	T 2 T 2					
	L21-			colligions Physical	12 13 D1					
	L25			meaning of resistivity	KI					
				Numerical value of						
				resistivity						
	L26-			Single fluid MHD	Т2 Т3					
	L20 I 30			equations. Diffusion in	R1					
	L30			fully ionized plasma.	K1					
				Bohm diffusion and						
				Neoclassical diffusion.						
	L31-			Concepts of elementary	T2 T3					
	L35			kinetic theory of plasmas,	R 1					
	L36-			The meaning of	T2 T3					
	140			distribution function,	R1					
	2.0			Boltzmann and Vlasov						
				equation						
	L41-			Electrical discharges,	T1 R1					
	L45			Electrical breakdown in						
				gases, glow discharge,						
				Self sustained discharges,						
				Paschen curve,						
	L46-			High frequency electrical	T1 R1					
	L50			discharge in gases,						
				electrode less discharge,						

		capacitively Inductively plasmas, ECR Electrical arcs.	and coupled Plasmas,			

Course code: PH 529 Course title: Plasma Confinement Pre-requisite(s): Co- requisite(s): Credits: 4L: 4T: 0 P: 0 Class schedule per week: Class: I.M.Sc. Semester / Level:PE VI / VII Branch: PHYSICS Name of Teacher:

Group : **E Option 2** Title: Plasma Confinement Code: L-T-P-C PH 529 [4-0-0-4] **Course Objective** 1. To learn about the fundamental and basics of plasma confinement. 2. To learn about the Magnetic confinement scheme and related heating machanicsm. 3. To learn about the transport of plasma. 4. To learn about plasma-surface interaction. 5. To learn about the Magnetohydrodynamics generator. **Course Outcome** 1. Will be familiar with the plasma confinement for thermonuclear fusion. 2. Will have an idea how plasma can be confined magnetically. 3. Be familiar with the transport of plasma and its role in thermonuclear fusion. 4. Be familiar with plasma surface interaction and its role in fusion. 5. Be familiar with the energy generation by MHD generator. Module-1 Nuclear Fusion and plasma physics: Fusion as energy source, Fusion reactions, [8] Controlled thermonuclear fusion and fusion reactor, Lawson criterion, Ignition, Fuel resources, Reactor economics, Plasma confinement schemes, Magnetic confinement, Inertial confinement, Laser-Fusion. Magnetic confinement: Larmor orbits, particle drifts, Magnetic mirror, Z-pinch, Module-2 [8] Theta-pinch, spheromak, Tokamak, safety factor, plasma beta, Aspect-ratio, Flux surfaces, plasma current, Grad-Shafranov equation, collisions, kinetic equation, Fokker-Planck equation, collision times, resistivity, plasma heating, Ohmic heating, RF heating, Neutral beam heating. Collisional Transport: Classical transport – minimal dissipation, diffusion, random Module-3 [8] walk estimate, heat conductivity, Fluid evolution in a torus - transport closure, radial fluxes, neoclassical transport, Surface flows, Axis symmetric fluxes. Module-4 Plasma-surface interaction: Plasma surface interactions, Boundary layer. [8] Recycling, Atomic and molecular processes, Desorption and wall cleaning, Sputtering, Arcing, Limiters, Divertors, Heat flux, Evaporation and heat transfer, Tritium inventory. Radiation from Plasma MHD Generator: Magnetohydrodynamic Generator, Basic theory, Principle of Module-5 [8] working, The fuel in MHD, Magnet in MHD Generator. References 1. Plasma Physics (Plasma State of Matter) S. N. Sen, Pragati Prakashan, 1999 2. Magnetic Fusion Technology, T J Dolan, 2014 3. Plasma Physics and Fusion energy, J P Freidberg Cambridge University Press, 2008 4. Tokamaks, J wessen, Oxford Science Publication, 1987
Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	Ν
Mini projects/Projects	Ν
Laboratory experiments/teaching aids	N
Industrial/guest lectures	Ν
Industrial visits/in-plant training	Ν
Self- learning such as use of NPTEL materials and internets	Y
Simulation	N

Course Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	\checkmark	\checkmark	\checkmark		
End Sem Examination Marks	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Quiz I			\checkmark	\checkmark	
Quiz II					

Indirect Assessment -

- 1. Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4	<u>5</u>
Α	Н	Μ	L	L	L
В	Μ	Н	L	L	L
С	L	L	Η	L	L
D	L	Μ	Μ	Η	L
Е	L	Μ	L	L	Н

Course		Program Outcomes										
Outcome #	a	b	c	d	Е	f	g	Н	Ι	j	k	1
1	Μ	Н	Μ	Μ	Η	Н						
2	М	Н	Μ	Μ	Η	Н						
3	Μ	Н	Μ	Μ	Η	Н						
4	Μ	Н	Μ	Μ	Η	Н						
5	Μ	Н	Μ	Μ	Η	Η						

Mapping of Course Outcomes onto Program Outcomes

	Mapping Between COs and Course Delivery (CD) methods								
CD	Course Delivery methods	Course Outcome	Course Delivery Method						
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1 CD2						
CD2	Tutorials/Assignments	CO2	CD1 CD2						
CD3	Seminars	CO3	CD1 CD2						
CD4	Mini projects/Projects	CO4	CD1 CD2						
CD5	Laboratory experiments/teaching aids	CO5	CD1 CD2						
CD6	Industrial/guest lectures								
CD7	Industrial visits/in-plant training								
CD8	Self- learning such as use of NPTEL materials and internets								
CD9	Simulation								

Lecture wise Lesson planning Details.

Week	Lect.	Tentative	Ch.	Topics to be covered	Text	COs	Actual	Methodology	Remarks
No.	No.	Date	No.		Book	mapped	Conten	Used	by
					/		t		faculty
					Refere		covere		if any
					Nces		d		
1	L1-			Nuclear Fusion and					
	L5			plasma physics:					
				Fusion as energy					
				source, Fusion					
				reactions, Controlled					
				thermonuclear fusion					
				and fusion reactor,					
				Lawson criterion,					
				Ignition,					
	L6-			Fuel resources,					
	L10			Reactor economics,					
				Plasma confinement					
				schemes, Magnetic					
				confinement, Inertial					
				confinement, Laser-					
				Fusion .					
	L11-			Magnetic confinement:					
	L15			Larmor orbits, particle					
				drifts, Magnetic					
				mirror, Z-pinch,					
				Theta-pinch,					
				spheromak, Tokamak,					
				safety factor, plasma					

		beta, Aspect-ratio,			
L16-		Flux surfaces, plasma			
L20		current. Grad-			
		Shafranov equation			
		collisions kinetic			
		equation Fokker			
		Dianaly aquation			
		r falles equation,			
		comston times,			
		resistivity, plasma			
		neating, Onmic			
		neating, RF neating,			
 		Neutral beam heating.			
L21-		Collisional Transport:			
L25		Classical transport –			
		minimal dissipation,			
		diffusion, random			
		walk estimate, heat			
		conductivity,			
L26-		Fluid evolution in a			
L30		torus – transport			
		closure, radial fluxes,			
		neoclassical transport,			
		Surface flows, Axis			
		symmetric fluxes			
L31-		Plasma-surface			
L35		interaction: Plasma			
		surface interactions,			
		Boundary layer,			
		Recycling, Atomic and			
		molecular processes.			
L36-		Desorption and wall			
L40		cleaning. Sputtering.			
		Arcing. Limiters.			
		Divertors Heat flux			
		Evaporation and heat			
		transfer Tritium			
		inventory Radiation			
		from Plasma			
I 41-		MHD Generator			
145		Magnetohydrodynami			
		Generator Dasia			
		theory			
 1.46		Dringinla of morting			
L40-		The fuel in MUD			
L30		Magnat in MIID,			
		Concreter			
		Generator.			

COURSE INFORMATION SHEET

Course code: PH 530 Course title: Waves and Instabilities in Plasma Pre-requisite(s): Co- requisite(s): Credits: 4 L: 3 T:1 P: 0 Class schedule per week: Class: I.M.Sc. Semester / Level: PE VI / VII Branch: PHYSICS Name of Teacher:

Group : E Option 3

Code:	Title: Waves and Instabilities in Plasma	L-T-P-C
PH 530		[3-1-0-4]
Course (Dbjective	
1. To le	arn the fundamental and basics of Plasma waves.	
2. To le	arn about the electromagnetic waves.	
3. To le	arn about the Landau Damping.	
4. To le	arn about the different type of instabilities.	
5. To le	arn about the MHD stability.	
Course o	utcome:	
1. Will	be familiar with the plasma waves.	
2. Be al	ble to handle electromagnetic waves mathematically.	
3. Be al	ble to derive mathematically Landau damping related concept.	
4. Will	be familiar with the different type of instabilities.	
5. Be al	ble to handle MHD stability mathematically.	
Module-1	Representations of waves, group velocity, Plasma Oscillations, Electron plasma w sound waves, ion waves, validity of plasma approximations, comparison of ion electron waves, electrostatic electron oscillations perpendicular to B.	aves, [8] and
Module-2 Electrostatic ion waves perpendicular to B, The lower hybrid frequency, electromagn waves with B=0, Experimental applications, electromagnetic waves perpendicular to Cutoffs and resonances, electromagnetic waves parallel to B, Whistler mode, Fara rotation		to B, raday
Module-3	Hydromagnetic waves, Magnetosonic waves, Alfven waves, Plasma oscillations Landau damping, A physical derivation of Landau damping.	and [8]
Module-4	Equilibrium and stability, Hydromagnetic equilibrium, Diffusion of magnetic field i plasma, Classification of instabilities, two stream instability, The gravitational instab Resistive drift waves.	nto a [8] bility,
Module-5	MHD stability, Energy principle, Kink instability, Internal kink, tearing modes, Rest layer, Tearing stability, Mercier criterion, Ballooning modes, Beta limit.	istive [8]
Referenc	es	
1. 7	okamaks, J Wessons, 1987, Oxford Science Publication.	
2. I	ntroduction to Plasma Physics f F Chen.	
3. Т	The theory of plasma waves, T H Stix, 1962, McGraw-Hill New York.	
4. F	Fundamental of Plasma Physics, J, A. Bittencourt, Springer-Verlag New York Inc., 200	4

Course Delivery methods		
Lecture by use of boards/LCD projectors/OHP projectors	Y	
Tutorials/Assignments	Y	
Seminars	Ν	
Mini projects/Projects	N	
Laboratory experiments/teaching aids	N	
Industrial/guest lectures	Ν	
Industrial visits/in-plant training	N	
Self- learning such as use of NPTEL materials and internets	Y	
Simulation	N	

Course Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a commitee	10
Three Quizes	30 (10+10+10)
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	\checkmark	\checkmark	\checkmark		
End Sem Examination Marks	\checkmark	\checkmark	\checkmark		\checkmark
Quiz I			\checkmark	\checkmark	
Quiz II					

Indirect Assessment -

- 1. Student Feedback on Faculty
- 2. Student Feedback on Course Outcome

<u>Mapping between Objectives and Outcomes</u> Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4	<u>5</u>			
Α	Н	Μ	L	L	L			
В	Μ	Η	L	L	L			
С	Μ	Μ	Η	L	L			
D	L	L	L	Н	Μ			
Е	L	L	L	Μ	Н			

Mapping of Course Outcomes onto Program Outcomes

Course	Program Outcomes											
Outcome #	a	b	C	D	Е	f	g	Η	i	j	k	1
1	Μ	Н	Μ	Μ	Н	Н						
2	М	Н	Μ	Μ	Н	Н						
3	Μ	Н	Н	Μ	Н	Н						
4	Μ	Н	Μ	M	Н	Н						
5	L	Н	L	Μ	Н	Н						

Mapping Between COs and Course Delivery (CD) methods								
CD	Course Delivery methods		Course Outcome	Course Delivery Method				
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1 CD2				
CD2	Tutorials/Assignments		CO2	CD1 CD2				
CD3	Seminars		CO3	CD1 CD2				
CD4	Mini projects/Projects		CO4	CD1 CD2				
CD5	Laboratory experiments/teaching aids		CO5	CD1 CD2				
CD6	Industrial/guest lectures							
CD7	Industrial visits/in-plant training							
CD8	Self- learning such as use of NPTEL materials and internets							
CD9	Simulation							

Lecture wise Lesson planning Details.

Week	Lect.	Tent	Ch.	Topics to be covered	Text	COs	Actual	Metho	Remar
No.	No.	ative	No.	_	Book /	Map	Content	dolog	ks by
		Date			Refere	ped	covered	у	faculty
					nces	-		used	if any
1	L1-			Representations of waves, group	T2 T3				
	L5			velocity, Plasma Oscillations, Electron	R1				
				plasma waves, sound waves, ion waves,					
	L6-			validity of plasma approximations,	T2 T3				
	L10			comparison of ion and electron waves,	R1				
				electrostatic electron oscillations					
				perpendicular to B.					
	L11-			Electrostatic ion waves perpendicular to	T2 T3				
	L15			B, The lower hybrid frequency,	R1				
				electromagnetic waves with B=0,					
				Experimental applications,					
	L16-			electromagnetic waves perpendicular to	T2 T3				
	L20			B, Cutoffs and resonances,	R1				
				electromagnetic waves parallel to B,					
				Whistler mode, Faraday rotation					
	L21-			Hydromagnetic waves, Magnetosonic	T2 T3				
	L25			waves, Alfven waves,	R1				
	L26-			Plasma oscillations and Landau					
	L30			damping, A physical derivation of					
				Landau damping					
	L31-			Equilibrium and stability,	T1 T2				
	L35			Hydromagnetic equilibrium, Diffusion	R1				
				of magnetic field into a plasma,					
	L36-			Classification of instabilities, two stream	T1 T2				
	L40			instability, The gravitational instability,	R1				
				Resistive drift waves.					
	L41-			MHD stability, Energy principle, Kink	T1 T2				
	L45			instability, Internal kink,	R1				
	L46-			tearing modes, Resistive layer, Tearing	T1 T2				
	L50			stability, Mercier criterion, Ballooning	R1				
				modes, Beta limit.					

COURSE INFORMATION SHEET

Course code: PH 519 Course title: Physics of Thin Films Pre-requisite(s): Co- requisite(s): Credits: 4 L: 4 T: 0 P: 0 Class schedule per week: Class: M.Sc. Semester / Level: IV/ PE VI- VII Branch: PHYSICS Name of Teacher: Dr. Sanat Mukherjee

Group : E

Option 4

Same given as above (in Group B)