CBCS based Syllabus for

I.M.Sc. (Physics) (1st -10th Semester)
and
M.Sc. (1st – 4th Semesters)

Department of Physics
B.I.T. Mesra, Ranchi
98A, Academic Council, 2nd May, 2018

CBCS based Course structure for I.MSc. programme of BIT: Important notes:

- The basic criteria of UGC have been followed in preparing the course structure of this programme.
- **The Exit option with B.Sc. (Physics Honours) can be offered to them who want to get it after successful completion of 6th semester.**
- On the other hand, a parallel entry is allowed in 7th semester in the form of M.Sc. progremme.

Department Vision

To become an internationally recognized centre of excellence in academics and research in the area of Physics and related inter-disciplinary fields.

Department Mission

The Department of Physics (previously known as Department of Applied Physics) since its inception in 1955 has played a pivotal role in the institute. Other than BE Courses, the important thrust of the Department of Physics is the 5 year Integrated M. Sc. Programme which has been offering since 2011. The course aims to train the young students with the following objectives:

- To impart high quality Science education in a vibrant academic ambience.
- To prepare students to take up challenges as a researcher in diverse areas of theoretical and experimental physics.
- Excellent lab and internet facilities.
- Opportunity of pursuing high end research as project work.
- Exit option available after completion of three years with a B.Sc. Honours Degree that enables students to take admission in the Integrated M.Sc. plus Ph.D. programs of different prestigious research organizations.
- During 9th and 10th semesters, students may opt special papers for the following areas: Theoretical and Computational Physics, Condensed Matter Physics, Electronics, Photonics and Plasma Sciences.

Program Educational Objectives of I.M.Sc. & M.Sc.:

1. To impart high quality education in Physical Sciences.
2. To prepare students to take up challenges as globally competitive physicists/researchers in diverse areas of theoretical and experimental physics.
3. To make the students technically and analytically skilled.
4. To provide opportunity of pursuing high end research as project work.
5. To give exposure to a vibrant academic ambience.
6. To create a sense of academic and social ethics among the students.
7. To prepare them to take up higher studies of interdisciplinary nature.

Program Outcomes of I.M.Sc. & M.Sc.:

1. The students will obtain good knowledge in Physical Sciences. They will be trained to compete national level tests like UGC-CSIR NET, JEST, GATE, etc., successfully.
2. They will be prepared to take up challenges as globally competitive physicists/researchers in diverse areas of theoretical and experimental physics.
3. They will be technically and analytically skilled enough to pursue their further studies.
4. They will have a sense of academic and social ethics.
5. They will be capable of taking up higher studies of interdisciplinary nature.
6. They will be able to recognize the need for continuous learning and develop throughout for the professional career.

The contents of laboratory papers are designed to meet the course objectives and outcomes of their respective theory papers.

Course : I.M.Sc. (Physics)

Level		Category	Code no.	Name of the subjects	L	T	P	C
1	Semester-I		**THEORY**					
		PC	PH 101	Mechanics	3	1	0	4
			PH 102	Electricity & Magnetism	3	1	0	4
		HSS	MT 123	Buisness Communications	2	0	2	3
		FS	CH 111	Chemistry I	3	1	0	4
			LABORATORIES					
		PC	PH 103	Mechanics Lab	0	0	4	2
			PH 104	Electricity& Magnetism Lab	0	0	4	2
		FS	CH 112	Chemistry I Lab	0	0	3	1.5
			Mandatory Course					
		MC	MC 101/102/103/104	NCC/ NSS/PT & Games/ Creative Arts				1
			Total					**21.5**

Level		Category	Code no.	Name of the subjects	L	T	P	C
1	Semester-II		**THEORY**					
		PC	PH 105	Mathematical Physics-I	3	1	0	4
			PH 106	Waves and Optics	3	1	0	4
		FS	MA 108	Mathematics III	5	1	0	6
			CE 101	Environmental Science	2	0	0	2
		GE	CS 101/EE 101/EC 101/ME 101	Programming for problem solving / Basics of Electrical Engineering / Basics of Electronics Engg. / Basics of Mechanical Engg	3	1	0	4
			LABORATORIES					
		PC	PH 107	Mathematical Physics-I Lab	0	0	4	2
			PH 108	Waves and Optics Lab	0	0	4	2
		GE	CS 102/PE 101/EC 102/ME 102	Programming for problem solving Lab / Workshop practice / Electronics Lab/ Engg Graphics Lab	0	0	3	1.5
			Mandatory Course					
		MC	MC 105/106/107/108	NCC/ NSS/PT & Games/ Creative Art				1
							Total	**26.5**

Level		Category	Code no.	Name of the subjects	L	T	P	C
2	Semester-III			**THEORY**				
		PC	PH 201	Thermal Physics	**3**	**1**	**0**	**4**
			PH 202	Digital Systems and Applications	**4**	**0**	**0**	**4**
			PH 203	Classical Dynamics	**4**	**1**	**0**	**5**
		FS	CH213	Chemistry II	**3**	**1**	**0**	**4**
		OE		Open Elective-I				**4.5**
				LABORATORIES				
		PC	PH 204	Thermal Physics Lab	**0**	**0**	**4**	**2**
			PH 205	Digital Systems & Applications Lab	**0**	**0**	**4**	**2**
		FS	CH214	Chemistry II Lab	**0**	**0**	**3**	**1.5**
				Mandatory Course				
		MC	MC 201/202/203/204	NCC/ NSS/PT & Games/ Creative Art				**1**
							Total	**28**

Level		Category	Code no.	Name of the subjects	L	T	P	C
2	Semester-IV			**THEORY**				
		PC	PH 206	Mathematical Physics II	**3**	**1**	**0**	**4**
			PH 207	Elements of Modern Physics	**3**	**1**	**0**	**4**
			PH 208	Analog Systems & Applications	**3**	**1**	**0**	**4**
		FS	MA 207	Mathematics IV	**5**	**1**	**0**	**6**
				LABORATORIES				
		PC	PH 209	Mathematical Physics II Lab	**0**	**0**	**4**	**2**
			PH 210	Elements of Modern Physics Lab	**0**	**0**	**4**	**2**
			PH 211	Analog Systems & Applications Lab	**0**	**0**	**4**	**2**
				Mandatory Course				
		MC	MC 205/206/207/208	NCC/ NSS/PT & Games/ Creative Art				**1**
							Total	**25**

Level		Category	Code no.	Name of the subjects	L	T	P	C
3	**Semester-V**			**THEORY**				
		PC	PH 301	Quantum Mechanics and Applications	**3**	**1**	**0**	**4**
			PH 302	Solid State Physics	**4**	**0**	**0**	**4**
		PE	PH 303/PH 304	**PE** -I (Annexure I)	**3**	**0**	**0**	**3**
			PH 305/PH 306 / PH 307	**PE** -II (Annexure I)	**3**	**0**	**0**	**3**
				LABORATORIES				
		PC	PH 308	Quantum Mechanics Lab	**0**	**0**	**4**	**2**
			PH 309	Solid State Physics Lab	**0**	**0**	**4**	**2**
		PE	PH310/PH311	**PE** -I Lab (Annexure I)	**0**	**0**	**4**	**2**
			PH312/PH313	**PE** -II Lab (Annexure I)	**0**	**0**	**4**	**2**
							Total	**22**

Level		Category	Code no.	Name of the subjects	L	T	P	C
3	**Semester-VI**			**THEORY**				
		PC	PH 314	Electromagnetic Theory	**3**	**1**	**0**	**4**
			PH 315	Statistical Mechanics	**3**	**1**	**0**	**4**
		PE	PH316/PH317/PH318	**PE** -III(Annexure I)	**3**	**0**	**0**	**3**
			PH319/PH320	**PE** -IV(Annexure I)	**3**	**0**	**0**	**3**
				LABORATORIES				
		PC	PH 321	Electromagnetic Theory Lab	**0**	**0**	**4**	**2**
			PH 322	Statistical Mechanics Lab	**0**	**0**	**4**	**2**
		PE	PH 323	**PE** -III Lab (Annexure I)	**0**	**0**	**4**	**2**
			PH324 PH325	**PE** -IV Lab (Annexure I)	**0**	**0**	**4**	**2**
							Total	**22**

Total Credit of I.M.Sc. - I to VI Semesters = 145

Notes: -

- **Internship (In-house/External) of at least 2 months should be done by the students (Non-credit) during 5th/6th semester.**
- **The Exit option with B.Sc. (Physics Honours) can be offered to the student who wants to get it after successful completion of 6^{th} semester.**

Level			Code no.	Name of the subjects	L	T	P	C
	Semester-VII			**THEORY**				
4		PC	PH 401	Mathematical Method in Physics	**3**	**0**	**0**	**3**
			PH 402	Electrodynamics	**3**	**0**	**0**	**3**
			PH 403	Classical Mechanics	**3**	**0**	**0**	**3**
			PH 404	Quantum Mechanics	**2**	**1**	**0**	**3**
			PH 405	Modern Computational Techniques & Programming	**2**	**0**	**0**	**2**
		OE		Open Elective II	**3**	**0**	**0**	**3**
				LABORATORIES				
		PC	PH 406	Modern Computational Techniques & Programming Lab	**0**	**0**	**4**	**2**
			PH 407	Modern Physics Lab	**0**	**0**	**4**	**2**
2		MC	MT204	Constitution of India	**2**	**0**	**0**	**Non-Credit**
							Total	**21**

Level			Code no.	Name of the subjects	L	T	P	C
	Semester-VIII	**Category**		**THEORY**				
4		PC	PH 408	Statistical Physics	**3**	**1**	**0**	**4**
			PH 409	Atomic and Molecular Spectroscopy	**3**	**1**	**0**	**4**
			PH 410	Electronic Devices & Circuits	**3**	**0**	**0**	**3**
			PH 411	Condensed Matter Physics	**3**	**0**	**0**	**3**
		OE		Open Elective III	**3**	**0**	**0**	**3**
				SESSIONAL / LABORATORY				
		PC	PH 412	Electronics Lab	**0**	**0**	**4**	**2**
			PH 413	Condensed Matter Physics Lab	**0**	**0**	**4**	**2**
							Total	**21**

Level		Category	Code no.	Name of the subjects	L	T	P	C
5	Semester-IX			**THEORY**				
		PC	PH 501	Nuclear and Particle Physics	**3**	**1**	**0**	**4**
			PH 502	Advanced Quantum Mechanics	**3**	**1**	**0**	**4**
			PH 503	Laser Physics and Applications	**3**	**1**	**0**	**4**
		PE	PH 504 to PH 512 **(Annexure II)**	PE- V One paper from Either Group A or B or C or D or E: Specialization	**4**	**0**	**0**	**4**
		PE	PH 500 **(Annexure II)**	Project (Phase-I) from Either Group A or B or C or D or E				**4**
				LABORATORIES				
		PC	PH 513	Laser Physics Lab	**0**	**0**	**4**	**2**
							Total	**22**

Level		Category	Code no.	Name of the subjects	L	T	P	C
5	Semester-X			**THEORY**				
		PE	PH 513 to PH 530 **(Annexure II)**	**PE** - VI: One paper from Either Group A or B or C or D or E: Specialization	**4**	**0**	**0**	**4**
				PE - VII: One paper from Either Group A or B or C or D or E: Specialization	**4**	**0**	**0**	**4**
			PH 550	Project (Phase-II) from Either Group A or B or C or D or E				**8**
			Total					**16**

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

Grand Total for I.M.Sc. (I to X Semesters)=145+80 = 225

(Minimum requirement for Degree award)

Annexure I

	PE		Subjects	L-T-P-C
			Theory and Lab Papers	
5th Semester	**PE-I**	PH 303 PH 304	Advanced Mathematical Physics Nano Materials and Applications	3-0-0-3 3-0-0-3
5th Semester	**PE-II**	PH 305 PH 306 PH 307	Computational Physics Materials Science and Nanotechnology Experimental Technique	3-0-0-3 4-1-0-5 3-0-0-3
5th Semester	**PE -I Lab**	PH 310 PH311	Advanced Mathematical Physics Lab Nano Materials and Applications Lab	0-0-4-2 0-0-4-2
5th Semester	**PE -II Lab**	PH312 PH313	Computational Physics Lab Experimental Technique Lab	0-0-4-2 0-0-4-2
6th Semester	**PE -III**	PH316 PH317 PH318	Nonconventional Sources of Energy Introduction to Nuclear and Particle Physics Nuclear Hazard and Waste Managements	3-0-0-3 4-1-0-5 4-1-0-5
6th Semester	**PE -IV**	PH319 PH320	Atmospheric Physics Advanced Experimental Technique	3-0-0-3 3-0-0-3
6th Semester	**PE III Lab**	PH323	Nonconventional Sources of Energy Lab	0-0-4-2
6th Semester	**PE -IV Lab**	PH324 PH325	Atmospheric Physics Lab Advanced Experimental Technique Lab	0-0-4-2 0-0-4-2

Annexure II

<table>
<tr><th>PE</th><th>Pre-requisites</th><th>Subjects</th><th></th></tr>
<tr><td rowspan="5">PE -V</td><td rowspan="5">One paper from Either Group A or B or C or D or E</td><td>Group A- Theoretical and Computational Physics:
• Numerical Methods for Physicists
• Theory of Solids</td><td>PH 504
PH 505</td></tr>
<tr><td>Group B- Condensed Matter Physics:
• Theory of Solids
• Functional Materials</td><td>PH 505
PH 506</td></tr>
<tr><td>Group C – Photonics:
• Fiber and Integrated Optics
• Quantum & Nonlinear Optics</td><td>PH 507
PH 508</td></tr>
<tr><td>Group D- Electronics
• Instrumentation and Control
• Physics of Low dimensional Semiconductors Devices</td><td>PH 509
PH 510</td></tr>
<tr><td>Group E- Plasma Sciences:
• Introduction to Plasma Physics
• Plasma Processing of Materials</td><td>PH 511
PH 512</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">PE -VI to VII</td><td rowspan="5">Two papers from any group
(Papers shall be chosen from same group in IX and X Semesters)</td><td>Group A- Theoretical and Computational Physics:
• Theoretical and Computational Fluid Dynamics
• Theoretical and Computational Condensed Matter Physics
• Nonlinear Dynamics and Chaos</td><td>PH 514
PH 515
PH 516</td></tr>
<tr><td>Group B- Condensed Matter Physics:
• Nonconventional Energy Materials
• Cryogenic Physics
• Physics of Thin Films
• Theory of Dielectrics and Ferroics
• Theoretical and Computational Condensed Matter Physics</td><td>PH 517
PH 518
PH 519
PH 520
PH 515</td></tr>
<tr><td>Group C- Photonics:
• Photonic and Optoelectronic Devices
• Holography and Applications
• Quantum photonics and applications
• Introduction to Nanophotonics</td><td>PH 521
PH 522
PH 523
PH 524</td></tr>
<tr><td>Group D- Electronics:
• Microprocessor and Microcontroller Applications
• Integrated Electronics
• Microwave Electronics</td><td>PH 525
PH 526
PH 527</td></tr>
<tr><td>Group E- Plasma Sciences:
• Theory of Plasmas
• Plasma Confinement
• Waves and Instabilities in Plasma
• Physics of Thin Films</td><td>PH 528
PH 529
PH 530
PH 519</td></tr>
</table>

I.M.Sc. (Physics) (VII -X Sem) as well as M.Sc. (I -IV Sem)

Semester	Subjects	Credit	Total
I.M.Sc. VII / M.Sc. I	Mathematical Method in Physics	3	**21**
	Electrodynamics	3	
	Classical Mechanics	3	
	Quantum Mechanics	3	
	Modern Computational Techniques & Programming	2	
	Open Elective I	3	
	Modern Computational Techniques & Programming Lab	2	
	Lab-II (Modern Physics Lab)	2	
I.M.Sc. VIII / M.Sc. 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	
I.M.Sc. IX / M.Sc. III	Nuclear and Particle Physics	4	**22**
	Advanced Quantum Mechanics	4	
	Laser Physics and Applications	4	
	PE - V One paper from Either Group A or B or C or D or E: Specialization	4	**Papers shall be chosen from same group in 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	
I.M.Sc. X / M.Sc. IV	PE - VI One paper from the same Group A or B or C or E	4+4	**16**
	PE - VII One paper from the same Group A or B or C or E		
	Project (Phase-II) from Either Group A or B or C or D or E	8	
	Comprehensive Viva		
		Total	**80**

Minimum requirement: 145 (UG)+80 (PG)= 225 Credits

<u>Internship (In-house/External)</u> of at least 2 months should be done by the students (Non-credit) during 5th/6th semester.

CORE COURSE (I.M.Sc. 1st to 6th Semesters)
Semester I

COURSE INFORMATION SHEET

Course code: PH 101
Course title: Mechanics
Pre-requisite(s): Intermediate Physics
Co- requisite(s):
Credits: 4 L: 3 T:1 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: I
Branch: PHYSICS
Name of Teacher: Dr. S. Lahiri

Theory: 50 Lectures

Code: PH 101	**Title : Mechanics**	**L-T-P-C [3-1-0-4]**
Course Objective: 1. A gentle introduction to the kinematics of rigid bodies and the concepts of work and energy. 2. Advancing the above notions to explain collision processes, and teaching rotational dynamics. 3. Exemplification of the notion of central force motion through discussions on gravitation. 4. Providing familiarity with the mathematical structure of waves and oscillations. 5. Introduction to the niceties of the special theory of relativity. 6. Discussion of some preliminary ideas of fluid motion and elasticity. **Course Outcome:** **1**. Ability to solve problems on mechanics using the notion of work and energy. 2. Developing intuitive as well as mathematical understanding of rotational dynamics. 3. Getting equipped with mathematical tools to handle problems on central force motion. 4. Capacity to grasp the underlying principles of waves and oscillations. 5. Solving problems related to relativistic transformation of variables in different inertial frames. 6. Ability to explain common effects of fluid motion and elasticity.		
Module-1	**Fundamentals of Dynamics:** Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable-mass system: motion of rocket. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. **Work and Energy:** Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy	**10**
Module-2	**Collisions:** Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames. **Rotational Dynamics**: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation **Fluid Motion:** Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube. **Elasticity:** Relation between Elastic constants. Twisting torque on a Cylinder or Wire.	**10**
Module-3	**Gravitation and Central Force Motion:** Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea	**12**

	of global positioning system (GPS). **Oscillations:** SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor.	
Module-4	**Non-Inertial Systems:** Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.	**8**
Module-5	**Special Theory of Relativity:** Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum.	**10**

Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
4. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
5. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.

Additional Books for Reference

1. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
2. University Physics, F.W.Sears, M.W.Zemansky, H.D.Young 13/e, 1986, Addison Wesley
   ii. Physics for Scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning
3. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

Gaps in the syllabus (to meet Industry/Profession requirements) :
POs met through Gaps in the Syllabus :
Topics beyond syllabus/Advanced topics/Design :
POs met through Topics beyond syllabus/Advanced topics/Design :

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**
A	H	L	L	L	M
B	M	H	-	-	-
C	L	-	H	-	-
D	-	-	-	H	-
E	-	-	-	-	H
F	-	-	-	L	-

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	a	b	c	d	e	f
1	H	H	H	L	H	M
2	H	H	H	L	L	M
3	H	H	H	L	H	M
4	H	H	H	L	H	M
5	H	H	H	L	L	M
6	H	H	H	L	H	M

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1.	L1-L3			Reference frames. Review of Newton's Laws Galilean transformations; Momentum of variable-mass system.	T1, R1	1			
2.	L4-L6			Motion of projectile Dynamics of a system of particles. Conservation of momentum.	T1, R1	1			
3.	L7-L9			Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy	T1, R1	1			
4.	L10-L1			Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Law of conservation of Energy	T1, R1	1			
5.	L12-L1			Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.	T1, R2				
6.	L15-L1			Angular momentum of a particle and system of particles. Conservation of angular momentum. Moment of Inertia. Motion involving both translation and rotation	T1,R2				
7.	L18-L2			Kinematics of Moving Fluids: Poiseuille's Equation. Relation between Elastic constants. Twisting torque on a Cylinder or Wire.	T3, R4				
8.	L21-L2			Law of gravitation. Gravitational potential energy. Potential and field due to spherical shell and solid sphere.	T3, R4				
	L24-26			Two-body problem and its reduction to one-body problem and its solution. Kepler's Laws. Satellite in circular orbit and applications.					

9.	L27-29			SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states;					
10.	L30			Resonance, sharpness of resonance; power dissipation and Quality Factor.	T1,T3				
11.	L31-33			Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications.	T1,T3				
12.	L34-36			Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.	T1,T3				
13.	L37-39			Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations.	T3, R2				
12.	L40-42			Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number.	T3, R2				
13.	L43-45			Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum.	T3, R2				

COURSE INFORMATION SHEET

Course code: PH 102
Course title: ELECTRICITY AND MAGNETISM
Pre-requisite(s): Intermediate Physics
Co- requisite(s):
Credits: 4 L: 3 T:1 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: I
Branch: PHYSICS
Name of Teacher: Dr R. Kumar

Theory: 50 Lectures

Code: PH 102	**Title: ELECTRICITY AND MAGNETISM**	**L-T-P-C [3-1-0-4]**

Course Objectives : This course enables the students to

1	know and apply the basic theorems related to electrostatics potential and field
2	know how to deal electrostatics situation when dielectric is involved.
3	know the various laws of magnetostatics in vacuum and when there is magnetic medium
4	know the laws of electrodynamics and its application in AC circuits.
5	know about Network theorems in linear circuits

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

1.	apply Gauss's law and uniqueness theorem to calculate electric field
2.	to calculate various quantities like displacement vector and polarization in the presence of dielectircs.
3.	to apply the laws of magnetostatics-like Biot-Savart law, Ampere's circuital law, and to calculate the hysteresis energy loss .
4.	to apply Maxwell's equations, and the laws of electromagnetic induction to deal AC circuits.
5.	to apply network theorems to get the information about the voltage and current in various branches of a dc circuit

Module-1	**Electric Field and Electric Potential** Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole.	**10**
Module-2	Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere **Dielectric Properties of Matter:** Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics.	**10**
Module-3	**Magnetic Field**: Magnetic force between current elements and definition of Magnetic FieldB. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of B: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. Magnetic Properties of Matter: Magnetization vector (**M**). Magnetic Intensity(**H**). Magnetic Susceptibility and permeability. Relation between **B, H, M**. Ferromagnetism. B-H curve and hysteresis.	**10**
Module-4	**Electromagnetic Induction:** Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to	**10**

	Maxwell's Equations. Charge Conservation and Displacement current . **Electrical Circuits:** AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit.	
Module-5	**Network theorems:** Ideal Constant-voltage and Constant-current Sources. Network Theorems Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits **Ballistic Galvanometer:** Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CD	**10**

References:

Text books:

1. Introduction to Electrodynamics by D.J. Griffits, Prentice Hall(1999).
2. Electricity and Magnetism by E. M. Purcell and D. J. Morin, Cambridge. University press(2013)
3. Schaum's outline of Theory and Problems of Electrical Circuits, TMH 2002, by Mahmood Nahri & J. Edminister

Reference books:

1. Classical electrodynamics, J.D. Jackson, John and Wiley press, Third edition

POs met through Topics beyond syllabus/Advanced topics/Design

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

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End SemExamination Marks	60
Assignment / Quiz (s)	15

AssessmentCompoents	CO1	CO2	CO3	CO4	
Mid Sem Examination Marks	Yes				
End Sem Examination Marks	Yes				
Assignment	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					
	a	b	c	d	e	f
1	H	H	H	M	M	H
2	H	H	H	L	L	M
3	H	H	H	M	M	M
4	H	H	H	M	M	M
5	H	H	H	M	M	M

Mapping of Course Outcomes onto Course Objective

Course Objective#	Course Outcomes					
	a	b	c	d	e	f
1	H	H	H	M	M	H
2	H	H	H	M	H	M
3	H	H	H	M	M	M
4	H	H	H	M	H	M
5	H	H	H	M	M	M

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	Tutorials/Assignments		CO2	CD1
CD3	Seminars		CO3	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
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 No.	Lect. No.	Tentative Date	Ch. No	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks byfaculty if any
1	L1,L2,L3,L4		1	Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential	T1, T2	1, 2		CD1 and CD2	
2	L5,L6,L7,L8		1	Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole.	T1, T2			CD1 and CD2	
3	L9,L10,L11,L12		2	Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated	T1, T2			CD1 and CD2	

				conductor.					
4.	L13,L14,L15,L16		2	Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant.	T1, T2			CD1 and CD2	
5.	L17,L18,L19,L20		2					CD1 and CD2	
6.	L21,L22,L23,L24		3	Magnetic Field: Definition of Magnetic Field B. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole).Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid.	T1, T2			CD1 and CD2	
7.	L25,L26,L27,L28		3	Properties of B: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. Magnetic Properties of Matter: Magnetization vector (M). Magnetic Intensity(H). Magnetic Susceptibility and permeability	T1, T2			CD1 and CD2	
8.	L29,L30, L31,L32		3, 4	Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis. Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance.	T1, T2				
9.	L33,L34,L35,L36		4	Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current .	T1, T2			CD1 and CD2	
10.	L37,L38,L39,L40		4	Electrical Circuits: AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor,)and (4) Band Width. Parallel LCR Circuit.	T1, T2			CD1 and CD2	
11.	L41,L42,L43,L44		5	Network theorems: Ideal Constant-voltage and Constant-	T3			CD1 and CD2	

				current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem,(					
12.	L45,L46, L47,L48		5	Maximum Power Transfer theorem. Applications to dc circuits Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping.	T3			CD1 and CD2	
13.	L49,L50		5	Logarithmic damping.				CD1 and CD2	

COURSE INFORMATION SHEET

Course code: PH 103
Course title: Mechanics Lab
Pre-requisite(s): Intermediate Physics
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 S Lahiri

MECHANICS LAB	L-T-P-C [0-0-4-2]
1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling icroscope. 2. To study the random error in observations. 3. To determine the height of a building using a Sextant. 4. To study the Motion of Spring and calculate (a) Spring constant, (b) **g** and (c) Modulus of rigidity. 5. To determine the Moment of Inertia of a Flywheel. 6. To determine **g** and velocity for a freely falling body using Digital Timing Technique 7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method). 8. To determine the Young's Modulus of a Wire by Optical Lever Method. 9. To determine the Modulus of Rigidity of a Wire by Maxwell's needle. 10. To determine the elastic Constants of a wire by Searle's method. 11. To determine the value of g using Bar Pendulum. 12. To determine the value of g using Kater's Pendulum. **Reference Books** • Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House • Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition,reprinted 1985, Heinemann Educational Publishers • A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal • Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd. • Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.	

COURSE INFORMATION SHEET

Course code: PH 104
Course title: ELECTRICITY AND MAGNETISM LAB
Pre-requisite(s): Intermediate Physics
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 R. Kumar

ELECTRICITY AND MAGNETISM LAB	L-T-P-C [0-0-4-2]
1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses. 2. To study the characteristics of a series RC Circuit. 3. To determine an unknown Low Resistance using Potentiometer. 4. To determine an unknown Low Resistance using Carey Foster's Bridge. 5. To compare capacitances using De'Sauty's bridge. 6. Measurement of field strength B and its variation in a solenoid (determine dB/dx) 7. To verify the Thevenin and Norton theorems. 8. To verify the Superposition, and Maximum power transfer theorems. 9. To determine self inductance of a coil by Anderson's bridge. 10. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width. 11. To study the response curve of a parallel LCR circuit and determine its (a) Anti- resonant frequency and (b) Quality factor Q. 12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer 13. Determine a high resistance by leakage method using Ballistic Galvanometer. 14. To determine self-inductance of a coil by Rayleigh's method. 15. To determine the mutual inductance of two coils by Absolute method. **Reference Books** • Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, AsiaPublishing House • A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal • Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers • Engineering Practical Physics, S.Panigrahi and B.Mallick, 2015, Cengage Learning. • A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, VaniPub.	

Semester II

COURSE INFORMATION SHEET

Course code: PH 105
Course title: MATHEMATICAL PHYSICS-I
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 4 L: 3 T: 1 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: II
Branch: PHYSICS
Name of Teacher: Dr. S. Keshri

Theory: 50 Lectures

Code: PH 105	**Title: MATHEMATICAL PHYSICS-I**	**L-T-P-C [3-1-0-4]**
Course Objectives: 1. To give students an understanding of expressing periodic functions as discrete Fourier series, and complex representation of Fourier series. 2. To provide fundamental concepts for solving ordinary differential equations which is required to understand the formulation of specialized courses in Physics. 3. To familiarize students with some special integrals and their solutions which frequently appear while modeling physical systems. 4. To train to estimate various errors in solving equations due to approximations or uncertainty in initial conditions. 5. To introduce the concepts of partial differential equations and their applications in various problems in physics. **Course Outcomes:** The student should be able to 1. Determine Fourier series of a given periodic function by evaluating Fourier coefficients. 2. Analyze first-order and second-order differential equations and recognize special functions as solutions of some differential equations. 3. Identify special integrals. 4. Calculate standard errors while solving equations. 1. Solve partial differential equations using classical solution methods.		
Module-1	**Fourier Series**: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.	**10**
Module- 2	Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions ($J_o(\mathbf{x})$ and $J_1(x)$) and Orthogonality.	**10**
Module-3	**Some Special Integrals:** Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral). **Theory of Errors:** Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope and intercept of a fitted line.	**10**

Module-4	**Partial Differential Equations**: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.	**10**
Module-5	**Orthogonal Curvilinear Coordinates:** Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.	**10**

Text Books:

1. T1: Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. T2: Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
3. T3: Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.

Reference Books:

1. R1: Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
2. R2: Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
3. R3: Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
4. R4: Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

Gaps in the syllabus (to meet Industry/Profession requirements)
POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

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
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz	10+10
Teacher’s assessment	5

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

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					
	a	b	c	d	e	f
1	H	H	H	L	M	L
2	M	H	H	L	L	L
3	H	M	M	M	M	M
4	M	H	M	M	H	M
5	H	H	H	L	H	L

Course Outcome #	Course Objectives				
	A	B	C	D	E
1	H	M	M	M	M
2	L	H	L	L	M
3	L	M	H	M	M
4	H	L	H	H	L
5	H	M	M	L	H

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			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Module No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		I	**Fourier Series**: Periodic functions. Orthogonality of sine and cosine functions,	T1,T2			PPT Digi Class/Chalk-Board	
1	L2			Dirichlet Conditions (Statement only).	T1, T2			PPT Digi Class/Chalk-Board	

1	L3-L4			Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients.	T1, T2			PPT Digi Class/Chalk-Board	
2	L5			Complex representation of Fourier series. Expansion of functions with arbitrary period.	T1, T3			PPT Digi Class/Chalk-Board	
2	L6-L8			Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions.	T1, T3			PPT Digi Class/Chalk-Board	
2	L9-L10			Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.	T2			PPT Digi Class/Chalk-Board	
3	L11-L13			Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations.	T1, T3			PPT Digi Class/Chalk-Board	
3	L14-L16		II	Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality.	T1, T3			PPT Digi Class/Chalk-Board	
3	L17-L18			Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function,	T1, T3			PPT Digi Class/Chalk-Board	
4	L19-L20			Simple recurrence relations. Zeros of Bessel Functions ($J_o(x)$ and $J_1(x)$) and Orthogonality.	T1, T3			PPT Digi Class/Chalk-Board	
4	L21-22			**Some Special Integrals:** Beta and Gamma Functions and Relation between them.	T1, T3			PPT Digi Class/Chalk-Board	
5	L23-24			Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).	T1, T3			PPT Digi Class/Chalk-Board	
5	L25-L26		III	**Theory of Errors:** Systematic and Random Errors.	T1, T3			PPT Digi Class/Chalk-Board	
6	L27-L28			Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit.	T1, T3			PPT Digi Class/Chalk-Board	
6-7	L29-			Error on the slope and intercept of a fitted line.	T1, T3			PPT Digi Class/Chalk-Board	

	L30								
	L31 - L32		IV	**Partial Differential Equations**: Solutions to partial differential equations, using separation of variables.. Diffusion Equation.	T1, T3			PPT Digi Class/Chalk-Board	
	L33 - L35			Laplace's Equation in problems of rectangular,	T1, T3			PPT Digi Class/Chalk-Board	
	L36 - L39			Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes.	T1, T3			PPT Digi Class/Chalk-Board	
	L40			Cylindrical and spherical symmetry	T1, T3			PPT Digi Class/Chalk-Board	
	L41 - L43		V	**Orthogonal Curvilinear Coordinates:** Orthogonal Curvilinear Coordinates.	T1, T2			PPT Digi Class/Chalk-Board	
	L44 - L46			Derivation of Gradient, Divergence.	T1, T3			PPT Digi Class/Chalk-Board	
	L47 - L48			Curl and Laplacian in Cartesian,	T1, T3			PPT Digi Class/Chalk-Board	
	L49 - L50			Spherical and Cylindrical Coordinate Systems.	T1, T3			PPT Digi Class/Chalk-Board	

COURSE INFORMATION SHEET

Course code: PH 106
Course title: WAVES AND OPTICS
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 4 L:3 T: 1 P: 0
Class schedule per week: 3
Class: I.M.Sc.
Semester / Level: II
Branch: PHYSICS
Name of Teacher:Dr Nishi Srivastava

Theory: 50 Lectures

Code: PH 106	**Title: WAVES AND OPTICS**	**L-T-P-C [3-1-0-4]**

Course Objectives: This course enables the students

A.	To provide thorough knowledge of superposition principle, superposition of collinear and perpendicular oscillations; and basic information about waves
B.	To appreciate the variation in velocity of waves and formation of standing waves.
C.	To understand the concept of interference and instruments based on this phenomenon.
D.	To know the concept of diffraction, its theory and classes
E.	To understand the polarized light and its basic principles.

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

A.	Be able to explain superposition principle, formation of Lissajous figure and classes of waves
B.	Be able to understand changes in waves and characteristics of standing waves
C.	Be able to explain the optical phenomenon interference and working of instruments based on this phenomenon
D.	Get familiar with optical phenomenon diffraction and various theory explaining it
E.	Acquire knowledge of polarization, various class of polarized light and its construction

Module-1	**Superposition of Collinear Harmonic oscillations**: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. **Superposition of two perpendicular Harmonic Oscillations**: Graphical and Analytical Methods Lissajous Figures with equal an unequal frequency and their uses. **Wave Motion:** Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves.	12
Module-2	**Velocity of Waves:** Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction. **Superposition of Two Harmonic Waves**: Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes.Superposition of N Harmonic Waves. **Wave Optics:** Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.	12
Module-3	**Interference:** Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index **Interferometer**: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.	12
Module-4	**Diffraction:** Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. (Qualitative discussion only)	10

	Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. **Fresnel Diffraction**: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.	
Module-5	**Polarization:** Unpolarised light, linear, circular, eliptical polarized light, Malus law, Polarisation by reflection, refraction, and scattering, double refraction, Nicol's prism, Babinet compensator, Jones vector, Jones matrices.	4

Text Books

T1: Optics, Ajoy Ghatak, 2008, Tata McGraw Hill

Reference Books

R1: Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
R2: Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
R3: Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
R4: The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
R5: The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
R6: Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	Y
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 Sem Examination Marks	50
Quiz	10+10
Teacher's assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√	√	
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
A	H	H	M	M	M
B	H	H	M	M	L
C	M	L	H	M	L
D	L	M	M	H	L
E	L	L	M	L	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	1	2	3	4	5	6
1	H	H	M	M	H	H
2	H	H	M	M	H	H
3	H	H	M	M	H	H
4	H	H	M	M	H	H
5	H	H	M	M	H	H

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	-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1-L4			Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.	T1,R1, R4				
	L5-L8			Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.	T1,R4				
	L9-L12			Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling)	T1,R1, R5				

				Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves.					
	L13-L16			Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction.	T1,R3				
	L17-L20			Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves.	T1,R3				
	L21-L24			Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.	T1,R5				
	L25-L26			Division of amplitude and wavefront. Young's double slit experiment.	T1,R5				
	L27-L28			Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment.	T1,R5				
	L29-L30			Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes);	T1,R6				
	L31-L32			Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index	T1,R6				
	L33-L36			Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.	T1,R6				
	L37-L39			Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. (Qualitative discussion only)	T1,R3				
	L40-L42			Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits.	T1,R3				

				Diffraction grating. Resolving power of grating.					
	L43-L44			Fresnel’s Assumptions. Fresnel’s Half-Period Zones for Plane Wave. Explanation of Rectilinear, Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel’s Integral,	T1,R3				
	L45-L46			Fresnel diffraction pattern of a straight edge, a slit and a wire	T1,R6				
	L47-L48			Unpolarised light, linear, circular, eliptical polarized light, Malus law, Polarisation by reflection, refraction, and scattering,	T1,R6				
	L49-50			double refraction, Nicol's prism, Babinet compensator, Jones vector, Jones matrices.	T1, R2				

COURSE INFORMATION SHEET

Course code: PH 107
Course title: MATHEMATICAL PHYSICS-I LAB
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week: 4
Class: I.M.Sc.
Semester / Level: II
Branch: PHYSICS
Name of Teacher:

MATHEMATICAL PHYSICS-I LAB

Course Objectives:

1. To give an overview of computer structure and organization.
2. To introduce the fundamentals of scientific computing.
3. To introduce the basics of programming in C/C^{++} .
4. To train students to solve linear equations and do interpolation by writing programs in C/C^{++} .
5. To teach to solve differential and integral equations using C/C++ programming and introduce Monte-Carlo method.

Course Outcomes: Students should be able to:

1. Understand the computer structure.
2. Significance of the form of input data to solve equations in computer.
3. Write simple programs in C/C++ .
4. Use C/C++ programming to solve problems like finding roots of linear equations, transcendental equations, etc.
5. Perform numerical integration and numerical differentiation on computer.

Topics	**Description with Applications**	**L-T-P-C [0-0-4-2]**
Introduction to Numerical computation software Scilab	Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting (2), Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization (2) User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays (2) an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program (2).	
Curve fitting, Least square fit, Goodness of fit, standard deviation Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems	Ohms law to calculate R, Hooke's law to calculate spring Constant Solution of mesh equations of electric circuits (3 meshes) Solution of coupled spring mass systems (3 masses)	
Generation of Special functions using User defined functions in Scilab	Generating and plotting Legendre Polynomials Generating and plotting Bessel function	

Solution of ODE	First order differential equation	
First order Differential equation Euler,	• Radioactive decay • Current in RC, LC circuits with DC source	
modified Euler and Runge-Kutta second order methods Second order differential equation Fixed difference method	• Newton's law of cooling • Classical equations of motion • Second order Differential Equation • Harmonic oscillator (no friction) • Damped Harmonic oscillator • Over damped • Critical damped • Oscillatory • Forced Harmonic oscillator • Transient and Steady state solution	
	• Apply above to LCR circuits also • Solve $x^2 \frac{d^2y}{dx^2} - 4x(1+x)\frac{dy}{dx} + 2(1+x)y = x^3$ with the boundary conditions at $x = 1, y = \frac{1}{2}e^2, \frac{dy}{dx} = -\frac{3}{2}e^2 - 0.5,$ in the range $1 \le x \le 3$. Plot y and $\frac{dy}{dx}$ against x in the given range on the same graph.	
Partial differential equations Using Scicos / xcos	Partial Differential Equation: • Wave equation • Heat equation • Poisson equation • Laplace equation • Generating square wave, sine wave, saw tooth wave • Solution to harmonic oscillator • Study of beat phenomenon • Phase space plots	

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
- Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
- First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett
- Computational Physics, D.Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández. 2014 Springer
- Scilab by example: M. Affouf 2012, ISBN: 978-1479203444
- Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company
- Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
- www.**scilab**.in/textbook_companion/generate_book/291

COURSE INFORMATION SHEET

Course code: PH 108
Course title: WAVES AND OPTICS LAB
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week:
Class: I.M.Sc.
Semester / Level: II
Branch: PHYSICS
Name of Teacher: Dr Nishi Srivastava

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WAVES AND OPTICS LAB

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2 –T law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. Familiarization with: Schuster`s focusing; determination of angle of prism.
5. To determine refractive index of the Material of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
7. To determine the wavelength of sodium source using Michelson's interferometer.
8. To determine wavelength of sodium light using Fresnel Biprism.
9. To determine wavelength of sodium light using Newton's Rings.
10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
11. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

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

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Semester III

COURSE INFORMATION SHEET

Course code: PH 201
Course title: THERMAL PHYSICS
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 4 L: 3 T:1 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: III
Branch: PHYSICS
Name of Teacher: Dr Nishi Srivastava

Theory: 50 Lectures

Code: PH 201	**Title: THERMAL PHYSICS**	**L-T-P-C [3-1-0-4]**

Course Objectives: This course enables the students

A.	To understand the basic laws, concepts of thermodynamics and heat engines
B.	To explains the second law of thermodynamics with concept of entropy, Carnot cycle and thermodynamic potentials
C.	To understand the derivation of Maxwell's thermodynamic relations
D.	To enlighten the kinetic theory of gases and distribution of velocities
E.	To appreciate behavior of ideal and real gas and detailed discussion about it.

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

A.	Be able to explain the laws of thermodynamics, reversible and irreversible processes and heat engines.
B.	Acquire knowledge of entropy, Carnot cycle and thermodynamic potential definitions
C.	Get familiar with Maxwell's thermodynamic relations and its applications.
D.	Be able to appreciate the kinetic theory of gases, equipartition of energy and molecular collision
E.	Be able to understand difference in ideal and real gases, laws and theory related with real gas.

Module-1	**Introduction to Thermodynamics** **Zeroth and First Law of Thermodynamics**: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient. **Second Law of Thermodynamics**: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.	**10**
Module-2	**Entropy**: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. **Thermodynamic Potentials**: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations	**10**
Module-3	**Maxwell's Thermodynamic Relations**: Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of C_p-C_v, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.	**8**

Module-4	**Kinetic Theory of Gases** **Distribution of Velocities**: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. **Molecular Collisions**: Mean Free Path. Collision Probability. Estimates of Mean FreePath. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance	**12**
Module-5	**Real Gases:** Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule- Thomson Cooling.	**10**

Text Books:

T1: Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
T2: A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press

Reference Books:

R1: Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
R2: Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
R3: Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
R4: Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
R5: Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	Y
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 Sem Examination Marks	50
Quiz	10+10
Teacher's assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√	√	
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
A	H	H	L	L	M
B	H	H	L	L	M
C	L	L	H	L	L
D	L	L	L	H	M
E	L	L	L	M	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	1	2	3	4	5	6
1	H	H	H	M	H	H
2	H	H	H	M	H	H
3	H	H	H	M	H	H
4	H	H	H	M	H	H
5	H	H	H	M	H	H

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	-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	TextBook / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1-L3			Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form,	T1,T2,R2				
	L4-L6			Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and	T1,T2,R2				

				Adiabatic Processes, Compressibility and Expansion Co-efficient.					
	L7-L8			Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance,	T1,T2, R2				
	L9-L10			2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.	T1,T2,R1				
	L11-L13			Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy.	T1,R4				
	L14-L16			Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.	T1,R1				
	L17-L18			Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work,	T1,R4				
	L19-L20			Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations	T1,R5				
	L21-L22			Derivations and applications of Maxwell's Relations,	T1, R2				
	L23-L28			Maxwell's Relations:(1) Clausius Clapeyron equation, (2)	T1, R2				

				Values of C_p-C_v, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.					
	L29-L31			Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler	T1,R4				
	L32-L34			Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases.	T1,R3				
	L35-L37			Mean Free Path. Collision Probability. Estimates of Mean FreePath.	T1,R4				
	L38-L40			Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance	T1,R4				
	L41-L43			Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO2 Gas.	T1,T2				
	L44-L46			Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States.	T1,T2				
	L47-50			Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule- Thomson Cooling.	T1, T2				

COURSE INFORMATION SHEET

Course code: PH 202
Course title: DIGITAL SYSTEMS AND APPLICATIONS
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 4 L:4 T: 0 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: III
Branch: PHYSICS
Name of Teacher: Dr Ela Sinha

Theory: 50 Lectures

Code PH 202	Title: DIGITAL SYSTEMS AND APPLICATIONS	L-T-P-C 4-0-0-4]
Course objectives : Students will try to learn 1. To understand number representation and conversion between different representation in digital electronic circuits 2. To analyze logic processes and implement logical operations using combinational logic circuits. 3. To understand characteristics of memory and their classification. 4. To understand concepts of sequential circuits and to analyze sequential systems. 5. To understand basic architecture of 16 bit and 32 bit microprocessors. **Course outcomes:** After successful completion of the course student will be able:- 1. To develop a digital logic and apply it to solve real life problems. 2. To analyze, design and implement combinational logic circuits. 3. To classify different semiconductor memories. 4. To analyze, design and implement sequential logic circuits. 5. To write programs to run on 8085 microprocessor based systems.		
Module-1	**Introduction to CRO:** Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. **Integrated Circuits** (Qualitative treatment only): Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs.	**10**
Module-2	**Digital Circuits:** Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. **Boolean algebra:** De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.	**10**
Module-3	**Data processing circuits**: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. **Arithmetic Circuits:** Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. **Sequential Circuits:** SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. **Timers**: IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator.	**10**
Module-4	**Shift registers:** Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in Parallel-out Shift Registers (only up to 4 bits). **Counters(4 bits):** Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter. **Computer Organization**: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.	**10**
Module-5	**Intel 8085 Microprocessor Architecture:** Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI. **Introduction to Assembly Language:** 1 byte, 2 byte & 3 byte instructions.	**10**

Text Books:

1. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw (T1)
2. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.(T2)
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.(T3)
4. Digital Electronics G K Kharate ,2010, Oxford University Press(T4)

Reference Books

1. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning (R1)
2. Logic circuit design, Shimon P. Vingron, 2012, Springer.(R2)
3. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.(R3)
4. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill (R4)
5. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall. (R5)

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√		
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
A	H	H	M	H	H
B	M	H	M	L	H
C	M	M	H	M	H
D	M	M	M	H	H
E	H	M	L	L	H

Mapping of Course Outcomes onto Program Outcomes

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

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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
	1		**1.**	Block Diagram of CRO. Electron Gun	**T1**			PPT Digi Class/Chock-Board	
	2-5			Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.	**T1, T2,R1**			PPT Digi Class/ chock-Board	
	6,7			Active & Passive components. Discrete components. Wafer. Chip.	**T2,T4**			PPT Digi Class/Chock -Board	
	8-10			Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of	**T2,T4, R4**			PPT Digi Class/Chock -Board	

				ICs. Examples of Linear and Digital lCs.					
	11		**2.**	Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion.	**T1,T2**			PPT Digi Class/Chock -Board	
	12-15			BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers.	**T1, T3**			PPT Digi Class/Chock -Board	
	16-18			De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms.	**T1, T4**			PPT Digi Class/Chock -Board	
	19-20			Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.	**T1, R1**			PPT Digi Class/Chock -Board	
	21-25		**3.**	Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. **Arithmetic Circuits:** Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor.	**T4**			PPT Digi Class/Chock -Board	
	26-28			SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.	**T3, R4**			PPT Digi Class/ Chock-Board	
	29-30			**Timers**: IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator	T4, R3			PPT Digi Class/ Chock-Board	
	31-32		**4.**	Serial-in-Serial-out, Serial-in-Parallel-out	**T2,T3**			PPT Digi Class/ Chock-Board	
	33-35			Parallel-in-Serial-out and Parallel-in Parallel-out Shift Registers (only up to 4 bits)	**T2,T3**			PPT Digi Class/ Chock -Board	
	36-37			Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter	**T1, T4**			PPT Digi Class/ Chock-Board	
	38-40			**Computer Organization**: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.	**T1, T4**			PPT Digi Class/ Chock-Board	

	41-42		**5.**	Main features of 8085. Block diagram. Components. Pin-out diagram.	**T3, R1**			PPT Digi Class/ Chock -Board	
	43-45			.Registers. ALU. Memory. Stack memory. Timing Control circuitry	**T2, T4**			PPT Digi Class/ Chock-Board	
	46-48			Timing states. Instruction cycle, Timing diagram of MOV and MVI.	**T1,T2**			PPT Digi Class/ Chock -Board	
	49-50			1 byte, 2 byte & 3 byte instructions.	**T1, R4**			PPT Digi Class/ Chock -Board	

COURSE INFORMATION SHEET

Course code: PH 203
Course title: Classical Dynamics
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 5 L: 4 T: 1 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: III
Branch: PHYSICS
Name of Teacher: Dr Rishi Sharma

Code PH 203	Title: Classical Dynamics	L-T-P-C [4-1-0-5]

Course Objectives This course enables the students:

A.	To recallthe concepts of Newtonian Mechanics and Electrodynamics.
B.	To explain the concepts of generalized coordinates and to introduce the formulation of Lagrangian and Hamiltonian Mechanics.
C.	To develop the conceptsof potential energy and small amplitude oscillations.
D.	To develop the foundation of special theory of relativity and Minkowski space.
E.	To build the concepts of fluid mechanics.

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

1.	Solve the problems of Newtonian Mechanics and Electrodynamics.
2.	Illustrate the formulation of Lagrangian and Hamiltonian mechanics and solve the related problems.
3.	Solve the problems of small amplitude oscillations.
4.	Explain the space-time diagrams, time-dilation, length contraction and twin paradox, four-velocity and acceleration,metric and alternating tensors,four-momentum and energy-momentum relation etc., and apply these to solve the problems.
5.	Illustrate the formulation of the basic equations in fluid mechanics like continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation, Navier-Stokes equation, etc.

Module-1	Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and gyrofrequency, motion in crossed electric and magnetic fields.	**5**
Module-2	Generalized coordinates and velocities, Hamilton's principle, Lagrangian and the Euler-Lagrange equations, one-dimensional examples of the Euler-Lagrange equations- one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity; applications to simple systems such as coupled oscillators Canonical momenta & Hamiltonian. Hamilton's equations of motion. Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momentum and energy.	**15**
Module-3	Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses connected in a linear fashion to (N -1) - identical springs.	**10**
Module-4	Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction and twin paradox. Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle	**15**
Module-5	Density ρ and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe, Navier-Stokes equation, qualitative description of turbulence, Reynolds number	**5**

Text books:

1. Classical Mechanics by H. Goldstein, Pearson Education Asia.
2. Classical Mechanics by N. C. Rana and P. S. Joag, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.

Reference books:

1. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
2. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
3. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
4. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
5. Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
6. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
7. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	25
End Sem Examination	50
Quiz I and Quiz II	10+10
Teacher's assessment	5

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

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**	**5**
A	H	M	M	M	M
B	-	H	M	M	L
C	M	M	H	L	-
D	M	M	L	H	-
E	M	-	-	-	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	a	b	c	d	e	f
1	M	L	-	H	M	H
2	H	H	H	H	M	H
3	M	M	M	H	M	H
4	H	H	H	H	H	H
5	M	L	L	H	M	H

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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
	L1-L5			Review of Newtonian Mechanics	T1,T2				
	L6- L10			Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and gyrofrequency, motion in crossed electric and magnetic fields	T1,T2				
	L11-L13			Generalized coordinates and velocities, Hamilton's principle, Lagrangian and the Euler-Lagrange equations	T1,T2				
	L14- L16			one-dimensional examples of the Euler-Lagrange equations- one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity; applications to simple systems such as coupled oscillators	T1,T2				
	L17-L22			Canonical momenta & Hamiltonian. Hamilton's equations of motion.Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple	T1,T2				

				Harmonic Oscillations					
	L23-L25			particle in a central force field-conservation of angular momentum and energy	T1,T2				
	L26-L28			Minima of potential energy and points of stable equilibrium,	T1,T2				
	L29- L32			expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations	T1,T2				
	L33-L35			example of N identical masses connected in a linear fashion to (N -1) - identical springs.	T1,T2				
	L36,L37			Postulates of Special Theory of Relativity. Lorentz Transformations.	T1,T2				
	L38-L42			Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction and twin paradox	T1,T2				
	L43-L46			Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four-vector perspective.	T1,T2				
	L47-L50			Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle.	T1,T2				
	L51-L53			Density ρ and pressure P in a fluid, an element of fluid and its velocity,	T1,T2				
	L54-L56			continuity equation and mass conservation, stream-lined motion, laminar flow	T1,T2				
	L57-L60			Poiseuille’s equation for flow of a liquid through a pipe, Navier-Stokes equation, qualitative description of turbulence, Reynolds number.	T1,T2				

<u>**COURSE INFORMATION SHEET**</u>

Course code: PH 204
Course title: THERMAL PHYSICS LAB
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week:
Class: I.M.Sc.
Semester / Level: III
Branch: PHYSICS
Name of Teacher: Dr Nishi Srivastava

THERMAL PHYSICS LAB	**L-T-P-C [0-0-4-2]**
1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method. 2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus. 3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method. 4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method. 5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT). 6. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions. 7. To calibrate a thermocouple to measure temperature in a specified Range using (1)Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature. **Reference Books** • Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House • A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal • Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers • A Laboratory Manual of Physics for undergraduate classes,D.P.Khandelwal,1985, Vani Pub.	

<u>**COURSE INFORMATION SHEET**</u>

Course code: PH 205
Course title: DIGITAL SYSTEMS AND APPLICATIONS LAB
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week:
Class: I.M.Sc.
Semester / Level: III
Branch: PHYSICS
Name of Teacher: Dr Ela Sinha

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

DIGITAL SYSTEMS AND APPLICATIONS LAB

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
2. To test a Diode and Transistor using a Multimeter.
3. To design a switch (NOT gate) using a transistor.
4. To verify and design AND, OR, NOT and XOR gates using NAND gates.
5. To design a combinational logic system for a specified Truth Table.
6. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
7. To minimize a given logic circuit.
8. Half Adder, Full Adder and 4-bit binary Adder.
9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
11. To build JK Master-slave flip-flop using Flip-Flop ICs
12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
14. To design an astable multivibrator of given specifications using 555 Timer.
15. To design a monostable multivibrator of given specifications using 555 Timer.
16. Write the following programs using 8085 Microprocessor
    a) Addition and subtraction of numbers using direct addressing mode
    b) Addition and subtraction of numbers using indirect addressing mode
    c) Multiplication by repeated addition.
    d) Division by repeated subtraction.
    e) Handling of 16-bit Numbers.
    f) Use of CALL and RETURN Instruction.
    g) Block data handling.
    h) Other programs (e.g. Parity Check, using interrupts, etc.).

Reference Books:

- Modern Digital Electronics, R.P. Jain, 4^{th} Edition, 2010, Tata McGraw Hill.
- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
- Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.
- Microprocessor 8085:Architecture, Programming and interfacing, A. Wadhwa, 2010, PHI Learning.

Semester IV

COURSE INFORMATION SHEET

Course code: PH 206
Course title: MATHEMATICAL PHYSICS-II
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 4 L: 3 T: 1 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: IV
Branch: PHYSICS
Name of Teacher: Dr. Madhu Priya

Theory: 50 Lectures

Code: **PH 206**	**Title: MATHEMATICAL PHYSICS-II** *The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.*	**L-T-P-C** **[3-1-0-4]**

Course Objectives

This course enables the students:

A	To understand the fundamental concepts of complex analysis and explain their role in applied physics.
B.	To use the Cauchy Residue Theorem to evaluate integrals and sum series
C.	To have an understanding of integral Fourier, inverse Fourier transforms and convolution theorem.
D	To learn to calculate Laplace transforms of elementary functions.

Course Outcomes

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

1.	Evaluate integrals along a path in the complex plane and obtain Taylor and Laurent expansions of simple functions.
2.	To solve problems using complex analysis techniques for various physics problems.
3.	To calculate the Fourier transform or inverse transform of common functions including sinusoidal, gaussian, delta, etc.
4.	To solve second-order ordinary differential equations using Laplace transforms and inverse Laplace transformation.

Module-1 -2	**Complex Analysis**: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integral	20
Module-3- 5	**Integrals Transforms**: Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations. **Laplace Transforms:** Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta	30

	function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.	

Text books:

T1**:** Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press

T2: Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications

Reference books:

R1: Complex Variables, A.S.Fokas & M.J.Ablowitz, 8th Ed., 2011, Cambridge Univ. Press

R2: Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press

R3: Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill

R4: First course in complex analysis with applications, D.G. Zill and P.D. Shanahan,1940, Jones & Bartlett

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	60
Assignment / Quiz (s)	15

AssessmentCompoents	CO1	CO2	CO3	CO4	
Mid Sem Examination Marks	√	√			
End Sem Examination Marks	√	√	√	√	
Quiz I	√				
Quiz 2			√		

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	c	d
1	H	M	L	L
2	M	H	L	L
3	L	L	H	M
4	L	L	M	H

Mapping of Course Outcomes onto Program Outcomes

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

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			
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 No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	TextBook /References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1-2	L1-L7			Complex Numbers and their, Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers, Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions.	T1, T2, R1, R2	1, 2		PPT Digi Class/Chock-Board	
2-4	L8-L16			Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch	T1, T2, R1, R2	1,2			

				cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion.					
5	L17-L20			Residues and Residue Theorem. Application in solvingDefinite Integrals.	T1, T2, R3, R4	1,2			
6-9	L21-L35			Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.	T1, T2	3			
9-14	L36-L50			Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1 st and 2nd order Derivatives and Integrals of Functions, derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.	T1,T2	4			

COURSE INFORMATION SHEET

Course code: PH 207
Course title: ELEMENTS OF MODERN PHYSICS
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 4 L: 3 T: 1 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: IV
Branch: PHYSICS
Name of Teacher: Dr. S. Lahiri

Theory: 50 Lectures

Code: PH 207	**Title: ELEMENTS OF MODERN PHYSICS**	**L-T-P-C [3-1-0-4]**

Course Objectives

This course enables the students:

A.	To teach about the history of Quantum Mechanics and appreciate the necessity for initiating such a new theory
B.	To help them become conversant with the basic mathematical tools of Quantum Mechanics.
C.	To introduce preliminary concepts in nuclear physics and radioactivity.
D.	To venture further into nuclear physics, and establish familiarity with the theories of stellar energy and lasers.

Course Outcomes

After the completion of this course, students will be:

1.	Understanding of concepts leading to the advent of quantum theory.
2.	Working out simple examples using Schrodinger equation.
3.	Getting a good grasp on the theory and simple numericals on radioactivity.
4.	Knowledge on nuclear fission/fusion and working principle of lasers.

Module-1	Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions. Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction.	**15**
Module- 2 & 3	Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension. One dimensional infinitely rigid box-energy eigen values and eigen functions, normalization; Quantum dot as example; Quantum mechanical scattering and tunneling in one dimension-across a step potential & rectangular potential barrier.	**15**
Module-4	Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers. **Radioactivity:** stability of the nucleus; Law of radioactive decay; Mean life and half-life;	**10**

	Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.	
Module-5	Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions). **Lasers:** Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing.	**10**

Reference Books:

- Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
- Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
- Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
- Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
- Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill
- Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan

Additional Books for Reference

- Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
- Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
- Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
- Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
- Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4
A	H	M	-	-
B	M	H	M	L
C	L	M	H	M
D	M	H	M	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	a	b	c	d	e	f
1	H	H	M	M	L	H
2	H	H	M	M	H	H
3	H	H	M	M	M	H
4	H	H	M	M	L	H

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch No.	Topics to be covered	Text Book / References	Cos mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1-3			Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment.	T1, R1				
2	L4-6			Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions.	T1, R1				
3	L7-10			Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction.	T1, R1				
4	L11-13			Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles;	T1, R1				
5		L14-16		Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.					
6		L17-20		One dimensional infinitely rigid box- energy eigen values and eigen functions, normalization; Quantum dot as example; Quantum mechanical scattering and tunneling in one dimension-across a step potential & rectangular potential barrier.					
7	L21-			Size and structure of atomic nucleus					

	23			and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle.					
8	L24-26			Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers					
9	L27-30			stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay-energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.					
10	L31-33			Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).					
11	L34-36			Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing.					

COURSE INFORMATION SHEET

Course code: PH 208
Course title: ANALOG SYSTEMS AND APPLICATIONS
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 4 L: 3 T: 1 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: IV
Branch: PHYSICS
Name of Teacher: Dr. D. K. Singh

Theory: 50 Lectures

Code: PH 208	Title: Analog Systems and Applications	L-T-P-C [3-1-0-4]

Course Objective :

- To provide a pedagogic introduction of the physics of solid state electronic devices and their applications. Power supply circuits and their operational principles are also introduced.
- The fundamentals of bipolar junction transistor, its biasing methodology are dealt with extensively including amplifiers built around it.
- Coupling and cascading amplifier sections, providing feedback as a means to enhancing stability of amplifiers and positive feedback as a handle to turn the amplifier into oscillator are the key ideas to be introduced.
- Light is thrown on integrated circuit operational amplifiers, their remarkable features and parameters. Some of the important and basic op-amp circuits are introduced and treated using the concept of virtual ground.
- A few digital to analog and analog to digital data conversion techniques are introduced to develop some understanding about the use of op-amps in data conversion.

Course Outcome:

- The students get acquainted with the basic building blocks of a simple data acquisition system.
- Students would develop a sufficiently wide understanding of the op-amp as a composite amplifier unit and the tweaks to achieve various signal processing requirements.
- Students learn to cascade amplifiers to achieve desired voltage gains and also learn to play with feedback network for turning the amplifier into an oscillator.
- The comprehensive understanding of the transistor as a basic building block of all amplifiers would enable the students to appreciate underlying marvel in the three terminal device. Students would be able to design amplifiers around it.
- Understanding the basic physics behind the operation of electronic devices, their characteristics and applications. Enable the understanding of simple building blocks of electronic power supply circuits.

Module-1	**Semiconductor Diodes:** P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode. **Two-terminal Devices and their Applications:** (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell.	**15**
Module-2	**Bipolar Junction transistors:** n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. **Amplifiers:** Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers.	**10**

Module-3	**Coupled Amplifier:** Two stage RC-coupled amplifier and its frequency response. **Feedback in Amplifiers:** Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **Sinusoidal Oscillators:** Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators	**10**
Module-4	**Operational Amplifiers (Black Box approach):** Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. **Applications of Op-Amps:** (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator	**10**
Module-5	**Conversion:** Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation)	**5**

Text books:

T1: Thomas L. Floyd. ELECTRONIC. DEVICES. 9th Edition. Prentice Hall.

T2: Louis Nashelsky and Robert Boylestad, Electronic Devices and Circuit Theory

Reference books:

R1: Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Y
Tutorials/Assignments	Y
Seminars	Y
Mini projects/Projects	Y
Laboratory experiments/teaching aids	Y
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 Sem Examination Marks	50
Quiz	10+10
Teacher’s assessment	5

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√	√	
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
A	H	M	M	L	H
B	M	H	M	L	H
C	L	L	H	L	L
D	-	L	L	H	H
E	H	M	L	L	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes										
	a	b	c	d	e	f	g	h	i	j	k	l
1	H	M		H	H	H		H	M	M		H
2	H	H		H	H	H		H	M	M		H
3	H	L		M	L	M		H	M	M		H
4	H			H	M	M		M	M	M		H
5	M	H		H	H	H	H	M	M	M		H

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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	TextBook / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		1		T1, R1				
	L2				T1				
	L3				T1				
	L4				T1, R1				
	L5				T1				
	L6				T2, R1				
	L7				T2, R1				
	L8				T2				
	L9				T2				
	L16-18				T2				
	L19				T2				
	L10				T3				
	L11				T3				
	L12				T3				

	L13				T3				
	L14				T3				
	L15				T3				
	L16				T3				
	L17				T3				
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	L50								

COURSE INFORMATION SHEET

Course code: PH 209
Course title: MATHEMATICAL PHYSICS-II LAB
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week:
Class: I.M.Sc.
Semester / Level: IV
Branch: PHYSICS
Name of Teacher: Dr. Madhu Priya

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MATHEMATICAL PHYSICS-II LAB

Scilab/C++ based simulations experiments based on Mathematical Physics problems like

Course Objectives:
1. To introduce Scilab and teach students to use it for various calculations.
2. To train students to do best curve fitting through data points using Scilab.
3. To teach to use Scilab for solving linear equations.
4. To solve ordinary differential equations and partial differential equations using Scilab.
5. To familiarize students with Scicos / Xcos.

Course Outcomes : Students should be able to
1. Write programs in Scilab.
2. Use graphical methods to solve problems like determination of resistance using Ohm's law, etc.
3. Numerically solve coupled equations arising in various physical systems.
4. Obtain numerical solutions of first order and higher order ordinary differential equations arising in problems like radioactive decay, harmonic oscillators, and partial differential equations like diffusion equation, using Scilab.
5. Use Scicos / Xcos to simulate dynamical systems.

</td><td>

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

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1. Solve differential equations:
   $dy/dx = e^{-x}$ with $y = 0$ for $x = 0$
   $dy/dx + e^{-x}y = x^2$
   $d^2y/dt^2 + 2\, dy/dt = -y$
   $d^2y/dt^2 + e^{-t}dy/dt = -y$

2. Dirac Delta Function:
   Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}}\int e^{\frac{-(x-2)^2}{2\sigma^2}}(x+3)dx$, for $\sigma = 1, 0.1, 0.01$ and show it tends to 5.

3. Fourier Series:
   Program to sum $\sum_{n=1}^{\infty}(0.2)^n$
   Evaluate the Fourier coefficients of a given periodic function (square wave)

4. Frobenius method and Special functions:
   $\int_{-1}^{+1} P_n(\mu)P_m(\mu)d\mu = \delta_{n,m}$
   Plot $P_n(x)$, $j_v(x)$
   Show recursion relation

5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.
7. Evaluation of trigonometric functions e.g. sin θ, Given Bessel's function at N points find its value at an intermediate point. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computer integration.
8. Compute the n^{th} roots of unity for n = 2, 3, and 4.
9. Find the two square roots of −5+12j.
10. Integral transform: FFT of e^{-x2}
11. Solve Kirchoff's Current law for any node of an arbitrary circuit using Laplace's transform.
12. Solve Kirchoff's Voltage law for any loop of an arbitrary circuit using Laplace's transform.
13. Perform circuit analysis of a general LCR circuit using Laplace's transform.

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
- Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
- Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
- Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company
- Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
- https://web.stanford.edu/~boyd/ee102/**laplace**_ckts.pdf
- ocw.nthu.edu.tw/ocw/upload/12/244/12handout.pdf

COURSE INFORMATION SHEET

Course code: PH 210
Course title: ELEMENTS OF MODERN PHYSICS LAB
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week:
Class: I.M.Sc.
Semester / Level: IV
Branch: PHYSICS
Name of Teacher: Dr. S. Lahiri

ELEMENTS OF MODERN PHYSICS LAB

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

1. Measurement of Planck's constant using black body radiation and photo-detector
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunneling effect in tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction of single slit.
12. To determine the wavelength of laser source using diffraction of double slits.
13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011,Kitab Mahal

COURSE INFORMATION SHEET

Course code: PH 211
Course title: ALOG SYSTEMS AND APPLICATIONS LAB
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: L: 0 T: 0 P: 4
Class schedule per week:
Class: I.M.Sc.
Semester / Level: IV
Branch: PHYSICS
Name of Teacher: Dr. D. K. Singh

ANALOG SYSTEMS AND APPLICATIONS LAB	L-T-P-C [0-0-4-2]
1. To study V-I characteristics of PN junction diode, and Light emitting diode. 2. To study the V-I characteristics of a Zener diode and its use as voltage regulator. 3. Study of V-I & power curves of solar cells, and find maximum power point & efficiency. 4. To study the characteristics of a Bipolar Junction Transistor in CE configuration. 5. To study the various biasing configurations of BJT for normal class A operation. 6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias. 7. To study the frequency response of voltage gain of a RC-coupled transistor amplifier. 8. To design a Wien bridge oscillator for given frequency using an op-amp. 9. To design a phase shift oscillator of given specifications using BJT. 10. To study the Colpitt`s oscillator. 11. To design a digital to analog converter (DAC) of given specifications. 12. To study the analog to digital convertor (ADC) IC. 13. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain 14. To design inverting amplifier using Op-amp (741,351) and study its frequency response 15. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response 16. To study the zero-crossing detector and comparator 17. To add two dc voltages using Op-amp in inverting and non-inverting mode 18. To design a precision Differential amplifier of given I/O specification using Op-amp. 19. To investigate the use of an op-amp as an Integrator. 20. To investigate the use of an op-amp as a Differentiator. 21. To design a circuit to simulate the solution of a $1^{st}/2^{nd}$ order differential equation. **Reference Books:** • Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill. • OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4^{th} edition, 2000, Prentice Hall. • Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill. • Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson	

Semester V

COURSE INFORMATION SHEET

Course code: PH 301
Course title: QUANTUM MECHANICS AND APPLICATIONS
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 4 L: 3 T: 1 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: V
Branch: PHYSICS
Name of Teacher: Dr. S. K. Mukherjee

Theory: 50 Lectures

Code: **PH 301**	**Title: QUANTUM MECHANICS AND APPLICATIONS**	L-T-P-C [3-1-0-4]

Course Objectives
This course enables the students to:

A.	Define wave functions associated with moving quantum systems and interpret their dynamical variables. Outline the basics of crystallography and define various types of imperfections in crystals.
B.	Define eigenstates and eigenvalues and demonstrate Heisenberg's uncertainty principle . Explain elastic and plastic deformation in solids and summarize the strain hardening mechanisms.
C.	Solve Schrödinger equations associated with quantum mechanical systems. Define ceramics and explain its types and applications.
D.	Illustrate the eigenstates and eigenvalues of hydrogen-like atoms. Define polymers and composites and categorize them on the basis of their applications.
E.	Demonstrate the behaviour of atoms in electric and magnetic fields. 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 wavefunction for any quantum mechanical system and predict its position, momentum and energy a function of time. formulate the Heisenberg & Dirac formulation of quantum mechanics explain various types of imperfections in crystals.
2.	construct Schrodinger equations for any quantum mechanical system in terms of linear combinations of stationary states, and interpret Gaussian wave-packet, measure the position and time of a particle wit limited accuracy.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.	solve square well potential and harmonic oscillator problem and explain the existence of bound states demonstrate angular momentum operators associated with spherical and symmetrical systems. summarize ceramics and its types and relate their applications with properties.
4.	Justify the discrete energy levels of hydrogen-like atoms and explain scattering theory, formulate and so scattering equation. classify polymers and composites based on their properties and applications.
5.	Demonstrate atomic phenomena like, Zeeman effect, Stark effect, etc., and illustrate the existence of different series of spectral lines in the atomic spectra of hydrogen-like atoms apply the Variational principle and WKB Approximation to solve the real problems . Classify nanomaterials, their fabrication techniques and co relate the effects of confinement to nanoscale on their properties.

Module-1	**Time dependent Schrodinger equation** Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.	6

Module-2	**Time independent Schrodinger equation** Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.	10
Module-3	**General discussion of bound states in an arbitrary potential** continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle.	12
Module-4	**Quantum theory of hydrogen-like atoms** time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells.	10
Module-5	**Atoms in Electric & Magnetic Fields** Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only). Pauli's Exclusion Principle. Symmetric & Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.).	12

Text books:

1. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
3. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
4. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
5. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
6. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
7. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press

Reference books:

1. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
2. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
3. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

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 Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	60
Quiz	15
Teachers Assessment	5

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 Outcome #	Program Outcomes					
	a	b	c	d	e	f
1	H	H	H	L	M	L
2	H	H	M	L	L	L
3	H	M	M	L	L	L
4	H	M	M	L	L	L
5	H	H	H	L	H	L

Course Outcome #	Course Objectives				
	a	b	c	d	e
1	H	M	M	M	L
2	M	H	M	M	L
3	M	M	H	L	L
4	M	M	H	L	L
5	M	M	L	L	H

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			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Modul No.	Topics to be covered	Text Book / References	Cos mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		I	Time dependent Schrodinger equation and dynamical evolution of a quantum state	T2	CO-1		PPT Digi Class/Chalk-board	
	L2			Properties of Wave Function. Interpretation of Wave Function, Conditions for Physical Acceptability of Wave Functions.	T2	CO-1		PPT Digi Class/Chalk-Board	
2	L3			Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions.	T1	CO-1		PPT Digi Class/Chalk-Board	
3	L4-L5			Position, momentum and Energy operators; commutator of position and momentum operators;	T1	CO-1		PPT Digi Class/Chalk-Board	
4	L6			Expectation values of position and momentum. Wave Function of a Free Particle.		CO-1		PPT Digi Class/Chalk-Board	
5	L7		II	Hamiltonian, stationary states and energy eigenvalues;	T3	CO-2		PPT Digi Class/Chalk-Board	
5	L8-9			expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions;	T3	CO-2		PPT Digi Class/Chalk-Board	
6	L10-11			General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states;	T1	CO-2		PPT Digi Class/Chalk-Board	

6	L12			Application to spread of Gaussian wave-packet for a free particle in one dimension;	T1	CO-2		PPT Digi Class/Chalk-Board	
6	L13			wave packets, Fourier transforms and momentum space wavefunction		CO-2		PPT Digi Class/Chalk-Board	
7	L15-16			Position-momentum uncertainty principle	T1, T2, T3	CO-2		PPT Digi Class/Chalk-Board	
7	L17-18		III	continuity of wave function,	T1	CO-3		PPT Digi Class/Chalk-Board	
7	L19-20			boundary condition and emergence of discrete energy levels		CO-3		PPT Digi Class/Chalk-Board	
8	L21-22			application to one-dimensional problem-square well potential	T2	CO-3		PPT Digi Class/Chalk-Board	
8	L23-24			Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method	T1, T2,	CO-3		PPT Digi Class/Chalk-Board	
8	L25-26			Hermite polynomials	T2, T3	CO-3		PPT Digi Class/Chalk-Board	
9	L27-28			ground state, zero point energy & uncertainty principle	T1, T3	CO-3		PPT Digi Class/Chalk-Board	
9	L29-30		IV	time independent Schrodinger equation in spherical polar coordinates;	T1	CO-4		PPT Digi Class/Chalk-Board	
9	L31-32			separation of variables for second order partial differential equation	T1	CO-4		PPT Digi Class/Chalk-Board	
10	L33-34			angular momentum operator & quantum numbers	T2	CO-4		PPT Digi Class/Chalk-Board	
10	L35-36			Radial wavefunctions from Frobenius method	T2	CO-4		PPT Digi Class/Chalk-oard	
11	L37			shapes of the	T2	CO-4		PPT Digi Class/Chal	

				probability densities for ground & first excited states				k -Board	
11	L38			Orbital angular momentum quantum numbers l and m; s, p, d,.. shells	T2	CO-4		PPT Digi Class/Chal kBoard	
11	L39-40		V	Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum.	T2	CO-5		PPT Digi Class/Chal k-Board	
12	L41-42			Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton.	T2	CO-5		PPT Digi Class/Chal k-Board	
12	L43-44			Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only). Pauli's Exclusion Principle.	T2	CO-5		PPT Digi Class/Chal k-Board	
13	L45-46			Symmetric & Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States.	T2	CO-5		PPT Digi Class/Chal k-Board	
13	L47-49			Total angular momentum. Vector Model. Spin-orbit coupling in atoms L-S and J-J couplings. Hund's Rule. Term symbols.	T2	CO-5		PPT Digi Class/Chal k-Board	
14	L50			Spectra of Hydrogen and Alkali Atoms (Na etc.)	T2	CO-5		PPT Digi Class/Chal k-Board	

COURSE INFORMATION SHEET

Course code: PH 302
Course title: SOLID STATE PHYSICS
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: L: 4 T: 0 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: V
Branch: PHYSICS
Name of Teacher: Dr. S . K. Rout

Theory: 50 Lectures

Course Objectives

This course enables the students:

A.	To become familiar with the concepts of crystal structure and understand how crystal structure affects X-ray diffraction.
B.	To understand how vibrations of atoms can be quantized and how this is manifested in physical properties like specific heat.
C.	To acquire an understanding of the magnetic and dielectric properties of matter.
D.	To get familiarized with ferroelectricity and understand formation of band gap and classification of solids into metals, semiconductors and insulators on the basis of band gap.
E.	To develop a basic understanding of superconductivity.

Course Outcomes

After the completion of this course, students will be:

1.	Able to differentiate between different crystal structures and predict the X-ray pattern for a particular crystal structure.
2.	Able to apply the concept of phonons to understand the differences between the predictions of classical and quantum theories regarding specific heat of solids.
3.	Able to explain the different theories of magnetism and the principles underlying the dielectric properties of matter.
4.	Able to describe ferroelectricity and the formation of ferroelectric domains and other related phenomena.
5.	Able to distinguish materials based on their band structure and associate the band structure with their electrical properties.

Code: PH 302	**Title: SOLID STATE PHYSICS**	**L-T-P-C [4-0-0-4]**
Module-1	**Crystal Structure:** Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor	**10**
Module-2	**Elementary Lattice Dynamics:** Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law	**10**
Module-3	**Magnetic Properties of Matter:** Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss. **Dielectric Properties of Materials:** Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes	**10**
Module-4	**Ferroelectric Properties of Materials:** Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop. **Elementary band theory:** Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N	**10**

	type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient.	
Module-5	**Superconductivity:** Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)	**10**

Text Books:
1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
3. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India

Reference Books:
1. Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
2. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
3. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
4. Solid State Physics, Rita John, 2014, McGraw Hill
5. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

Gaps in the syllabus (to meet Industry/Profession requirements)
POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

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**
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz (s)	20
Teacher's Assessment	05

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 Program Outcomes

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

Course Outcome #	Course Objectives				
	A	B	C	D	E
1	H	L	M	M	M
2	L	H	M	L	M
3	L	M	H	M	M
4	L	L	M	H	L
5	L	M	M	L	H

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			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Module. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		I	Introduction to Solids	T1, R1	1, 2		PPT Digi Class/Chalk-Board	
1	L2			Amorphous and Crystalline Materials.	T1, T2			PPT Digi Class/Chalk-Board	
1	L3			Lattice TranslationVectors. Lattice with a Basis – Central and Non-Central Elements.	T1, T2			PPT Digi Class/Chalk-Board	

2	L4			Unit Cell. Miller Indices.	T1, T2			PPT Digi Class/Chalk-Board	
2	L5			Reciprocal Lattice.	T1, T2			PPT Digi Class/Chalk-Board	
2	L6			Types of Lattices.	T1, T2			PPT Digi Class/Chalk-Board	
3	L7			Brillouin Zones.	T1, T2			PPT Digi Class/Chalk-Board	
3	L8			Diffraction of X-rays by Crystals. Bragg's Law.	T1, T2			PPT Digi Class/Chalk-Board	
3	L9-L10			Atomic and Geometrical Factor	T1, T2			PPT Digi Class/Chalk-Board	
4	L11		II	Lattice Vibrations and Phonons	T1, T3			PPT Digi Class/Chalk-Board	
4	L12-13			Linear Monoatomicand Diatomic Chains.	T1, T3			PPT Digi Class/Chalk-Board	
5	L14-15			Acoustical and Optical Phonons	T1, T3			PPT Digi Class/Chalk-Board	
5	L16			Qualitative Description of the Phonon Spectrum in Solids.	T1, T3			PPT Digi Class/Chalk-Board	
6	L17			Dulong and Petit's Law	T1, T3			PPT Digi Class/Chalk-Board	
6-7	L18-20			Einstein and Debye theories of specific heat of solids. T^3 law	T1, T3			PPT Digi Class/Chalk-Board	
	L21			Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains.	T1, T3			PPT Digi Class/Chalk-Board	
	L22			Quantum Mechanical Treatment of Paramagnetism.	T1, T3			PPT Digi Class/Chalk-Board	
	L23			Curie's law, Weiss's Theory of Ferromagnetism	T1, T3			PPT Digi Class/Chalk-Board	
	L24			Ferromagnetic Domains. Discussion of B-H Curve.	T1, T3			PPT Digi Class/Chalk-Board	
	L25			Hysteresis and Energy Loss.	T1, T3			PPT Digi Class/Chalk-Board	
	L26			Polarization. Local Electric Field	T1, T3			PPT Digi Class/Chal	

				at an Atom. Depolarization Field.				k-Board	
	L27			Electric Susceptibility. Polarizability. ClausiusMosotti Equation.	T1, T3			PPT Digi Class/Chal k-Board	
	L28			Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion.	T1, T3			PPT Digi Class/Chal k-Board	
	L29			Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant.	T1, T3			PPT Digi Class/Chal k-Board	
	L30			Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes	T1, T3			PPT Digi Class/Chal k-Board	
	L31		III	Ferroelectric Properties of Materials	T1, T2			PPT Digi Class/Chal k-Board	
	L32			Structural phase transition, Classification ofcrystals,	T1, T2			PPT Digi Class/Chal k-Board	
	L33			Piezoelectric effect, Pyroelectric effect, Ferroelectric effect,	T1, T2			PPT Digi Class/Chal k-Board	
	L34-L35			Electrostrictive effect, Curie-Weiss Law,	T1, T2			PPT Digi Class/Chal k-Board	
	L36			Ferroelectric domains, PE hysteresis loop	T1, T2			PPT Digi Class/Chal k-Board	
	L37		IV	Elementary band theory	T1, T2			PPT Digi Class/Chal k-Board	
	L38-L39			Kronig Penny model.	T1, T2			PPT Digi Class/Chal k-Board	
	L40			Band Gap. Conductor, Semiconductor(P and N type) and insulator	T1, T2			PPT Digi Class/Chal k-Board	
	L41-L42			Conductivity of Semiconductor, mobility, Hall Effect.	T1, T2			PPT Digi Class/Chal k-Board	
	L43-44			Measurement of conductivity (04 probe method) & Hall coefficient	T1, T2			PPT Digi Class/Chal k-Board	
	L45		V	Superconductivity: Experimental Results.	T1, T2			PPT Digi Class/Chal k-Board	
	L46			Critical Temperature. Critical magnetic field.Meissner effect.	T1, T2			PPT Digi Class/Chal k-Board	
	L47			Type I and type II Superconductors,	T1, T2			PPT Digi Class/Chal k-Board	

	L48-49			London's Equation and Penetration Depth.	T1, T2			PPT Digi Class/Chalk-Board	
	L50			Isotope effect. Idea of BCS theory (No derivation)	T1, T2			PPT Digi Class/Chalk-Board	

COURSE INFORMATION SHEET

Course code: PH 308
Course title: QUANTUM MECHANICS LAB
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: L: 0 T: 0 P: 4
Class schedule per week: 0x
Class: I.M.Sc.
Semester / Level: V
Branch: PHYSICS
Name of Teacher:

	L-T-P-C [0-0-4-2]
QUANTUM MECHANICS LAB	

Use C/C^{++}/Scilab for solving the following problems based on Quantum Mechanics like

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom: $\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$ where $V(r) = -\frac{e^2}{r}$

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wave functions. Remember that the ground state energy of the hydrogen atom is □ -13.6 eV. Take $e = 3.795\ (eVÅ)^{1/2}$, $\hbar c = 1973$ (eVÅ) and $m = 0.511\times10^6\ eV/c^2$.

2. Solve the s-wave radial Schrodinger equation for an atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential

$$V(r) = -\frac{e^2}{r}e^{-r/a}$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take $e = 3.795\ (eVÅ)^{1/2}$, $m = 0.511\times10^6\ eV/c^2$, and a = 3 Å, 5 Å, 7 Å. In these units $\hbar c = 1973$ (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass m:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$

For the anharmonic oscillator potential

$$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose $m = 940\ MeV/c^2$, $k = 100\ MeV\ fm^{-2}$, b = 0, 10, 30 $MeV\ fm^{-3}$ In these units, cħ = 197.3 MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2\mu}{\hbar^2}[V(r) - E]$$

Where μ is the reduced mass of the two-atom system for the Morse potential

$$V(r) = D\left(e^{-2\alpha r'} - e^{-\alpha r'}\right), \quad r' = \frac{r - r_o}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.
Take: $m = 940\times10^6 eV/C^2$, D = 0.755501 eV, α = 1.44, ro = 0.131349 Å

Laboratory based experiments:

5. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
7. To show the tunneling effect in tunnel diode using I-V characteristics.
8. Quantum efficiency of CCDs

Reference Books:

- Schaum's outline of Programming with C++. J.Hubbard, 2000,McGraw-Hill Publication
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007, Cambridge University Press.
- An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.
- Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
- Scilab Image Processing: L.M.Surhone.2010 Betascript Publishing ISBN:978-6133459274

COURSE INFORMATION SHEET

Course code: PH 309
Course title: SOLID STATE PHYSICS LAB
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: **2** L: 0 T: 0 P: 4
Class schedule per week:
Class: I.M.Sc.
Semester / Level: V
Branch: PHYSICS
Name of Teacher:

SOLID STATE PHYSICS LAB	L-T-P-C [0-0-4-2]
1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method) 2. To measure the Magnetic susceptibility of Solids. 3. To determine the Coupling Coefficient of a Piezoelectric crystal. 4. To measure the Dielectric Constant of a dielectric Materials with frequency 5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR) 6. To determine the refractive index of a dielectric layer using SPR 7. To study the PE Hysteresis loop of a Ferroelectric Crystal. 8. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis. 9. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 ^{o}C) and to determine its band gap. 10. To determine the Hall coefficient of a semiconductor sample. **Reference Books** • Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House. • Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers. • A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal • Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.	

Semester VI

COURSE INFORMATION SHEET

Course code: PH 314
Course title: ELECTROMAGNETIC THEORY
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 4 L: 3 T: 1 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: VI
Branch: PHYSICS
Name of Teacher:

Theory: 50 Lectures

Code PH 314	**Title: ELECTROMAGNETIC THEORY**	**L-T-P-C [3-1-0-4]**

Course Objectives

This course enables the students:

A.	To teach Maxwell's equations and how they modified some of the existing relations.
B.	Provide understanding about Electromagnetic waves and their propagation in unbounded media.
C	Discuss the theory of electromagnetic waves in bounded media.
D	To provide in-depth study of polarization of radiations and of polarizing materials.
E	Introduction of rotatory polarization and waveguides.

Course Outcomes

After the completion of this course, students will be:

1.	Expertise on the usage of Maxwell's equations.
2.	Ability to solve problems related to propagation of electromagnetic radiation in unbounded media.
3.	Gaining insights into the behaviour of electromagnetic waves in bounded media.
4.	Knowledge about the principles and applications of polarization.
5.	Learning about basic principles of waveguides and optical fibres.

Module-1	**Maxwell Field Equations:** Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density	**10**
Module-2	**EM Wave Propagation in Unbounded Media:** Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere	**10**
Module-3	**EM Wave in Bounded Media:** Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence)	**10**
Module-4	**Polarization of Electromagnetic Waves:** Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices.	**10**

	Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light	
Module-5	**Rotatory Polarization:** Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter. **Wave Guides:** Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission. **Optical Fibres:-** Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only).	**10**

Reference Books:

- Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
- Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
- Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
- Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
- Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
- Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Additional Books for Reference

- Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.
- Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
- Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Assessment Compoents	**CO 1**	**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**
A	H	H	H	M	H
B	H	H	H	L	L
C	H	H	H	L	L
D	M	M	M	H	H
E	H	M	M	H	H

Mapping of Course Outcomes onto Program Outcomes

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

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / Refere nces	Cos mapped	Actual Content covered	Methodologyused	Remarks by faculty if any
1	L1-L3			Maxwell Field Equations: Review of Maxwell's equations. Displacement Current. Vectorand Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge.	T1	1			
2	L4-L6			Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector.	T1	1			
3	L7-L9			Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density		1			
4	L10-L12			Plane EM waves through vacuum andisotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance.	T1	2			
5	L12-L15			Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma	T2	2			
6	L16-L18			electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere	T2	2			
7	L19-L22			Boundary conditions at a plane interface between twomedia. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction.	T1,T2	3			
8	L23-L26			Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal	T1,T2	3			

				Incidence)					
9	L27-L29			Description of Linear, Circular and EllipticalPolarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula.	T1,T2	4			
10	L30-L32			Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices.	T1,T2	4			
11	L33-L35			Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light	T1,T2	4			
12	L36-L39			Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.	T1,T2	5			
13	L40-L43			Planar optical wave guides. Planar dielectric wave guide. Condition ofcontinuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission.	T1,T2	5			

COURSE INFORMATION SHEET

Course code: PH 315
Course title: STATISTICAL MECHANICS
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: L: 3 T: 1 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: VI
Branch: PHYSICS
Name of Teacher:

Code PH 315	Title: STATISTICAL MECHANICS	L-T-P-C [3-1-0-4]

Course Objectives:

1. To learn to use classical statistics to compute the macroscopic properties of the system by using the knowledge of microscopic properties of the particles.
2. To understand the theory of radiation by using the statistical properties of particles obeying classical mechanics.
3. To predict the laws of radiations assuming that the photons behave quantum mechanically and follow Bose-Einstein statistics.
4. To investigate various physical systems and phenomena arising due to the particles following Bose-Einstein statistics.
5. To study thermodynamic properties of various systems following Fermi-Dirac statistics.

Course Outcomes: Students will be able to

1. Understand the connection between statistics and thermodynamics.
2. Apply the concept of classical statistics to understand the properties of radiations and the failure of classical theory.
3. Appreciate the correctness of Bose-Einstein statistics in explaining the properties of radiations.
4. Identify the systems following Bose-Einstein statistics and predict their macroscopic behavior.
5. Compute thermodynamic properties of the systems which follow Fermi-Dirac statistics.

Module-1	**Classical Statistics:** Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.	**10**
Module-2	**Classical Theory of Radiation:** Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe.	**10**
Module-3	**Quantum Theory of Radiation:** Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law.	**10**
Module-4	**Bose-Einstein Statistics:** B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.	**10**
Module-5	**Fermi-Dirac Statistics:** Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.	**10**

Text books:

T1: Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.

Reference books:

R1: Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
R2: Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
R3: Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986,

Narosa.
R4: Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
R5: An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design : NA

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 Sem Examination Marks	60
Assignment / Quiz (s)	15

AssessmentCompoents	CO1	CO2	CO3	CO4	C05
Mid Sem Examination Marks	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I	√				
Quiz 2			√	√	

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	c	d	e
1	H	M	L	L	L
2	M	H	L	L	L
3	L	L	H	M	L
4	L	L	M	H	L
5	L	L	L	L	H

Mapping of Course Outcomes onto Program Outcomes

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

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			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1-3	L1-L10			Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.	T1, R1, R2	1		PPT Digi Class/Chock -Board	
3-5	L11-L20			Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law:	T1,R1, R2, R3	2			

				Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe. Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion.					
6-8	L21-L30			Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law.	T1,R4, R5	3			
8-10	L31-L40			B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.	T1, R3, R4, R5	4			
11-14	L41-L50			Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.	T1, R3, R4, R5	5			

COURSE INFORMATION SHEET

Course code: PH 321
Course title: ELECTROMAGNETICS LAB
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: **2**L: 0 T: 0 P: 4
Class schedule per week:
Class: I.M.Sc.
Semester / Level: VI
Branch: PHYSICS
Name of Teacher:

ELECTROMAGNETICS LAB

Course Objectives: This course enables the students
1. Developing a feel for polarization and interference of light.
2. To help in studying reflection and refraction in microwaves.
3. To equip with insights into the working of a basic dipole antenna.
4. Complementing the theoretical knowledge about Stefan's and Boltzmann Laws.

Course Outcomes: After the completion of this course, students will
1. Gaining visual experience of reflection, refraction and polarization.
2. Understanding interference of light waves.
3. Comprehending the working principle of diodes.

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet's compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating
6. To study the reflection, refraction of microwaves
7. To study Polarization and double slit interference in microwaves.
8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
11. To verify the Stefan`s law of radiation and to determine Stefan's constant.
12. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

<u>**COURSE INFORMATION SHEET**</u>

Course code: PH 322
Course title: STATISTICAL MECHANICS LAB
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: L: 0 T: 0 P: 4
Class schedule per week:
Class: I.M.Sc.
Semester / Level: VI
Branch: PHYSICS
Name of Teacher:

STATISTICAL MECHANICS LAB

Course Objectives:

1. To learn to simulate evolution of a system of particles under different initial conditions.
2. To learn to compute the partition function of ideal gases satisfying classical or quantum statistics using C/C^{++}/Scilab.
3. To learn to plot radiation laws like Planck's law, Rayleigh-Jeans law in different temperature regimes.
4. To learn to calculate and plot specific heat in different temperature regimes using C/C^{++}/Scilab.
5. To plot classical and quantum distribution functions using C/C^{++}/Scilab.

Course Outcomes: Using programs in C/C^{++} /Scilab students should be able to:

1. Calculate the equilibrium properties and study transient behavior of a system of interacting particles.
2. Calculate the partition function of ideal gases.
3. Compare laws of radiations in various temperature regimes.
4. Compare specific heat predicted by various laws at different temperatures.
5. Compare distribution functions predicted by classical and quantum statistics.

Use C/C^{++}/Scilab/other numerical simulations for solving the problems based on Statistical Mechanics like

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
   a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations
   b) Study of transient behavior of the system (approach to equilibrium)
   c) Relationship of large N and the arrow of time
   d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution
   e) Computation and study of mean molecular speed and its dependence on particle mass
   f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed
2. Computation of the partition function Z(β) for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics:
   a) Study of how Z(β), average energy <E>, energy fluctuation ΔE, specific heat at constant volume Cv, depend upon the temperature, total number of particles N and the spectrum of single particle states.
   b) Ratios of occupation numbers of various states for the systems considered above

c) Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.

3. Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.
4. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.
5. Plot the following functions with energy at different temperatures
   a) Maxwell-Boltzmann distribution
   b) Fermi-Dirac distribution
   c) Bose-Einstein distribution

Reference Books:

- Elementary Numerical Analysis, K.E.Atkinson, 3rd Edn. 2007, Wiley India Edition
- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
- Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
- Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010.
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB:
- Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
- Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
- Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

PE-I

COURSE INFORMATION SHEET

Course code: PH 303
Course title: ADVANCED MATHEMATICAL PHYSICS
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C : 3
Class schedule per week:
Class: I.M.Sc.
Semester / Level: PE I
Branch: PHYSICS
Name of Teacher:

Code PH 303	Title: ADVANCED MATHEMATICAL PHYSICS	L-T-P-C [3-0-0-3]

Course Objectives
This course enables the students:

A.	To learn algebra of linear transformations which is the background for problem formulation in quantum mechanics.
B.	To introduce matrix operations and classification of different types of matrices.
C.	To learn transformation properties of tensors in cartesian coordinates.
D.	To learn algebra and classification of tensors.

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

1.	Use the definition and properties of linear transformations and matrices of linear transformations, and understand the concepts of change of basis, homomorphism and isomorphism of vector spaces.
2.	Find the eigenvalues and corresponding eigenvectors of a given matrix, determine whether a given matrix is diagonalizable and classify matrices as hermitian/skew-hermitian, singular/non-singular, etc.
3.	Use tensor calculus to represent various vector operations like scalar and cross product of vectors, calculate gradient, divergence and curl of tensor fields, etc.
4.	Perform tensor operations like sum and product of two tensors and classify tensors as symmetric and anti-symmetric.

Module-1	**Linear Vector Spaces:** Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices.	**12**
Module-2	**Matrices:** Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit Matrices. Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of Matrix. Inner Product	**8**
Module-3	Eigen-values and Eigenvectors. Cayley- Hamiliton Theorem. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary Differential Equations. Functions of a Matrix	**10**
Module-4	**Cartesian Tensors:** Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Invariant Tensors : Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors : Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry : Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the	**20**

	Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors : Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law	
Module-5	**General Tensors:** Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor.	**10**

Reference Books:

1. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
2. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier.
3. Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press
4. Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.
5. Linear Algebra, W. Cheney, E.W.Cheney & D.R.Kincaid, 2012, Jones & Bartlett Learning
6. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
7. Mathematical Methods for Physicis & Engineers, K.F.Riley, M.P.Hobson, S.J.Bence,3rd Ed., 2006, Cambridge University Press

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

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**
A	L	M	-	L
B	M	H	-	M
C	-	M	H	H
D	-	M	M	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	**Program Outcomes**					
	a	b	c	d	e	f
1	H	H	H	M	H	M
2	H	H	H	M	H	M
3	L	H	H	M	M	M
4	L	H	H	M	M	M

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	Cos mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1-L4			Abstract Systems. Binary Operations and Relations.Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors		1			
2	L5-L8			Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces.		1			
3	L9-L12			Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices.		1			
4	L13-L15			Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar andUnit Matrices. Upper-Triangular and Lower-Triangular Matrices.		2			
5	L15-L17			Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices.		2			
6	L18-L19			Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of Matrix. Inner Product		2			
7	L20-L24			Eigen-values and Eigenvectors. Cayley-Hamiliton Theorem. Diagonalization of Matrices.		3			
8	L25-			Solutions of Coupled		3			

	L29			Linear Ordinary Differential Equations. Functions of a Matrix					
9	L30-L34			Transformation of Co-ordinates. Einstein's Summation Convention.Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors.		4			
10	L35-L39			Invariant Tensors : Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors : Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation.		4			
11	L40-L44			Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry : Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line.		4			
12	L45-L49			Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors : Symmetric Nature.		4			

				Elasticity Tensor. Generalized Hooke's Law					
13	L50-L54			Transformation of Co-ordinates. Minkowski Space. Contravariant &Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors.		5			
14	L55-L59			Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor.		5			

COURSE INFORMATION SHEET

Course code: PH 304
Course title: Nano Materials and Applications
Pre-requisite(s): Intermediate Physics
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C : 3
Class schedule per week:
Class: I.M.Sc.
Semester / Level: PE I
Branch: PHYSICS
Name of Teacher:

Code PH 304	**Title: Nano Materials and Applications** **Theory: 40 Lectures**	**L-T-P-C [3-0-0-3]**

Course Objectives : This course enables the students:

1.	To become familiar with length scales in physics and their relevance for nanoscience.
2.	To be familiarized with the top down and bottom up processes for synthesis of nanomaterials.
3.	To become familiar with the various methods of characterization of nanomaterials.
4.	To become acquainted with optical properties of nanostructures and the role of quasiparticles.
5.	To develop an understanding of the quantization of charge transport in nanostructures and application of nanomaterials.

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

1.	Able to quantify the change in the energy levels as materials are confined in one, two or three dimensions.
2.	Able to describe the various methods of nanomaterial synthesis.
3.	Able to compare and choose from the different characterization tools available for nanomaterial characterization.
4.	Able to relate the optical properties with the concept of quasiparticles.
5.	Able to correlate the discrete nature of charge and energy states with the quantization of electron transport in nanostructures.

Module-1	**NANOSCALE SYSTEMS:** Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods)**,** Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.	**10**
Module-2	**SYNTHESIS OF NANOSTRUCTURE MATERIALS:** Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots	**10**
Module-3	**CHARACTERIZATION:** X-Ray Diffraction. Optical Microscopy Scanning Electron Microscopy Transmission Electron Microscopy Atomic Force Microscopy Scanning Tunneling Microscopy	**8**
Module-4	**OPTICAL PROPERTIES:** Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of heterostrctures and nanostructures.	**12**
Module-5	**ELECTRON TRANSPORT**: Carrier transport in nanostrcutures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects. **APPLICATIONS:** Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).	**10**

Reference books:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).

4. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
5. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).
6. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
7. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).

Gaps in the syllabus (to meet Industry/Profession requirements)
POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

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 Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

_Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End SemExamination Marks	60
Quiz	15
Teachers Assessment	5

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 Outcome #	Program Outcomes					
	a	b	c	d	e	f
1	H	H	H	L	M	L
2	H	H	M	L	L	L
3	H	M	H	L	L	L
4	H	M	M	M	L	L
5	H	H	H	L	H	L

Course Outcome #	Course Objectives				
	a	b	c	d	e
1	H	M	M	M	L
2	M	H	M	M	L
3	M	M	H	L	L
4	M	M	M	H	L
5	M	M	L	M	H

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			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Module No.	Topics to be covered	Text Book / References	Cos mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		I	Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods),	R	CO-1		PPT Digi Class/Chalk-Board	
	L2-L4			Band structure and density of states of materials at nanoscale, Size Effects in nano systems,	R	CO-1		PPT Digi Class/Chalk-Board	
2	L5-L7			Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box,	R	CO-1		PPT Digi Class/Chalk-Board	
2	L8-L10			quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.	R	CO-1		PPT Digi Class/Chalk-Board	
3	L11-L13		II	Top down and Bottom up approach, Photolithography. Ball milling. Gas phase	R	CO-2		PPT Digi Class/Chalk-Board	

				condensation. Vacuum deposition. Physical vapor deposition (PVD):					
3	L14-16			Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD).	R	CO-2		PPT Digi Class/Chalk-Board	
4	L17-L18			Sol-Gel. Electro deposition. Spray pyrolysis.	R	CO-2		PPT Digi Class/Chalk-Board	
4-5	L19-L20			Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots	R	CO-2		PPT Digi Class/Chalk-Board	
5-6	L21-24		III	X-Ray Diffraction. Optical Microscopy, Scanning Electron Microscopy	R	CO-3		PPT Digi Class/Chalk-Board	
6-7	L25-28			Transmission Electron Microscopy Atomic Force Microscopy Scanning Tunneling Microscopy	R	CO-3		PPT Digi Class/Chalk-Board	
7	L29-31		IV	Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure.	R	CO-4		PPT Digi Class/Chalk-Board	
8	L32-34			Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals.	R	CO-4		PPT Digi Class/Chalk-Board	
9	L35-L37			Quantitative treatment of quasi-particles and excitons, charging effects.. Radiative processes: General formalization-absorption, emission and luminescence	R	CO-4		PPT Digi Class/Chalk-Board	
10	L38-40			Optical properties of heterostrctures and nanostructures.	R	CO-4		PPT Digi Class/Chalk-Board	
11	L41-44		V	Carrier transport in nanostrcutures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects. **APPLICATIONS:** Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices	R	CO-5	T3	PPT Digi Class/Chalk-Board	

				(LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors.					
12	L45-47			Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage.	R	CO-5	T3	PPT Digi Class/Chalk-Board	
13	L48-50			Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).	R	CO-5	T3	PPT Digi Class/Chalk-Board	

COURSE INFORMATION SHEET

Course code: PH 310
Course title: ADVANCED MATHEMATICAL PHYSICS LAB
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C : 2
Class schedule per week:
Class: I.M.Sc.
Semester / Level: PE I
Branch: PHYSICS
Name of Teacher:

ADVANCED MATHEMATICAL PHYSICS LAB

Course Objectives:

1. To perform computer simulations in C/C++ /Scilab for solving problems like matrix multiplication, matrix diagonalization, etc.
2. To use C/C++ /Scilab programming to calculate eigenvalues and corresponding eigenvectors of a matrix.
3. To do simulations for lagrangian formulation in constrained classical systems.
4. To learn to compute geodesics for various spaces and obtain ground state energy level and wave function of a quantum system.

Course Outcomes: Students should be able to

1. Multiply and diagonalize matrices of rank 3 using computer program.
2. Find eigenvalues and eigenvectors of 3x3 matrices with real or complex elements.
3. Write programs in C/C++ /Scilab for obtaining lagrangian and calculation of Euler-Lagrange equations for conservative systems.
4. Find the shortest distance between two points in curved spaces and solve quantum systems for their lowest energy levels and wave-functions computationally.

Scilab/ C^{++} based simulations experiments based on Mathematical Physics problems like

1. Linear algebra:
   - Multiplication of two 3 x 3 matrices.
   - Eigenvalue and eigenvectors of

$$\begin{pmatrix} 2 & 1 & 1 \\ 1 & 3 & 2 \\ 3 & 1 & 4 \end{pmatrix}; \begin{pmatrix} 1 & -i & 3+4i \\ +i & 2 & 4 \\ 3-4i & 4 & 3 \end{pmatrix}; \begin{pmatrix} 2 & -i & 2i \\ +i & 4 & 3 \\ -2i & 3 & 5 \end{pmatrix}$$

2. Orthogonal polynomials as eigenfunctions of Hermitian differential operators.
3. Determination of the principal axes of moment of inertia through diagonalization.
4. Vector space of wave functions in Quantum Mechanics: Position and momentum differential operators and their commutator, wave functions for stationary states as eigenfunctions of Hermitian differential operator.
5. Lagrangian formulation in Classical Mechanics with constraints.
6. Study of geodesics in Euclidean and other spaces (surface of a sphere, etc).
7. Estimation of ground state energy and wave function of a quantum system.

Reference Books:

- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB:
- Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
- Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444
- Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

COURSE INFORMATION SHEET

Course code: PH 311
Course title: Nano Materials and Applications Lab
Pre-requisite(s): Intermediate Physics
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C : 2
Class schedule per week:
Class: I.M.Sc.
Semester / Level: PE-I
Branch: PHYSICS
Name of Teacher:

Nano Materials and Applications Lab

1. Synthesis of metal nanoparticles by chemical route.
2. Synthesis of semiconductor nanoparticles.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. XRD pattern of nanomaterials and estimation of particle size.
5. To study the effect of size on color of nanomaterials.
6. To prepare composite of CNTs with other materials.
7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and study its XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study transmittance spectra in UV-Visible region.
10. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.
11. Fabricate a PN diode by diffusing Al over the surface of N-type Si and study its V-I characteristic.

Reference Books:

- C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
- S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).
- K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience & Technology (PHI Learning Private Limited).
- Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

PE-II

COURSE INFORMATION SHEET

Course code: PH 305
Course title: Computational Physics
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: L: 3 T: 0 P:0 C: 3
Class schedule per week:
Class: I.M.Sc.
Semester / Level: PE II
Branch: PHYSICS
Name of Teacher:

<table>
<tr><td>Course Code:
PH 305</td><td>Title: COMPUTATIONAL PHYSICS</td><td>L-T-P-C
3-0-0-3</td></tr>
<tr><td colspan="3">Course Objectives
This course enables the students:
<table>
<tr><td>A.</td><td>To learn about the basics of Fortran programming</td></tr>
<tr><td>B.</td><td>Learn about control statements in Fortran</td></tr>
<tr><td>C.</td><td>To learn about preparing codes</td></tr>
<tr><td>D.</td><td>Learn about Latex and Gnuplot</td></tr>
</table>
Course Outcomes
After the completion of this course, students will be:
<table>
<tr><td>1.</td><td>Able to write simple programs in Fortran</td></tr>
<tr><td>2.</td><td>Able to use control statements</td></tr>
<tr><td>3.</td><td>Preparing complex codes to solve physical problems</td></tr>
<tr><td>4.</td><td>Having good grasp on Latex and Gnuplot</td></tr>
</table></td></tr>
<tr><td>Module 1</td><td>Scientific Programming: Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.</td><td>[8]</td></tr>
<tr><td>Module 2</td><td>Control Statements: Types of Logic (Sequential, Selection, Repetition), BranchingStatements (Logical IF, Arithmetic IF, Block IF, Nested Block IF), Looping Statements (DO-ENDDO, DO-WHILE), Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN and CALL Statements, Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.</td><td>[10]</td></tr>
<tr><td>Module 3</td><td>Exercises on syntax on usage of Fortran, Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write codes in C.</td><td>[7]</td></tr>
<tr><td></td><td>To print out all natural even/ odd numbers between given limits.
To find maximum, minimum and range of a given set of numbers.
Calculating Euler number using exp(x) series evaluated at x=1</td><td></td></tr>
</table>

Module 4	Scientific word processing: Introduction to LaTeX: TeX/LaTeX word processor,preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.	[10]
Module 5	Visualization: Introduction to graphical analysis and its limitations. Introduction toGnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot	[10]

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Objectives	**1**	**2**	**3**	**4**
A	**H**	**H**	**H**	**-**
B	**L**	**H**	**H**	**-**
C	**L**	**H**	**H**	**-**
D	**-**	**-**	**-**	**H**

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	**Program Outcomes**					
	a	**b**	**c**	**d**	**e**	**f**
1	**-**	**L**	**L**	**M**	**L**	**M**
2	**-**	**L**	**L**	**M**	**L**	**M**
3	**-**	**H**	**H**	**M**	**M**	**M**
4	**-**	**H**	**H**	**M**	**L**	**M**

Lecture wise Lesson planning Details.

Week No.	**Lect. No.**	**Tentative Date**	**Ch. No.**	**Topics to be covered**	**Text Book / References**	**COs mapped**	**Actual Content covered**		**Remarks by faculty if any**
1	L1-L3			Some fundamental Linux Commands (Internal and External commands). Basics of Fortran, Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program.	T1, T2	1			
2	L4-L6			Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment	T1, T2	1			

				Expressions. Fortran Statements: I/O Statements, Executable and Non-Executable Statements, Layout of programs, Format of writing Program, Examples from physics problems.					
3	L7-L9			Types of Logic (Sequential, Selection, Repetition), Branching Statements, Looping Statements, Jumping Statements	T1, T2	2			
4	L10-L12			Subscripted Variables (Arrays), Functions and Subroutines, I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.	T1, T2	2			
5	L13-L15			Exercises on syntax on usage of Fortran, Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write codes in Fortran.	T1, T2	3			
6	L16-L18			To print out all natural even/ odd numbers between given limits. To find maximum, minimum and range of a given set of numbers. Calculating Euler number using exp(x) series evaluated at x=1	T1, T2	3			
7	L19-L21			Introduction to LaTeX: TeX/LaTeX word processor,preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages.	T4	4			
8	L22-L24			Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.	T4	4			
9	L25-L27			Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data	T3	5			
10	L28-L30			Basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file	T3	5			
11	L31-33			physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot	T3	5			

COURSE INFORMATION SHEET

Course code: 306
Course title: Materials Science and Nanotechnology
Pre-requisite(s):
Co- requisite(s):
Credits: L: 4 T: 1 P: 0 C : 5
Class schedule per week:
Class: I.M.Sc.
Semester / Level: PE II
Branch :PHYSICS
Name of Teacher:

CODE PH306	Title: Materials Science and Nanotechnology	L-T-P-C [4-1-0-5]

Course Objectives

This course enables the students to:

A.	Outline the basics of crystallography and define various types of imperfections in crystals.
B.	Explain elastic and plastic deformation in solids and summarize the strain hardening mechanisms.
C.	Define ceramics and explain its types and applications.
D.	Define polymers and composites and categorize them on the basis of their applications.
E.	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.	explain various types of imperfections in crystals.
2.	analyze the mechanisms behind elastic and plastic deformation is solids and compare different strengthening techniques.
3.	summarize ceramics and its types and relate their applications with properties.
4.	classify polymers and composites based on their properties and applications.
5.	Classify nanomaterials, their fabrication techniques and co relate the effects of confinement to nanoscale on their properties.

Module 1	**Imperfections in solids and elastic deformation** Introduction to crystallography, types of imperfections, point defects, edge dislocation, screw dislocation, mixed dislocation, Burger's vector,dislocation density, surface defects, grains, grain boundary,volume defects	**[8]**
Module 2	**Elastic and Plastic deformation** Elastic deformation, Hooke's law, atomic view of elasticity,anelasticity, elastic moduli.plastic deformation, yield point phenomena, slip, slip systems, resolved shear stress, plastic deformation of single crystals and polycrystalline materials, strain hardening, annealing, recovery, recrystallization, grain growth, introduction to fracture, fatigue, creep.	**[10]**
Module 3	**Ceramics** Ceramic structures, imperfections in ceramics, mechanical properties of ceramics, types and applications of ceramics, advanced ceramics and their applications.	**[7]**
Module 4	**Polymers and composites** Polymer structure, polymer crystallinity, mechanical behaviour of polymers, types of polymers and their applications, advanced polymers and their application, general properties, types, and applications of composites, fibre reinforced composites, various types of fibres - plastic, glass, carbon, etc, influence of fibre length & orientation.	**[7]**
Module 5	**Nanotechnology** Basic concepts of nanotechnology, nanomaterials (nanoparticles, nanoclusters, quantum dots) nanoscale, effect of nano scale on material, properties: thermal, mechanical, electrical, magnetic and optical properties. introduction to nanomaterials fabrication techniques: top-down process (ball milling, lithography), bottom-up process (sputtering techniques, chemical routes).	**[8]**

Text books:

1. W. D. Callister, Materials Science and Engineering: An Introduction, John Wiley, 6th Edition, 2003.
2. W. F. Smith, Principles of Materials Science and Engineering, McGraw Hill International, 1986.

3. Introduction to Nanotechnology, Charles P. Poole, Jr., Frank J. Owens, John Wiley & Sons, 2013.

Reference books:

1. The Structure and Properties of Materials, Wiley Eastern
   Vol. –I, Moffatt, Pearsall and Wulff
   Vol. –III, Hayden, Moffatt and Wulff
2. Physical Properties of Materials, M. C. Lovell, A. J. Avery, M. W. Vernon, ELBS

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

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 Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

_Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End SemExamination Marks	60
Quiz	15
Teachers Assessment	5

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 Outcome #	Program Outcomes					
	a	b	c	d	e	f
1	H	H	H	L	M	L
2	H	H	M	L	L	L
3	H	M	M	L	L	L
4	H	M	M	L	L	L
5	H	H	H	L	H	L

Course Outcome #	Course Objectives				
	a	b	c	d	e
1	H	M	M	M	L
2	M	H	M	M	L
3	M	M	H	L	L
4	M	M	H	L	L
5	M	M	L	L	H

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			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Module No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		I	Introduction to materials science and relevance of nanotechnology, course objectives and grading schemes.	T1	CO-1		PPT Digi Class/Chalk -Board	
	L2-L4			Introduction to crystallography	T1	CO-1		PPT Digi Class/Chalk -Board	
2	L5-7			Types of imperfections, point defects, edge dislocation, screw dislocation, mixed dislocation, Burger's vector	T1	CO-1		PPT Digi Class/Chalk -Board	

2	L8			Dislocation density, surface defects, grains, grain boundary	T1	CO-1		PPT Digi Class/Chalk -Board	
3	L9-L10		II	Elastic deformation, Hooke's law, atomic view of elasticity, anelasticity, elastic moduli	T1	CO-2		PPT Digi Class/Chalk -Board	
3	L11-12			Plastic deformation, yield point phenomena, slip, slip systems, resolved shear stress	T1	CO-2		PPT Digi Class/Chalk -Board	
4	L12-L14			Plastic deformation of single crystals and polycrystalline materials	T1	CO-2		PPT Digi Class/Chalk -Board	
4-5	L15-18			Strain hardening, annealing, recovery, recrystallization, grain growth, introduction to fracture, fatigue, creep	T1	CO-2		PPT Digi Class/Chalk -Board	
5-6	L19-22		III	Ceramic structures, imperfections in ceramics, mechanical properties of ceramics.		CO-3		PPT Digi Class/Chalk -Board	
6-7	L23-25			Types and applications of ceramics, advanced ceramics and their applications.		CO-3		PPT Digi Class/Chalk -Board	
7	L25-28		IV	Polymer structure, polymer crystallinity, mechanical behaviour of polymers, types of polymers and their applications, advanced polymers and their application	T1	CO-4		PPT Digi Class/Chalk -Board	
8	L29-31			General properties, types, and applications of composites, fibre reinforced composites, various types of fibres - plastic, glass, carbon, etc, influence of fibre length & orientation.		CO-4		PPT Digi Class/Chalk -Board	
9	L33-34		V	Basic concepts of nanotechnology, nanomaterials (nanoparticles, nanoclusters, quantum		CO-5	T3	PPT Digi Class/Chalk-Board	

				dots) nanoscale, effect of nano scale on material, properties: thermal, mechanical, electrical, magnetic and optical properties					
9	L35-40			Introduction to nanomaterials fabrication techniques: top-down process (ball milling, lithography), bottom-up process (sputtering techniques, chemical routes).		CO-5	T3	PPT Digi Class/Chalk-Board	

COURSE INFORMATION SHEET

Course code: PH 307
Course title: EXPERIMENTAL TECHNIQUES
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C : 3
Class schedule per week:
Class: I.M.Sc.
Semester / Level: PE II
Branch: PHYSICS
Name of Teacher: Dr. Dilip K. Singh

Code PH 307	**Title: EXPERIMENTAL TECHNIQUES**	**L-T-P-C [3-0-0-3]**

Course Objectives

This course enables the students:

A	The course on *Experimental techniques* is designed to cater need of understanding of basic instrumentation to leaners.
B.	Module-1 contains information about various measurement parameters like precession, accuracy and curve fitting.
C.	Under 2nd Module knowledge about variety of signals, frequency response of systems and noise measurements would be transferred.
D.	Module-3 contains information about working, efficiency and applications of Transducers and sensors.
E.	The 4th module contains knowledge about working and construction of digital multimeter, impedance bridges and Q-meter.
F.	The working, construction and efficiency of variety of vacuum pumps and techniques of vacuum level measurement are topic of 5th module.

Course Outcomes

After the completion of this course, students will be:

1.	The course intends to impart knowledge of basic instrumentation tools and techniques to physics undergraduates, so that they can conceive / design experiments to test physic principles.
2.	Leaners would gain knowledge of accuracy, precession and types of errors.
3.	Students would also gain knowledge of type of signals, variety of noise types and methods of grounding / shielding.
4.	Course intends to impart knowledge of variety of transducers / sensors required for industrial instrumentation.
5.	Working and design of digital multimeters and bridges is planned to be covered in this course.
6.	Knowledge about variety of vacuum pumps and vacuum measurement techniques will enrich the learners about vacuum techniques: one of the basic experimental skill required to understand working / experiments of variety of branches of physics and engineering like low-temperature physics (cryogenics), ion-beam physics, semiconductor growth and devices and nuclear instrumentation.

Module-1	**Measurements:** Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Guassian distribution	**8**
Module-2	**Signals and Systems:** Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise **Shielding and Grounding:** Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference	**8**

Module-3	**Transducers & industrial instrumentation (working principle, efficiency, applications):** Static and dynamic characteristics of measurement Systems. Generalized performance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration. Transducers and sensors. Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector	**14**
Module-4	**Digital Multimeter:** Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement. **Impedance Bridges and Q-meter:** Block diagram and working principles of RLC bridge. Q-meter and its working operation. Digital LCR bridge.	**10**
Module-5	**Vacuum Systems:** Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system- Chamber, Mechanical pumps, Diffusion pump & Turbo Modular pump, Pumping speed, Pressure gauges (Pirani, Penning, ionization).	**10**

Text books:

T1: Thomas L. Floyd. ELECTRONIC. DEVICES. 9th Edition. Prentice Hall.

T2: Louis Nashelsky and Robert Boylestad, Electronic Devices and Circuit Theory

Reference books: R1:

Reference books: R1: Gaps in the syllabus (to meet Industry/Profession requirements) : NA

POs met through Gaps in the Syllabus : NA

Topics beyond syllabus/Advanced topics/Design : NA

POs met through Topics beyond syllabus/Advanced topics/Design

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 Sem Examination Marks	50
Quiz	10+10
Teacher's assessment	5

_Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I	√	√	√		
Quiz II			√	√	√
Assignment	√	√	√	√	√

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	6
A	H	H	H	H	H	H
B	H	H	L	L	L	L
C	H	L	H	L	L	L
D	H	L	L	H	L	L
E	H	L	L	L	H	L
F	H	L	L	L	L	H

Mapping of Course Outcomes onto Program Outcomes

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

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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No	Topics to be covered	Text Book / References	Cos mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		1	**Measurements:** Accuracy and precision. Significant figures.	T1, T2				
	L2			Error and uncertainty analysis.	T1, T2				
	L3			Types of errors: Gross error, systematic error, random error.	T1, T2				
	L4			Statistical analysis of data	T1, T2				

				(Arithmetic mean,					
	L5			deviation from mean, average deviation,	T1, T2				
	L6			standard deviation,	T1, T2				
	L7			chi-square) and curve fitting.	T1, T2				
	L8			Guassian distribution.	T1, T2				
	L9		2	**Signals and Systems:** Periodic and aperiodic signals.	T1, T2				
	L10			Impulse response, transfer function and frequency response of first and second order systems.	T1, T2				
	L11			Fluctuations and Noise in measurement system.	T1, T2				
	L12			S/N ratio and Noise figure. Noise in frequency domain.	T1, T2				
	L13			Sources of Noise: Inherent fluctuations, Thermal noise,	T1, T2				
	L14			Shot noise, 1/f noise	T1, T2				
	L15			**Shielding and Grounding:** Methods of safety grounding. Energy coupling. Grounding.	T1, T2				
	L16			Shielding: Electrostatic shielding. Electromagnetic Interference.	T1, T2				
	L17		3	**Transducers & industrial instrumentation (working principle, efficiency, applications):** Static and dynamic characteristics of measurement Systems.	T1, T2				
	L18			Generalized performance of systems,	T1, T2				
	L19			Zero order first order systems	T1, T2				
	L20			Second order and higher order systems.	T1, T2				
	L21			Electrical, Thermal and Mechanical systems.	T1, T2				
	L22			Calibration. Transducers and sensors.	T1, T2				
	L23			Characteristics of Transducers. Transducers as electrical element and their signal conditioning.	T1, T2				
	L24			Temperature transducers: RTD, Thermistor, Thermocouples	T1, T2				
	L25			Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning.	T1, T2				
	L26			Linear Position transducer: Strain gauge	T1, T2				
	L27			Piezoelectric. Inductance change transducer	T1, T2				
	L28			Linear variable differential	T1, T2				

				transformer (LVDT), Capacitance change transducers.					
	L29			Radiation Sensors:	T1, T2				
	L30			Principle of Gas filled detector, ionization chamber, scintillation detector.	T1, T2				
	L31		4	**Digital Multimeter:** Comparison of analog and digital instruments.	T1, T2				
	L32								
	L33			Block diagram of digital multimeter	T1, T2				
	L34								
	L35			Principle of measurement of I, V, C.	T1, T2				
	L36				T1, T2				
	L37			Accuracy and resolution of measurement.	T1, T2				
	L38			**Impedance Bridges and Q-meter:** Block diagram and working principles of RLC bridge.	T1, T2				
	L39			Q-meter and its working operation.	T1, T2				
	L40			Digital LCR bridge.	T1, T2				
	L41		5	**Vacuum Systems:** Characteristics of vacuum:	T1, T2				
	L42			Gas law, Mean free path.	T1, T2				
	L43			Application of vacuum.	T1, T2				
	L44			Vacuum system-	T1, T2				
	L45			Chamber, Mechanical pumps,	T1, T2				
	L46			Diffusion pump	T1, T2				
	L47			Turbo Modular pump,	T1, T2				
	L48			Pumping speed	T1, T2				
	L49			Pressure gauges (Pirani)	T1, T2				
	L50			Penning, ionization gauge.	T1, T2				

<u>COURSE INFORMATION SHEET</u>

Course code: PH 312
Course title: Computational Physics Lab
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: L: 0 T: 0 P:4 C: 2
Class schedule per week:
Class: I.M.Sc.
Semester / Level: PE II
Branch: PHYSICS
Name of Teacher: Dr. Madhu Priya

Computational Physics Lab

1. Working with basic Linux commands.
2. Defining variables and using arithmetic/logical operators in FORTRAN.
3. Using control statements in FORTRAN.
4. Exercises on usage of FORTRAN.
5. Preparing reports/articles with Latex.
6. Writing equations and incorporating figures in Latex.
7. Plotting data files and simple functions using Gnuplot.
8. Writing codes in Gnuplot.

COURSE INFORMATION SHEET

Course code: PH 313
Course title: EXPERIMENTAL TECHNIQUES LAB
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C : 2
Class schedule per week: 0x
Class: I.M.Sc.
Semester / Level: PE II
Branch: PHYSICS
Name of Teacher:

EXPERIMENTAL TECHNIQUES LAB

1. Determine output characteristics of a LVDT & measure displacement using LVDT
2. Measurement of Strain using Strain Gauge.
3. Measurement of level using capacitive transducer.
4. To study the characteristics of a Thermostat and determine its parameters.
5. Study of distance measurement using ultrasonic transducer.
6. Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75)
7. To measure the change in temperature of ambient using Resistance Temperature Device (RTD).
8. Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.
9. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of importance of grounding using function generator of mV level & an oscilloscope.
10. To design and study the Sample and Hold Circuit.
11. Design and analyze the Clippers and Clampers circuits using junction diode
12. To plot the frequency response of a microphone.
13. To measure Q of a coil and influence of frequency, using a Q-meter.

Reference Books:

1. Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, 2008, Springer
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1990, Mc-Graw Hill
3. Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer and A. Mansingh, 2005, PHI Learning.

PE-III

COURSE INFORMATION SHEET

Course code: PH 316
Course title: Nonconventional Sources of Energy
Pre-requisite(s): Student should have knowledge of Solid State Physics
Co- requisite(s): Knowledge of Basic Mathematics
Credits: L: 3 T:0 P: 0 C : 3
Class schedule per week: 3
Class: I.M.Sc.
Semester / Level: III
Branch: Physics
Name of Teacher:

Title: Nonconventional Sources of Energy

Course Objectives : This course enables the students:

A.	To show the energy status in India and world, and environmental aspects of the conventional and non-conventional sources of energy.
B.	To illustrate the basics of solar thermal and solar cell.
C.	To explain the concepts of wind energyand tidal energy.
D.	To illustrate thebio mass, geo thermal energy and hydro energy.
E.	To explain the facts about thermoelectric generators, thermionic generators, magneto hydro dynamics generators, batteries and fuel cells.

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

1.	Define the energy scenario in Indiaand World and the need of non-conventional energy sources.
2.	Explain the various method for converting the solar radiation to heat and electricity.
3.	Illustrate the generation of electricity by wind turbine and also explain the potential of tidal and ocean energies in the generation of power.
4.	Explain the process of generation of bio energy and basic concepts of geo thermal energy and hydro energy.
5.	Define the concepts of thermoelectric generators, thermionic generators, magneto hydro dynamics generators, batteries and fuel cells.

Code PH 316	**Title: Nonconventional Sources of Energy**	L-T-P-C [3-0-0-3]
Module-1	**Energy Sources**:World energy status, current energy scenario in India, environmental aspects of energy utilization, Classification of energy, Energy Resources, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean energy, Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity. Energy conservation and storage.	10
Module-2	Solar energy, its importance, storage of solar energy, 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,absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.	10
Module-3	Wind Energy: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. Ocean Energy, Potential against Wind and Solar, Wave Characteristics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.	10
Module-4	Biomass energy, resources, conversion, gasification, liquefaction, production, energy farming, Geothermal Energy: Geothermal Resources, Geothermal Technologies. small hydro resources.	10

	Layout, water turbines, classifications, generators, status.	
Module-5	Direct Energy conversion: Thermoelectric effects, generators, Thermionic generators, magneto hydro dynamics generators, Fuel cells, photovoltaic generators, electrostatic mechanical generators, Thin film solar cells, nuclear batteries.	10

Text books:

1. Solar cells: Operating principles, technology and system applications by Martin A Green, Prentice Hall Inc, Englewood Cliffs, NJ, USA, 1981.

Reference books:

1. Non conventional Energy Resources, B. H. Khan, Tata McGraw Hill, 2010
2. Non conventional energy Sources and Utilization, R. K. Rajput, S Chand Publ., 2014

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

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 I and Quiz II	10+10
Teacher's assessment	5

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

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 Objectives	Course Outcomes 1	2	3	4	5
A	H	L	L	L	L
B	M	H	M	M	L
C	M	M	H	L	L
D	M	L	L	H	L
E	M	L	L	L	H

Mapping of Course Outcomes onto Program Outcomes

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

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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
	L1			World energy status, current energy scenario in India, environmental aspects of energy utilization, Classification of energy, Energy Resources, need of renewable energy, non-conventional energy sources.	R1				
	L2, L3			An overview of developments in Offshore Wind Energy,	R1				

				Tidal Energy, Wave energy systems, Ocean energy,					
	L4, L5			Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity. Energy conservation and storage.	R1				
	L6-L10			Solar energy, its importance, storage of solar energy, 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	R1, R2 T1				
	L11-L15			absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems	R1, R2 T1				
	L16-L19			Wind Energy: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.	R1, R2				
	L20-L22			Ocean Energy, Potential against Wind and Solar, Wave Characteristics, Wave Energy Devices.	R1, R2				
	L23-L25			Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.	R1, R2				
	L26-L30			Biomass energy, resources, conversion, gasification, liquefaction, production, energy farming,	R1, R2				
	L31-L33			Geothermal Energy: Geothermal Resources, Geothermal Technologies.	R1, R2				
	L34,			small hydro resources. Layout,	R1, R2				

	L35			water turbines, classifications, generators, status.					
	L36-L38			Direct Energy conversion: Thermoelectric effects, generators, Thermionic generators, magneto hydro dynamics generators, Fuel cells	R1, R2				
	L39, L40			photovoltaic generators, electrostatic mechanical generators, Thin film solar cells, nuclear batteries.	R1, R2				

COURSE INFORMATION SHEET

Course code: PH 317
Course title: Introduction to Nuclear and Particle Physics
Pre-requisite(s): Intermediate Physics and Mathematics
Co- requisite(s):
Credits: 5 L:4 T: 1 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: PE III
Branch: PHYSICS
Name of Teacher:

Title: Introduction to Nuclear and Particle Physics

Course objectives

Students will try to learn;

1. The fundamental principles governing nuclear and particle physics and have a working knowledge of their application to real life problems.
2. About the subatomic physics, including radioactivity, experimental techniques, nuclear structure, particle interactions, and particle collisions and decays.
3. Skills needed to explain how radiation detector function and use for the measurement of radioactivity.
4. About the different types of nuclear reactors in use and how they produce nuclear energy for the useful purposes.
5. Classification of elementary particles and their decay modes.

Course outcomes

After successful completion of the course student will be able to;

1. Understand the fundamental principles and concepts governing classical nuclear and particle physics and have a working knowledge of their application to real -life problems.
2. Explain why nuclear radiations are emitted by radionuclides with very heavy atoms, and understand the nature and properties of the radiations.
3. Explain how charged and uncharged ionizing radiations interact with matter and the effects of the interactions on the material through which they traverse.
4. Classify and explain the function of different nuclear reactors.
5. Classify elementary particles and their possible decay modes

Code **PH 317**	**Title: Introduction to Nuclear and Particle Physics**	L-T-P-C [4-1-0-5]
Module-1	General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.	20
Module-2	Radioactivity decay:(a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) α-decay: energy kinematics for α-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).	15
Module-3	Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter. Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.	12

Module-4	Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.	5
Module-5	Particle physics: Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons.	8

Text Books:

1. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
3. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
4. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons

Reference Books

1.Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi

2. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

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 Sem Examination Marks	50
Quiz	10+10
Teacher's assessment	5

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√		
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
A	H	H	M	H	H
B	M	H	H	M	M
C	M	H	H	M	M
D	M	H	H	H	M
E	M	M	H	H	H

Mapping of Course Outcomes onto Program Outcomes

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

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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
	1-5		1.	quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number	T1, T2			PPT Digi Class/Chock-Board	
	6-10			main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.	T1, T2			PPT Digi Class/Chock -Board	
	11-15			Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas)	T1, T2			PPT Digi Class/Chock -Board	

	16-20			evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.	T1, T2			PPT Digi Class/Chock -Board	
	21-25		2.	(a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) α-decay: energy kinematics for α-decay, positron emission	T1, T2			PPT Digi Class/Chock -Board	
	26-30			electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. Nuclear Reactions: Types of Reactions,	T1, T2			PPT Digi Class/Chock -Board	
	31-35			Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).	T1, T2			PPT Digi Class/Chock -Board	
	36-37		3.	Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter	T3, R1			PPT Digi Class/Chock -Board	
	38-42			photoelectric effect, Compton scattering, pair production, neutron interaction with matter. Gas detectors: estimation of electric field	T3, R1			PPT Digi Class/Chock -Board	
	43-47			mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.	T3, R1			PPT Digi Class/Chock -Board	
	48-52		4.	Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.	T4, R1			PPT Digi Class/Chock -Board	
	53-55		5.	Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum	T4, R2			PPT Digi Class/Chock -Board	
	56-60			angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons	T4, R2			PPT Digi Class/Chock -Board	

COURSE INFORMATION SHEET

Course code: PH 318
Course title: Nuclear Hazard and Waste Managements
Pre-requisite(s): Intermediate Physics
Co- requisite(s): Modern Physics
Credits: **5** L: 4 T: 1 P:0
Class schedule per week: 5
Class: I.M.Sc.
Semester / Level: PE III
Branch: PHYSICS
Name of Teacher:

Title: Nuclear Hazard and Waste Managements

Course objectives

This course will describe:

1. What must be considered and achieved to satisfy the International Atomic Energy Agency (IAEA) Nuclear Energy Basic Principles in the area of radioactive waste management.
2. A framework for the design of programmes relating to radioactive waste management technology
3. A basis for the development of guidelines on radioactive waste management decommissioning and environmental remediation.

Course outcomes

After successful completion of the course student will be able to;

1. Know about the rules of IEAE and basic principles of Nuclear Energy
2. Get some knowledge relating to radioactive waste management technology
3. Understand guidelines on radioactive waste management decommissioning and environmental remediation

Code **PH 318**	**Title: Nuclear Hazard and Waste Managements**	L-T-P-C [4-1-0-5]
Module-1	Radiation interaction fundamentals, Alpha particle, Beta particle, Gamma ray, Table of nuclides Half-life., Radioactive decay. Radioactive waste, Classification of Radioactive Wastes, High-level Waste (HLW), Intermediate-level Waste (ILW), Low-level Waste (LLW). Who is Responsible for Radioactive Wastes, Pertinent Legislation in the US Regarding Radioactive Hazards and Wastes: Examples.	12
Module-2	Splitting the Atom for Energy, Status of Nuclear Power World-wide, Commercial Nuclear Power Generation, Nature of HLW as a Function of Time, Fast Reactors, The Nuclear Fuel Cycle, Options in the Fuel Cycle that Impact Waste Management, Once-Through Fuel Option, The Reprocessing Fuel Cycle (RFC), Advanced Fuel Cycle (AFC), Important Characteristics of Actinides.	12
Module-3	Separations Technologies for the Nuclear Fuel Cycle, PUREX Process, DIAMEX Process, TRUEX Process, TRAMEX Process, TALSPEAK Process, Stereospecific Extractants, Non-aqueous Processes, Volatility Processes, Molten Salt Processes, Electrochemical Separations using Non-Aqueous Processes, Advanced Fuel Cycle Concepts and Partitioning and Transmutation (P&T).	12
Module-4	Transmutation of Minor Actinides, Transmutation of the Long-lived Fission Products, Partitioning Schemes for the Minor Actinides and Long-lived Fission Products, Aqueous Chemical Processing, Improved PUREX Process - Removal of Np, I, and Tc, UREX and UREX+ Processes, Non-Aqueous Chemical Processing, Transmutation Devices for the Advanced Fuel Cycle.	12
Module-5	Strategies for Implementation of an Advanced Fuel Cycle, Generation IV Nuclear Energy Systems, Advanced Fuel Cycle Development to Support Generation IV Energy Systems, The Advanced Fuel Cycle Initiative (AFCI), Areas of Scientific Concerns in the AFCI, Future of P&T Radioactive Waste Regulations, Nuclear Waste Policy Act	12

Text Book:

T1: Natural and Human Induced Hazards and Environmental Waste Management Volume 2 e-ISBN: 978-1-84826-300-0 ISBN : 978-1-84826-750-3 No. of Pages: 370

Ref. book:

R1: Management of Radioactive Waste after a Nuclear Power Plant Accident
© OECD 2016 NEA No. 7305 NUCLEAR ENERGY AGENCY ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT.

Gaps in the syllabus (to meet Industry/Profession requirements)
POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

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
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz	10+10
Teacher's assessment	5

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

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					
	a	b	c	d	e	f
1	H	H	H	L	M	L
2	M	H	H	L	L	L
3	H	M	M	M	M	M
4	M	H	M	M	H	M
5	H	H	H	L	H	L

Course Outcome #	Course Objectives				
	A	B	C	D	E
1	H	M	M	M	M
2	L	H	L	L	M

3	L	M	H	M	M
4	H	L	H	H	L
5	H	M	M	L	H

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			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

Lecture wise Lesson planning Details

Week No.	Lect. No.	Tentative Date	Module. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		I	Radiation interaction fundamentals, Alpha particle, Beta particle,	T1			PPT Digi Class/Chalk-Board	
1	L2			Gamma ray, Table of nuclides Half-life.,	T1			PPT Digi Class/Chalk-Board	
1	L3-L4			Radioactive decay. Radioactive waste,	T1			PPT Digi Class/Chalk-Board	
2	L5			Classification of Radioactive Wastes, High-level Waste (HLW), Intermediate-level Waste (ILW),	T1			PPT Digi Class/Chalk-Board	
2	L6-L8			Low-level Waste (LLW).Who is Responsible for Radioactive Wastes,	T1			PPT Digi Class/Chalk-Board	
2	L9-L10			Pertinent Legislation in the US Regarding Radioactive Hazards and Wastes: Examples.	T1			PPT Digi Class/Chalk-Board	
3	L11-L13			Splitting the Atom for Energy, Status of Nuclear Power World-wide	T1			PPT Digi Class/Chalk-Board	
3	L14-L16			Commercial Nuclear Power Generation, Nature of HLW as a Function of Time	T1			PPT Digi Class/Chalk-Board	
3	L17-L18			Fast Reactors, The Nuclear Fuel Cycle, Options in the Fuel Cycle	T1			PPT Digi Class/Chalk-Board	

				that Impact Waste Management, Once-Through Fuel Option					
4	L19-L20		II	The Reprocessing Fuel Cycle (RFC), Advanced Fuel Cycle (AFC), Important Characteristics of Actinides	T1			PPT Digi Class/Chalk-Board	
4	L21-22			Separations Technologies for the Nuclear Fuel Cycle	T1			PPT Digi Class/Chalk-Board	
5	L23-24			PUREX Process, DIAMEX Process, TRUEX Process	T1			PPT Digi Class/Chalk-Board	
5	L25-L26			Non-aqueous Processes, Volatility Processes, Molten Salt Processes	T1			PPT Digi Class/Chalk-Board	
6	L27-L28			Electrochemical Separations using Non-Aqueous Processes	T1			PPT Digi Class/Chalk-Board	
6-7	L29-L30			Advanced Fuel Cycle Concepts and Partitioning and Transmutation (P&T).	T1			PPT Digi Class/Chalk-Board	
	L31-L32			Transmutation of Minor Actinides, Transmutation of the Long-lived Fission Products	T1			PPT Digi Class/Chalk-Board	
	L33-L35			Partitioning Schemes for the Minor Actinides and Long-lived Fission Products	T1			PPT Digi Class/Chalk-Board	
	L36-L38			Aqueous Chemical Processing, Improved PUREX Process - Removal of Np, I, and Tc, UREX and UREX+ Processes	T1			PPT Digi Class/Chalk-Board	
	L39-L40			Non-Aqueous Chemical Processing, Transmutation Devices for the Advanced Fuel Cycle.	T1			PPT Digi Class/Chalk-Board	
	L41-L43			Strategies for Implementation of an Advanced Fuel Cycle, Generation IV Nuclear Energy Systems	T1			PPT Digi Class/Chalk-Board	
	L44-L46			Advanced Fuel Cycle Development to Support Generation IV Energy Systems	T1			PPT Digi Class/Chalk-Board	
	L47-L48			Advanced Fuel Cycle Initiative (AFCI), Areas of Scientific Concerns in the AFCI	T1			PPT Digi Class/Chalk-Board	
	L49-L50			Future of P&T Radioactive Waste Regulations, Nuclear Waste Policy Act.	T1			PPT Digi Class/Chalk-Board	

COURSE INFORMATION SHEET

Course code: PH 323
Course title: Nonconventional Sources of Energy Lab
Pre-requisite(s): Student should have knowledge of Solid State Physics
Co- requisite(s): Knowledge of Basic Mathematics
Credits: L: 0 T:0 P: 4 C : 2
Class schedule per week: 3
Class: I.M.Sc.
Semester / Level: III
Branch: Physics
Name of Teacher:

Nonconventional Sources of Energy Lab

Experiments

1. Measurement of solar cell characteristic of wafer based Si solar cell
2. Fabrication of DSSC and Measurement of solar cell characteristic
3. Conversion of vibration to voltage using piezoelectric materials
4. Conversion of thermal energy into voltage using thermocouple
5. Effect of Load on Wind Turbine Output by using wind experiment kit
6. Solar thermal energy convertor: Solar water heater efficiency, Solar room heater efficiency, solar cooker max temp. determination
7. Solar thermal energy convertor: Solar water heater efficiency, Solar room heater efficiency, solar cooker max temp. determination Parabolic type solar collector
8. Concentrating type solar collector (Reflector or solar Scheffler dish by tracking system).
9. Fuel cells efficiency determination
10. Light efficiency measurement and comparison of sources (like: incandescent bulb, tube, CFL, LED, etc)
11. Wind mill blade design parameters and torque relationship
12. Experiments in Power Electronics for interconnection of various subsystems: dc-dc convertors, ac-dc / dc to ac convertors for PV systems, wind generators, etc.
13. Data acquisition for obtaining parameters of water waves

PE-IV

COURSE INFORMATION SHEET

Course code: PH 319
Course title: Atmospheric Physics
Pre-requisite(s):
Co- requisite(s): Intermediate Physics
Credits: 3 L:3 T: 0 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: PE IV
Branch: PHYSICS
Name of Teacher:

Code PH 319	Title: Atmospheric Physics	L-T-P-C [3-0-0-3]

Course Objectives: This course enables the students

A.	To explains the various component of the Earth system specially atmosphere and to understand the physics associated with atmospheric phenomenon.
B.	To understand the dynamics associated with the atmospheric motion
C.	To appreciate the basic laws associated with the solar radiation and remote sensing
D.	To understand the basic instruments based on the remote sensing
E.	To enlighten atmospheric aerosols and related laws to govern its role in atmosphere

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

A.	Be able to explain thermal structure of earth, composition of atmosphere and various atmospheric phenomenon
B.	Be able to explain the dynamics of atmospheric motion
C.	Be able to appreciate the laws of atmospheric radiation balance and basic laws of remote sensing.
D.	Get familiar with instruments based on remote sensing
E.	Acquire knowledge of atmospheric aerosols and its impact

Module-1	**General features of Earth's atmosphere:** Thermal structure of the Earth's Atmosphere, Ionosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect and effective temperature of Earth, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations	**8**
Module-2	**Atmospheric Dynamics:** Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity	**8**
Module-3	**Atmospheric radiation and remote sensing** Fundamental laws of radiation: Planks law, Stefan's Boltzmann law, Wien's displacement law, Kirchhoff's law; Spectral distribution of solar radiation and atmosphere interaction, path radiance, turbulance, cloud effect; Outgoing long-wave radiation, Radiation budget, Atmospheric windows, Emissivity, Absorption spectra of atmospheric gases, optical depth, atmospheric correction techniques for remote sensing data, SST extraction	**8**
Module-4	**Atmospheric Radar and Lidar:** Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques	**8**
Module-5	**Atmospheric Aerosols:** Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Lambert's and Beer's laws, Radiative and health effects, Air pollution/pollutants, Effect of boundary layer dynamics on air pollutants	**8**

Text/Reference Books:

T1: Atmospheric Science : An Introductory Survey ,Second Edition -John M.Wallace and Peter V. Hobbs, University of Washington
R2: Atmospheric chemistry and physics: from air pollution to climate change, Second edition- John H. Seinfeld, Spyros N. Pandis, a wiley-interscience publication, john wiley & sons, inc.
R3: An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004

R4: Radar for meteorological and atmospheric observations – S. Fukao and K. Hamazu, Springer Japan, 2014
R5: Fundamentals of Remote Sensing, George Joseph and Jeganathan, c. (2017). 3rd Edition, Universities Press, ISBN 978 93 86235 46 6

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	Y
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 Sem Examination Marks	50
Quiz	10+10
Teacher's assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√	√	
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
A	H	H	H	H	M
B	H	H	M	L	M
C	M	L	H	H	M
D	H	M	H	H	H
E	M	M	M	M	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	1	2	3	4	5	6
1	H	H	M	M	H	H
2	H	H	M	M	H	H
3	H	H	M	M	H	H

4	H	H	M	M	H	H
5	H	H	M	M	H	H

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	-	-

Lecture wise Lesson planning Details.

T1: Atmospheric Science : An Introductory Survey ,Second Edition -John M.Wallace and Peter V. Hobbs, University of Washington

R1: Atmospheric chemistry and physics: from air pollution to climate change, Second edition- John H. Seinfeld, Spyros N. Pandis, a wiley-interscience publication, john wiley & sons, inc.

R2: An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004

R3: Radar for meteorological and atmospheric observations – S. Fukao and K. Hamazu, Springer Japan, 2014

R4: Fundamentals of Remote Sensing, George Joseph and Jeganathan, c. (2017). 3rd Edition, Universities Press, ISBN 978 93 86235 46 6

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1-L2			Thermal structure of the Earth's Atmosphere, Ionosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics,	T1,R2				
	L3-L4			Greenhouse effect and effective temperature of Earth, Local winds, monsoons, fogs, clouds, precipitation,	T1,R2				
	L5-L6			Atmospheric boundary layer, Sea breeze and land breeze.	T1				
	L7-L8			Instruments for meteorological observations	T1,R3, R4				
	L9-L12			Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system,	R2				
	L13-L16			scale analysis of equation of motion, Applications of the	R2				

				basic equations, Circulations and vorticity						
	L17-L20			Fundamental laws of radiation: Planks law, Stefan's Boltzmann law, Wien's displacement law, Kirchhoff's law; Spectral distribution of solar radiation and atmosphere interaction, path radiance, turbulance, cloud effect; Outgoing long-wave radiation,	R1,R4					
	L21-L24			Radiation budget, Atmospheric windows, Emissivity, Absorption spectra of atmospheric gases, optical depth, atmospheric correction techniques for remote sensing data, SST extraction	R1,R4					
	L25-L28			Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena,	R3, R4					
	L31-L32			Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques	R3, R4					
	L33-L36			Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Lambert's and Beer's laws,	T1,R1					
	L37-L40			Radiative and health effects, Air pollution/pollutants, Effect of boundary layer dynamics on air pollutants	T1,R1					

COURSE INFORMATION SHEET

Course code: PH 320
Course title: Advanced Experimental Techniques
Pre-requisite(s):
Co- requisite(s): Intermediate Physics
Credits: L: 3 T: 0 P: 0 C : 3
Class schedule per week:
Class: I.M.Sc.
Semester / Level: PE IV
Branch: PHYSICS
Name of Teacher:

Code PH 320	Title: Advanced Experimental Techniques	L-T-P-C [3-0-0-3]

Course Objectives:

A. To provide knowledge of various types of experimental techniques used to analyze all types of materials.
B. Students learn to analyze gaseous, liquid, amorphous and crystalline materials.
C. They learn to analyze elemental composition, thickness of the thin film, elemental depth profiling, etc.
D. They will know how to generate vacuum to prepare different types of materials.
E. To understand the use and applications of vacuum systems

Course Outcomes:

1. Student will be able to judge that which techniques will be useful to analyze the given materials.
2. They can design novel experiments to take up scientific problems.
3. They will be able to collect, critically analyze and interpreted the data.
4. They can generate good quality of data and will be able to take up the industrial problems of any field.
5. Students learn about basics of vacuum and various pumps and their applications in R&D.

Module-1	**X-ray Diffraction Methods:** Classification of crystal system, Bragg's law and Laue conditions, Powder methods, crystal size analysis, Rietvold method of structural analysis, X-ray fluorescence spectroscopy, applications of emission spectra for compounds and alloys, Applications of absorption spectra for solid solutions and transitional metal compounds, Neutron spectroscopy. X-Ray Reflectivity	**10**
Module-2	**Microscopy & Spectroscopy** Optical microscopy, metallurgical microscope, TEM, SEM and AFM, Atomic absorption spectrophotometer and its application to environmental analysis, UV-visible spectroscopy and its application, IR-spectroscopy and its application, AES, XPS, Introduction to RBS, SIMS, and its applications. Basic principles of ESR, Instrumentations and applications, Principle of Mossbauer spectroscopy, Isomer shift, Quadruple splitting and hyperfine interaction, applications-in determination of phases and diffusion studies.	**15**
Module-3	**Thermochemical analysis** Thermo analytical techniques, Instrumentation and applications of TGA, DTA, DSC. [	**5**
Module-4	**Electrochemical Techniques** Electrochemical Instrumentation, Coulometry, polarography, cyclic voltametry, application to oxidation-reduction reaction, Principle of Corrosion, types and prevention	**10**
Module-5	**Vacuum Technology & Thin film Deposition Technique** Application to Vacuum Technology, Types of vacuum pumps, different technique of thin film deposition CVD, PVD, MBE, MOCVD	**10**

References:

1. Solid State Physics- Structure and Properties of Materials M. A. Wahab, Narosa 2015.
2. Spectroscopy, Vol. I, II and III, ed. By Straughan and Walker, John Wiley.
3. Surface Analysis – The Principal Techniques, Edited by J. C. Vickerman, John Willey & Sons
4. Instrumental Methods of Chemical Analysis By G. W. Ewing, Mcgraw –Hill Book Company
5. Vacuum Science and Technology by V.V. Rao, T.B. Gosh, K.L. Chopra, Allied Publishers, 17-Oct-1998

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA

Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

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

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

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

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I	√				
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
A	H	H	H	H	M
B	H	H	M	L	M
C	M	L	H	H	M
D	H	M	H	H	H
E	H	M	M	H	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	1	2	3	4	5	6
1	H	H	M	M	H	H
2	H	H	M	M	H	H
3	H	H	M	M	H	H
4	H	H	M	M	H	H
5	H	H	M	M	H	H

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	-	-

Lecture wise Lesson planning Details.

T1: Atmospheric Science : An Introductory Survey ,Second Edition -John M.Wallace and Peter V. Hobbs, University of Washington

R1: Atmospheric chemistry and physics: from air pollution to climate change, Second edition- John H. Seinfeld, Spyros N. Pandis, a wiley-interscience publication, john wiley & sons, inc.

R2: An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004

R3: Radar for meteorological and atmospheric observations – S. Fukao and K. Hamazu, Springer Japan, 2014

R4: Fundamentals of Remote Sensing, George Joseph and Jeganathan, c. (2017). 3rd Edition, Universities Press, ISBN 978 93 86235 46 6

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
3	L1-L10			Module I	R1				
3	L11-L25			Module 2	R2,34,5				
1	L26-L30			Module 3	R2,3,4,5				
2	L31-L40			Module 4	R1,4				
3	L41-50			**Module 5**	R5				

COURSE INFORMATION SHEET

Course code: PH 324
Course title: Atmospheric Physics Lab
Pre-requisite(s): Intermediate Physics
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C : 2
Class schedule per week:
Class: I.M.Sc.
Semester / Level: PE IV
Branch: PHYSICS
Name of Teacher:

Atmospheric Physics Lab	**40 Lectures**

1) Monitoring and estimation of Respirable Suspended Particulate Matter in the ambient air by respirable dust sampler.
2) Monitoring and estimation of NO_x in the ambient air by NO_x analyzer.
3) Monitoring and estimation of SO_x in the ambient air by High Volume Sampler.
4) Monitoring and estimation of CO in the ambient air by CO analyzer.
5) Monitoring and analysis of CO_2 in the ambient air by CO_2 monitor.
6) Statistical analysis for one month data of atmospheric parameters (Temperature, Relative humidity, pressure, wind speed)
7) Computational analysis for few months data of atmospheric parameters i.e. Temperature, Relative humidity, pressure, wind speed (find daily variation, diurnal variation, wind rose)
8) Estimation and analysis of aerosol optical with satellite data
9) Estimation of analysis of aerosol related properties from AERONET data of any site
10) Estimation and analysis of Sea surface temperature with satellite data
11) Estimation and analysis of Outgoing longwave radiation with satellite data
12) Calculation of color temperature by Planck law.

<u>COURSE INFORMATION SHEET</u>

Course code: PH 325
Course title: Advanced Experimental Techniques Lab
Pre-requisite(s):
Co- requisite(s): Intermediate Physics
Credits: L: 0 T: 0 P: 4 C : 2
Class schedule per week:
Class: I.M.Sc.
Semester / Level: PE IV
Branch: PHYSICS
Name of Teacher:

Advanced Experimental Techniques Lab

1. To find corrosion rate using tafel plot
2. To do plasma nitriding coating using nitriding system
3. To understand the working of magnetron coating unit and deposit thin film.
4. To deposit nanocrystalline coating
5. To deposit hard coating and determine hardness of thin film
6. To deposit thin film using anodic vacuum arc coating
7. Determination of elemental and structural analysis using EDX and SEM
8. structural and particle size determination using XRD
9. Band gap determination using UV-visible spectrometer
10. To study the polarizattion vs electric field of ferroelectric materials
11. Phase transition study of barium titanate

I.M.Sc. (Physics) (VII -X Sem) as well as M.Sc. (I -IV Sem)

Semester	Subjects	Credit	Total
I.M.Sc. VII / M.Sc. I	Mathematical Method in Physics	3	**20**
	Electrodynamics	3	
	Classical Mechanics	3	
	Quantum Mechanics	3	
	Open Elective I	3	
	Modern Computational Techniques & Programming (Th + Lab-I)	3	
	Lab-II	2	
I.M.Sc. VIII / M.Sc. II	Statistical Physics	3	**22**
	Electronics Devices & Circuits	4	
	Atomic and Molecular Spectroscopy	4	
	Condensed Matter Physics	4	
	Open Elective II (Other Dept)	3	
	Lab III	2	
	Labs IV	2	
I.M.Sc. IX / M.Sc. III	Nuclear and Particle Physics	3	**22**
	Advanced Quantum Mechanics	3	
	Laser Physics and Applications	3	
	PE- V One paper from Either Group A or B or C or D or E: Specialization	4	**Papers shall be chosen from same group in I.M.Sc. IX and X Semesters**
	Project from Either Group A or B or C or D or E	4	
	Lab -V	2	
I.M.Sc. X / M.Sc. IV	PE- VI & VII Two papers from the same Group A or B or C or E	8	**16**
	Project from the same Group A or B or C or E	8	
		Total	**80**

Minimum requirement: 145 (UG)+80 (PG)= 225 Credits

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

I.M.Sc. VII / M.Sc. I Semester

COURSE INFORMATION SHEET

Course code: PH 401
Course title: Mathematical Methods in Physics
Pre-requisite(s): Mathematical Physics
Co- requisite(s):
Credits: L: 4 T: 0 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: VII / I
Branch: PHYSICS
Name of Teacher:

Code: PH 401	Title: Mathematical Methods in Physics	L-T-P-C [4-0-0-4]

Course Objectives: The objectives of the course are

1.	To train the students to solve problems related to complex variables which contain real and imaginary parts.
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 complex variables.
2.	They will be familiarized with different special functions like Associated Legendre Polynomials, Polynomials, etc. and their solutions in solving different physical problems.
3.	This module will be helpful to obtain knowledge of Fourier and Laplace Transforms 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.

Module-1	**Complex variables** Analytic functions, Cauchy-Riemann conditions, Cauchy's Integral theorem and Integral formula, Laurent expansion, Singularities, Evaluation of residues, Residue theorem.	**[6]**
Module-2	**Special Functions** Associated Legendre Polynomials, Recurrence relations, Rodrigue's formula, Orthogonality of Legendre Polynomials, Hermite Polynomials, Green's function.	**[8]**
Module-3	**Integral Transform** Laplace Transform, Inversion, Applications of Laplace Transform; Fourier Transform, Inversion, Fourier Sine and Cosine transform, Convolution Theorem, Fourier transforms of derivatives, Applications of Fourier Transform. **Probability** Elementary probability theory, simple properties, random variables, binomial and normal distribution , centre limit theorem	**[10]**
Module-4	**Tensors** Covariant, Contravariant and Mixed tensors, Tensors of rank 2, Algebra of tensors: Sum, Difference & Product of Two Tensors, Contraction, Quotient Law of Tensors, Pseudotensors, dual tensors, Tensors in General Coordinates, Tensor derivative operators, Jacobians, Inverse of Jacobians. Diad and Triad.	**[8]**
Module-5	**Introductory group theory**	**[8]**

	Review of sets, Mapping and 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).	

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

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design : NA

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
Quiz (s)	30
End Sem Examination Marks	60
Assignment	10

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	c	d	e
1	H	L	L	L	L
2	L	H	L	L	L
3	L	L	H	L	L
4	L	L	L	H	L
5	L	L	L	L	H

Mapping of Course Outcomes onto Program Outcomes

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

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			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1-2	L1-L6			Analytic functions, Cauchy-Riemann conditions, Cauchy's Integral theorem and Integral formula, Laurent expansion, Singularities, Evaluation of residues, Residue theorem.	T1, R1	1		PPT Digi Class/ Chock -Board	
3-5	L7-			Associated Legendre Polynomials,	T1,	2			

	L14			Recurrence relations, Rodrigue's formula, Orthogonality of Legendre Polynomials, Hermite Polynomials, Green's function.	T2, R2					
5-7	L15-L20			Laplace Transform, Inversion, Applications of Laplace Transform; Fourier Transform, Inversion, Fourier Sine and Cosine transform, Convolution Theorem, Fourier transforms of derivatives, Applications of Fourier Transform.	T1,R3	3				
7-8	L21-L24			Elementary probability theory, simple properties, random variables, binomial and normal distribution, central limit theorem	T2, R2	3				
9-11	L25-L32			Covariant, Contravariant and 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.	T1, T2	4				
11-14				Review of sets, Mapping and 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).	T3, R4	5				

<u>**COURSE INFORMATION SHEET**</u>

Course code: PH 402
Course title: Electrodynamics
Pre-requisite(s): Electricity and Magnetism
Co- requisite(s):
Credits: L: 4 T: 0 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: VII / I
Branch: PHYSICS
Name of Teacher:

Code: PH 402	**Title: Electrodynamics**	**L-T-P-C [4-0-0-4]**

Course Objectives

This course enables the students:

A.	Introducing the mathematical tools used in electrodynamics.
B.	Review of electrostatics and magnetostatics in matter.
C.	Providing easy headway into the covariant formulation of Maxwell's equations.
D.	Teaching basic principles of waveguides and transmission lines.
E.	Rendering insights into fields generated by oscillating sources, and their applications.

Course Outcomes

After 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.	Learning about TM, TE and TEM modes in waveguides.
5.	Understanding radiations by moving charges.

Module-1	The concept of a scalar potential. Poisson's and Laplace's equations for scalar potential. Green's theorem, Electrostatic field energy density. Solutions of Laplace's equation in rectangular, spherical and cylindrical coordinates using the method of separation of variables, Method of images, Multipole expansion of potential due to a localized charge distribution.	**[8]**
Module-2	Electrostatics in matter; Polarization and electric displacement vector. Electric field at the boundary of an interface, Linear dielectrics. Magnetostatics, Biot-Savart Law, Ampere's Law, Scalar and Vector potentials, Magnetic moment of a current distribution. Macroscopic magnetostatics, Magnetization. M and H vectors, Boundary conditions.	**[8]**
Module-3	Electromagnetic induction, Faraday's Law, Maxwell's equations, Maxwell's equations in matter, Conservation of charge, Poynting's theorem, Solutions of Maxwell's Equations, Covariant formulation of electrodynamics, Inhomogeneous wave equations and their solutions.	**[8]**
Module-4	Electromagnetic waves in matter, 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, propagation in a conductor, skin depth. Transmission lines and wave guides; Dynamics of charged particles in static and uniform electromagnetic fields.	**[8]**
Module-5	EM Field of a localized oscillating source. Fields and radiation in dipole and quadrupole approximations. Antenna; Radiation by moving charges, Lienard-Wiechert potentials, total power radiated by an accelerated charge, Lorentz formula.	**[8]**

References:

1. Introduction to Electrodynamics by D. J. Griffiths
2. Classical Electrodynamics by J. D. Jackson
3. Lectures on Electromagnetism by A. Das

Gaps in the syllabus (to meet Industry/Profession requirements)
POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

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
A	H	M	-	M	L
B	H	H	-	L	-
C	H	M	H	H	M
D	H	L	-	H	L
E	H	L	M	M	H

Mapping of Course Outcomes onto Program Outcomes

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

Lecture wise Lesson planning Details.

Week No.	Lect.No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COsmapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1-L4			The concept of a scalar potential. Poisson's and Laplace's equations for scalar potential. Green's theorem, Electrostatic field energy density. Solutions of Laplace's equation in rectangular coordinates	T1,T3	1			
2	L5-L8			Laplace's equation in spherical and cylindrical coordinates using the method of separation of variables, Method of images, Multipole expansion	T1,T3	1			

				of potential due to a localized charge distribution.					
3	L9-L12			Electrostatics in matter; Polarization and electric displacement vector. Electric field at the boundary of an interface, Linear dielectrics. Magnetostatics, Biot-Savart Law, Ampere's Law,	T1,T3	2			
4	L13-L16			Scalar and Vector potentials, Magnetic moment of a current distribution. Macroscopic magnetostatics, Magnetization. M and H vectors, Boundary conditions.	T1,T3	2			
5	L17-L20			Electromagnetic induction, Faraday's Law, Maxwell's equations, Maxwell's equations in matter, Conservation of charge, Poynting's theorem,	T1,T3	3			
6	L21-L24			Solutions of Maxwell's Equations, Covariant formulation of electrodynamics, Inhomogeneous wave equations and their solutions.	T1,T3	3			
7	L25-L28			Electromagnetic waves in matter, 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,	T1,T3	4			
8	L29-32			propagation in a conductor, skin depth. Transmission lines and wave guides; Dynamics of charged particles in static and uniform electromagnetic fields.	T1,T3	4			
9	L33-L36			EM Field of a localized oscillating source. Fields and radiation in dipole and quadrupole approximations.	T1,T3	5			
10	L37-L40			Antenna; Radiation by moving charges, Lienard-Wiechert potentials, total power radiated by an accelerated charge, Lorentz formula.	T1,T3	5			

COURSE INFORMATION SHEET

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: L: 3 T: 0 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: VII / I
Branch: PHYSICS
Name of Teacher:

Code: PH 403	Title: Classical Mechanics	L-T-P-C [3-0-0-3]

Course Objectives

This course enables the students:

A.	To define the concepts of Langrangian Mechanics.
B.	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:

1.	Formulate the Lagrangian mechanics concepts and solve the problems with the help of Lagrangian mechanics.
2.	Compare the formulation of Hamiltonianand 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.

Module-1	Constraints, classification of constraints, generalized coordinates, principal of virtual work, D 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.	**[10]**
Module-2	Hamilton's function and Hamilton's equation of motion, configuration space, phase space and state space, Lagrangian and Hamiltonian of relativistic particles, Relativistic Lagrangian and Hamiltonian of a charged particle in an electromagnetic field.	**[7]**
Module-3	Generating function, Conditions for canonical transformation and problem. Poisson Brackets , its definitions, identities, Poisson theorem, Jacobi-Poisson theorem, Jacobi identity, invariance of PB under canonical transformation. Lagrange bracket.	**[5]**
Module-4	Dynamics of a Rigid Body: Rigid body and space reference system, Euler's angles, angular 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	**[10]**
Module-5	Coupled Oscillator: Potential energy and equilibrium of one dimensional oscillator, 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	**[8]**

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

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	25
End Sem Examination	50
Quiz I and Quiz II	10+10
Teacher’s assessment	5

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

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**	**5**
A	H	M	M	L	L
B	H	H	M	L	L
C	M	M	H	L	L
D	L	L	L	H	L
E	L	L	L	L	H

Mapping of Course Outcomes onto Program Outcomes

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

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	-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
	L1-L3			Constraints, classification of constraints, generalized coordinates, principal of virtual work, D Alembert's principal, Langrange's equations of motion	T1 T2				
	L4-L6			properties of kinetic energy function, theorem on total energy, generalized momenta, cyclic-coordinates, integrals of motion, Jacobi integrals and energy conservation, concept of symmetry	T1 T2				
	L7-L10			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	T1 T2				

				integrals, differential equation for an orbit, Kepler's law, stability of orbits, virial theorem, scattering in a central force field					
	L11-L13			Hamilton's function and Hamilton's equation of motion	T1 T2				
	L14			configuration space, phase space and state space	T1 T2				
	L15-L17			Lagrangian and Hamiltonian of relativistic particles, Relativistic Lagrangian and Hamiltonian of a charged particle in an electromagnetic field.	T1 T2				
	L18, L19			Generating function, Conditions for canonical transformation and problem.	T1 T2				
	L20-L22			Poisson Brackets, its definitions, identities, Poisson theorem, Jacobi-Poisson theorem, Jacobi identity, invariance of PB under canonical transformation. Lagrange bracket.	T1 T2				
	L23-L27			Dynamics of a Rigid Body: Rigid body and space reference system, Euler's angles, angular 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	T1 T2				
	L28-L32			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,	T1 T2				

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

<u>**COURSE INFORMATION SHEET**</u>

Course code: PH 404
Course title: Quantum Mechanics
Pre-requisite(s): Previous papers of Quantum Mechanics
Co- requisite(s):
Credits: L: 4 T: 0 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: VII / I
Branch: PHYSICS
Name of Teacher:

Code: PH 404	**Title: Quantum Mechanics**	**L-T-P-C [4-0-0-4]**

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.
5. apply the Variational principle and WKB Approximation to solve the real problems-Classify nanomaterials, their fabrication techniques and co relate the effects of confinement to nanoscale on their properties.

Module-1	**Introduction to Dirac and Heisenberg Formulation:** Linear vector space, Dirac Bra-Ket notations. Determination of eigen-values and eigen-functions using matrix representations. Coordinate and momentum representation. Uncertainty principle.	**[10]**
Module-2	**Harmonic Oscillator and Hydrogen atom problem:** 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.	**[10]**
Module-3	**Angular momentum and its addition:** 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	**[10]**

	particles, Pauli's exclusion principle.	
Module-4	**Scattering theory:**Scattering Theory, differential and total scattering cross-section laws, partial wave analysis and application to simple cases; Integral form of scattering equation, Born approximation validity and simple applications.	**[5]**
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.	**[5]**

Text books:

1. J. J. Sakurai, Modern Quantum Mechanics , Addison-Wesley Publishing Company, 1994.
2. Nouredine Zettili, Qunatum Mechanics: Concepts and Application, Wiley Publications 2016.
3. R. Shankar, Principles of Quantum Mechanics, Plenum Press, 1994.

Reference books:

1. L. I. Schiff, Quantum Mechanics, Tata McGraw Hill, New Delhi
2. L. D. Landau and E. M. Lifshitz, Quantum Mechanics, Pergamon, Berlin.

Gaps in the syllabus (to meet Industry/Profession requirements)
POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

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 Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	60
Quiz	15
Teachers Assessment	5

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 Outcome #	**Program Outcomes**					
	a	b	c	d	e	f
1	H	H	H	L	M	L
2	H	H	M	L	L	L
3	H	M	M	L	L	L
4	H	M	M	L	L	L
5	H	H	H	L	H	L

Course Outcome #	**Course Objectives**				
	a	b	c	d	e
1	H	M	M	M	L
2	M	H	M	M	L
3	M	M	H	L	L
4	M	M	H	L	L
5	M	M	L	L	H

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			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

Lecture wise Lesson planning Details.

Week No.	**Lect. No.**	**Tentative Date**	**Module No.**	**Topics to be covered**	**Text Book / References**	**Cos mapped**	**Actual Content covered**	**Methodology used**	**Remarks by faculty if any**
1	L1		I	Linear vector space	T2	CO-1		PPT Digi Class/Chalk Board	
	L2-L3			Dirac Bra-Ket notations	T2	CO-1		PPT Digi Class/Chalk-Board	
2	L4-6			Determination of	T1	CO-1		PPT Digi	

				eigen-values and eigen-functions using matrix epresentations.				Class/Chalk-Board	
3	L7-8			Coordinate and momentum representation	T1	CO-1		PPT Digi Class/Chalk-Board	
3-4	L9-L10			Uncertainty principle	T3	CO-1		PPT Digi Class/Chalk-Board	
4	L11		II	Linear harmonic oscillator	T3	CO-2		PPT Digi Class/Chalk-Board	
4-5	L12-13			Heisenberg and quantum mechanical treatments.	T3	CO-2		PPT Digi Class/Chalk-Board	
5	L14			Asymptotic behaviour, energy levels,	T1	CO-2		PPT Digi Class/Chalk-Board	
5	L15			correspondence with classical theory.	T1	CO-2		PPT Digi Class/Chalk-Board	
6	L16-17			Spherically symmetric potential in three dimensions,		CO-2		PPT Digi Class/Chalk-Board	
6-7	L18-19			hydrogen atom, wave functions, eigenvalues, degeneracy, etc.	T1, T2, T3	CO-2		PPT Digi Class/Chalk-Board	
7	L20-21		III	Theory of angular momentum, symmetry, invariance and conservation laws,	T2	CO-3		PPT Digi Class/Chalk-Board	
8	L22-23			relation between rotation and angular momentum.	T2	CO-3		PPT Digi Class/Chalk-Board	
8-9	L24-25			Commutation rules, eigenvalues and eigen functions of the angular momentum.	T1	CO-3		PPT Digi Class/Chalk-Board	
9	L26-27			Stern-Gerlach experiment, spin, spin operators	T1	CO-3		PPT Digi Class/Chalk-Board	
10	L28			Pauli's spin matrices. Spin states of two spin-1/2 particles.	T1, T2, T3	CO-3		PPT Digi Class/Chalk-Board	
10	L29			Addition of angular momenta, Clebsch-Gordon coefficients.	T1, T2, T3	CO-3		PPT Digi Class/Chalk-Board	
10	L30			Principle of	T1,	CO-3		PPT Digi	

				indistinguishablity of identical particles,	T2, T3			Class/Chalk-Board	
11	L31			Pauli's exclusion principle	T3	CO-3		PPT Digi Class/Chalk-Board	
11	L29		IV	Scattering Theory, differential and total scattering cross-section laws	T2	CO-4		PPT Digi Class/Chalk-Board	
11	L30			partial wave analysis and application to simple cases	T2	CO-4		PPT Digi Class/Chalk-Board	
12	L31			Integral form of scattering equation	T1	CO-4		PPT Digi Class/Chalk-Board	
12	L32-33			Born approximation validity and simple applications	T2	CO-4		PPT Digi Class/Chalk-Board	
13	L34		V	Variational Principle, WKB approximation	T2	CO-5		PPT Digi Class/Chalk-Board	
13	L35			solution near a turning point	T2	CO-5		PPT Digi Class/Chalk-Board	
13	L36			connection formula, tunnelling through barrier	T2	CO-5		PPT Digi Class/Chalk-Board	
14	L37			boundary conditions in the quasi classical case	T2	CO-5		PPT Digi Class/Chalk-Board	

<u>**COURSE INFORMATION SHEET**</u>

Course code: PH 405
Course title: Modern Computational Techniques & Programming
Pre-requisite(s): Mathematical Physics
Co- requisite(s):
Credits: L: 4 T: 0 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: VII / I
Branch: PHYSICS
Name of Teacher:

Code: PH405	**Title: Modern Computational Techniques & Programming**	**L-T-P-C [3-0-0-3]**
Course Objectives: The idea behind the course is to teach students to solve problem in physics using MAPLE and MATLAB. In this regard the objectives are to 1. Teach to calculate various errors which arise while solving different equations. 2. Train them to solve systems of linear equations. 3. Teach them the concept of interpolation. 4. Instruct them to calculate integrals and differentials using different numerical methods. 5. Train them to solve partial differential equations numerically. **Program Outcomes:** After completion of the course, students should be able to 1. Estimate errors while solving equations. 2. Effectively use methods like matrix inversion, Gauss elimination and LU decomposition to solve linear equations. 3. Enrich a given set of data points using interpolation methods like cubic spline, Newton's divided difference, etc. 4. Numerically differentiate and integrate expressions. 5. Solve equations from physics like heat equation, diffusion equation, etc. numerically.		
Module-1	Approximation Methods, Errors and Roots of Equations, Accuracy and precision, Truncation and round-off errors, Bracketing Methods (false position, bisection), Iteration Methods (Newton-Raphson and secant).	**[8]**
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 books: T1: Introductory Methods of Numerical Analysis, S.S. Sastry, Prentice Hall of India (1983) **Reference books:** R1: Numerical Analysis, V. Rajaraman R2: Numerical Methods for Engineering, S.C. Chopra and R.C. Canale, McGraw-Hill (1989). R3: Numerical Methods for Scientists and Engineers, Prentice Hall of India (1988).		

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design : NA

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	Y

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Quiz (s)	30
End Sem Examination Marks	60
Assignment /	10

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	c	d	e
1	H	L	L	L	L
2	L	H	L	L	L
3	L	L	H	L	L
4	L	L	L	H	L
5	L	L	L	L	H

Mapping of Course Outcomes onto Program Outcomes

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

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			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if 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), Iteration Methods (Newton-Raphson and secant).	T1, R1	1		PPT Digi Class/Chock -Board	
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			

<u>COURSE INFORMATION SHEET</u>

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

Title: Modern Computational Techniques & Programming Lab

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) $\dfrac{1}{1-0.1}$

3. Let $u = \dfrac{5xy^3}{z^2}$. 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.

$$x + 3y - 2z = 10$$
$$3x + 5y + 6z = 7$$
$$2x + 4y + 3z = 8$$

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 $x = 1.2$.

x	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:

x	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):

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

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,

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

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).
5. Electromagnetics and Calculation of Fields, Nathan P-Ida and J.P.A. Bastos, Springer-Verlag (1992).

COURSE INFORMATION SHEET

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

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)

I.M.Sc. VIII / M.Sc. II Semester

COURSE INFORMATION SHEET

Course code: PH 408
Course title: Statistical Physics
Pre-requisite(s): Mathematical Physics
Co- requisite(s): Quantum Physics
Credits: L: 4 T: 0 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: VIII / II
Branch: PHYSICS
Name of Teacher:

Code: PH 408	Title: Statistical Physics	L-T-P-C [3-0-0-3]

Course Objectives

1. To understand the dependence of equilibrium properties of various systems on their microscopic constituents and compute thermodynamic parameters by using classical statistics.
2. To learn to use methods of quantum statistics to obtain properties of systems made of microscopic particles 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 physics.

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.
3. 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** 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.	**[8]**
Module-2	**Quantum Statistics** Formalism of Fermi-Dirac and Bose-Einstein statistics. Applications of the formalism to: (a) 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	**[8]**
Module-3	**Phase Transitions and Critical Phenomena** First and Second order Phase transitions, Diamagnetism, paramagnetism, and ferromagnetism, Landau theory, critical phenomena, Critical exponents, scaling hypothesis.	**[8]**
Module-4	**Ising Model :** Ising Model, mean-field theory, exact solution in one dimension.	**[6]**
Module-5	**Nonequilibrium Systems:** Correlation of space-time dependent fluctuations, fluctuations and transport phenomena, Diffusion equation, Random walk and Brownian motion, Langevin theory, fluctuation dissipation theorem, Fokker-Planck equation.	**[10]**

Text books:

T1: Statistical Physics, Landau and Lifshitz, Pergamon Press

Reference books:

R1: Statistical 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

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design : NA

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
Quiz (s)	30
End Sem Examination Marks	60
Assignment /	10

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	c	d	e
1	H	L	L	L	L
2	L	H	L	L	L
3	L	L	H	L	L
4	L	L	L	H	L
5	L	L	L	L	H

Mapping of Course Outcomes onto Program Outcomes

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

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			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1-3	L1-L8			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.	T1	1		PPT Digi Class/Chock -Board	
3-6	L9-L16			Formalism of Fermi-Dirac and Bose-Einstein statistics. Applications of the formalism to: (a) 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	T1, R1, R2	2			
6-8	L17-L24			First and Second order Phase transitions, Diamagnetism, paramagnetism, and ferromagnetism, Landau theory, critical phenomena, Critical	T1,R2 3	3			

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

COURSE INFORMATION SHEET

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

Code: PH 409	**Title: Atomic and Molecular Spectroscopy**	**L-T-P-C [3-1-0-4]**

Course Objectives

This course enables the students:

A.	To learn about the intricacies of spectra of Hydrogen-like atoms
B.	To understand the details of rotational, vibrational and Raman spectra of molecules.
C.	To know about the different regions of spectra, and the corresponding instrumentations.
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

After 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 molecules
3.	Able to comprehend the instrumentation techniques that are used in different regions of spectra
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]**
Module-5	Principle and applications of Mass Spectroscopy, Thomson's method of determining e/m of electrons, Aston mass spectrograph, Dempster's mass spectrometer, Ionization Methods, instrumentation and applications.	**[10]**

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.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

_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
A	H	-	L	L	-
B	-	H	H	-	-
C	L	H	H	-	-
D	-	-	L	H	-
E	-	-	-	-	H

Mapping of Course Outcomes onto Program Outcomes

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

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1-L3			Atomic Physics: Quantum states of an electron in an atom; Electron spin; Stern-	T2, R1	1		PPT Digi Class/Choc k	

				Gerlach experiment; Spectrum of Hydrogen, helium and alkali atoms; Relativistic corrections for energy levels of hydrogen				-Board	
2	L4-L6			Hyperfine structure and isotopic shift; Spectral terms, L-S and J-J coupling schemes, Singlet-Triplet separation for interaction energy of L-S coupling	T2, R1	1			
3	L7-L9			Lande Interval rule, Zeeman, Paschen Back & Stark effect; width of spectral lines	T2, R1	1			
4	L10-L12			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.	T2, R1	2			
5	L13-L15			Molecular hydrogen, Fluorescence and Phosphorescence, Instrumentations of IR and Microwave Spectroscopy and Applications. Raman Effect	T2, R1	2			
6	L16-L19			Rotational Raman spectra. Vibrational Raman spectra. Stokes and anti-Stokes lines and their Intensity difference, Instrumentation and applications.	T2, R1	2			
7	L20-L22			Characterization of electromagnetic	T2, R1	3			

				radiation, regions of spectrums, spectra representation, basic elements if practical spectroscopy					
8	L23-L25			resolving power, width and intensity of spectral transition, Fourier transform spectroscopy, concept of stimulated emission.	T2	3			
9	L26-L29			NMR Spectroscopy: Nuclear spin, nuclear resonance, saturation, spin-spin and spin-lattice relaxations	T2, R2	4			
10	L30-L33			chemical shift, de shielding, coupling constant, instrumentation and applications.	T2, R2	4			
11	L34-L37			Principle and applications of Mass Spectroscopy, Thomson's method of determining e/m of electrons, Aston mass spectrograph,	R2	5			
12	L38-L41			Dempster's mass spectrometer, Ionization Methods, instrumentation and applications.	R2	5			

<u>**COURSE INFORMATION SHEET**</u>

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

<table>
<tr><td>Code:
PH 410</td><td>Title: Electronic Devices & Circuits</td><td>L-T-P-C
[3-0-0-3]</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td>Module-1</td><td>Electronic Devices
Varactor diode, photo-diode, Schottky diode, solar cell, Principle of Operation and I-V Characteristics of JFET, MOSFET. Thyristors (SCR, LASCR, Triac and Diac) Microwave semiconductor devices: Tunnel diode, IMPATT, Gunn effect and Gunn diode.</td><td>8</td></tr>
<tr><td>Module-2</td><td>Integrated circuits: Monolithic lC's, Hybrid lC's. Materials for IC fabrication (Si and GaAs), 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.</td><td>8</td></tr>
<tr><td>Module-3</td><td>Amplifiers using discrete devices
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.</td><td>12</td></tr>
<tr><td>Module 4</td><td>Operational amplifiers
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</td><td>10</td></tr>
</table>

	compensation, step response of op-amps.	
Module 5	**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, A/D converters, simultaneous, counter type, dual slope converter. **Single electron devices:** Quantum point contact, Coulomb blockade, Resonant tunneling transistor, Single electron transistor (SET).	12

Text books:

T1: Physics of Semiconductor Devices- S. M. Sze
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

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	NA
End Sem Examination Marks	60
Quiz	15+15
Assignment	10

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

Mapping between Objectives and Outcomes

Mapping between Course Objectives and Course Outcomes

Course Objectives	1	2	3	4	5	6
A	H	H	H	H	H	H
B	H	H	H	L	H	H
C	H	L	H	L	M	L
D	H	M	M	H	H	M
E	H	H	H	H	H	M
F	H	H	H	L	M	H
G	H	H	L	M	L	L

Mapping of Course Outcomes onto Program Outcomes

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

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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		Module-1	Varactor diode, Schottky diode,	T1				
	L2			photo-diode,	T1				
	L3			solar cell,	T1				
	L4			Principle of Operation and I-V Characteristics of JFET, MOSFET.	T1, T2, T4				
	L5								

	L6			Thyristors (SCR, LASCR, Triac and Diac)	T1, T4				
	L7								
	L8			Tunnel diode, IMPATT, Gunn effect and Gunn diode.	T1				
	L9		Module-II	**Integrated circuits:** Monolithic lC's, Hybrid lC's. Materials for IC fabrication (Si and GaAs)	T1, T3				
	L10			Crystal growth and wafer preparation, processes Epitaxy, Vapour phase epitaxy (VPE)	T1, T3				
	L11			Molecular beam epitaxy (BME), MOCVD Oxidation	T1, T3				
	L12			Ion implantation	T1, T3				
	L13			Optical lithography	T1, T3				
	L14			electron beam lithography, Etching processes	T1, T3				
	L15		Module-III	**Amplifiers using discrete devices** Amplifiers using BJTs	T4, T5, T6				
	L16			Amplifiers using FETs, MOSFETs and their analysis	T4, T5, T6				
	L17			Feedback in amplifiers, characteristics of negative feedback amplifiers	T4, T5, T6				
	L18			input resistance, output resistance,	T4, T5, T6				
	L19			method of analysis of a feedback amplifier	T4, T5, T6				
	L20			feedback types and their analyses, Bode plots, two-pole and three–pole transfer function with Feedback, approximate analysis of a multipole feedback amplifier	T4, T5, T6				

	L21			stability, gain and phase margins	T4, T5, T6				
	L22			compensation, dominant-pole compensation, pole-zero compensation	T4, T5, T6				
	L23		Module-IV	**Operational amplifiers** Differential Amplifier,	T4, T7				
	L24			emitter-coupled differential amplifier	T4, T7				
	L25								
	L26								
	L27			current mirror and active load	T7, T9				
	L28			transfer characteristics of a differential amplifier	T4, T7				
	L29			Measurement of op-amps parameters, frequency response of op-amps	T4, T7				
	L30			dominant–pole compensation, pole-zero compensation, lead compensation, step response of op-amps.	T4, T9				
	L31		Module-V	**Applications of Op-Amps** **Linear:** instrumentation amplifier	T5				
	L32			Precision rectifiers	T5,T9				
	L33			Active filters (low-pass, high-pass, band-pass, band-reject/ notch), Analog computation circuits	T5,T9				
	L34			**Nonlinear:** Comparators, Schmitt trigger	T5,T9				
	L35			multivibrators, AMV and MMV using 555 timer	T5,T9				
	L36			Waveform generation, D/A converters, binary weighted, A/D converters, simultaneous,	T5,T9				

				counter type, dual slope converter.					
	L37		Module-VI	**Single electron devices:** Quantum point 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: PH 411
Course title: Condensed Matter Physics
Pre-requisite(s): Quantum Mechanics
Co- requisite(s):
Credits: L: 3 T: 0 P: 0
Class schedule per week:
Class: I.M.Sc./M.Sc.
Semester / Level: VIII / II
Branch: PHYSICS
Name of Teacher: Dr S K Rout

Title: Condensed Matter Physics

Course Objectives

This course enables the students:

A.	To relate crystal structure to symmetry, recognize the correspondence between real and reciprocal space.
B.	Acquire knowledge of the behaviour of electrons in solids based on classical and quantum theories.
C.	To become familiar with the different types of magnetism and magnetism based phenomenon.
D.	To develop an understanding of the dielectric properties and ordering of dipoles in ferroelectrics.
E.	To get familiarized with the different parameters associated with superconductivity and the theory of superconductivity.

Course Outcomes

After the completion of this course, students will be:

1.	Able to correlate the X-ray diffraction pattern for a given crystal structure based on the corresponding reciprocal lattice.
2.	Able to explain how the predicted electronic properties of solids differ in the classical free electron theory, quantum free electron theory and the nearly free electron model.
3.	Able to explain various magnetic phenomena and describe the different types of magnetic ordering based on the exchange interaction.
4.	Able to differentiate between ferroelectric, anti-ferroelectric, piezoelectric and pyroelectric materials.
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 [3-1-0-4]**
Module-1	**CRYSTAL DIFFRACTION AND RECIPROCAL LATTICE** Revision of concepts, 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.	**[8]**
Module-2	**ENERGY BAND THEORY** 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.	**[8]**
Module-3	**MAGNETISM** 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,	**[8]**

	ferrimagnetism, spin glasses.	
Module-4	**DIELECTRICS AND FERROELECTRICS** 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.	**[8]**
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]**

Textbooks:

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. 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.

Gaps in the syllabus (to meet Industry/Profession requirements)
POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

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
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz (s)	20
Teacher's Assessment	05

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 Program Outcomes

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

Course Outcome #	Course Objective				
	a	b	c	d	e
1	H	L	M	M	M
2	L	H	M	M	L
3	L	M	H	L	M
4	L	L	M	H	L
5	L	M	M	L	H

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			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Module No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		I	Revision of concepts, crystal structure, Bravais Lattice,	T1, T2	1, 2		PPT Digi Class/Chalk -Board	
1	L2			lattice translation vector, symmetry operations, simple crystal structures, Miller indices, lattice planes, Braggs' law,	T1, T2			PPT Digi Class/Chalk -Board	

1	L3-L4			reciprocal lattice to SC, BCC, FCC, Laue's equation and Bragg's law in terms of reciprocal lattice vector,	T1, T2			PPT Digi Class/Chalk -Board	
2	L5			diffraction and the structure factor,	T1, T2			PPT Digi Class/Chalk -Board	
2	L6			Ewald's construction,	T1, T2			PPT Digi Class/Chalk -Board	
2	L7			structure determination using Laue's method, powder crystal diffraction, rotating crystal method,	T1, T2			PPT Digi Class/Chalk -Board	
3	L8			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	
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 Digi Class/Chalk -Board	
4	L12-13			density of states, Fermi-Dirac statistics, effect of temperature on Fermi distribution function	T1, T2			PPT Digi Class/Chalk -Board	
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 Digi Class/Chalk -Board	
5	L16			Energy band structure of conductors, semiconductors and insulators.	T1, T2			PPT Digi Class/Chalk -Board	
	L17		III	Magnetic Susceptibility, diamagnetism, Paramagnetism, The ground state of an ion and Hund's rules, adiabatic demagnetization	T1, T2, R2			PPT Digi Class/Chalk -Board	
	L18			Crystal fields, orbital quenching	T1, T2, R2			PPT Digi Class/Chalk -Board	
	L19			Jahn-Teller effect Nuclear magnetic resonance	T1, T2, R2			PPT Digi Class/Chalk -Board	
	L20-21			Electron spin resonance Mossbauer spectroscopy,	T1, T2, R2			PPT Digi Class/Chalk -Board	
	L22			Magnetic dipolar interaction, Exchange interaction,	T1, T2, R2			PPT Digi Class/Chalk -Board	
	L23-L24			Ferromagnetism, anti-ferromagnetism,Ferrimagnetisms,	T1, T2, R2			PPT Digi Class/Chalk	

				Spin glasses.				-Board	
	L25		IV	Macroscopic Maxwell equation of electrostatics	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L26			Theory of local field, theory of Polarisability, dielectric constant, Claussius-Mosotti relation	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L27			Optical properties of ionic crystals.	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L28-29			Dielectric breakdown, dielectric losses, ferroelectric, anti-ferroelectric.	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L30-31			Piezoelectric, Pyroelectric, frequency dependence of dielectric properties.	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L32			Classification of ferroelectric crystal, ferroelectric phase transitions, relaxor ferroelectrics.	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L33		V	Basic properties of Superconductors, Phenomenological thermodynamic treatment	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L34-35			London equation, penetration depth	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L36			Superconducting transitions, order parameter, Ginzburg-Landau theory	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L37			Cooper pair, electron-phonon interaction, BCS theory	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L38			Josephson junction	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L39			Coherence length, Flux quantization	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L40			High T_c superconductors, mixed state.	T1, T2, R1			PPT Digi Class/Chalk -Board	

COURSE INFORMATION SHEET

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:

COURSE INFORMATION SHEET

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:

I.M.Sc. IX / M.Sc. III Semester

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:

Code: 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 its 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	
Module	**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.	

References

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

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus: NA
Topics beyond syllabus/Advanced topics/Design: NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	00
End SemExamination Marks	60
Quiz	15+15
Teacher's assessment	10

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks					
End Sem Examination Marks	√	√	√	√	√
Quiz I			√	√	
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
A	H	M	L	L	L
B	M	H	L	L	L
C	M	L	H	L	L
D	L	L	L	H	L
E	L	M	L	L	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	A	b	c	D	E	f	g	h	I	J	k	l
1	H	H	L	M	M	M						
2	H	H	L	M	M	H						
3	H	H	M	M	M	H						
4	H	H	M	M	M	H						
5	H	H	L	M	M	H						

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 No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology Used	Remarks by faculty if any
1	L1-L2			Nuclear Models Liquid drop Model, semi-empirical mass formula,	T1 R1				
	L3-L4			transitions between odd A isobars, transitions between even isobars,	T1 R1				
	L5-L8			odd-even effects and magic numbers, Shell model, collective model. L	T1 R1				
	L9-L11			Two nucleon problem, The deuteron, ground state of deuteron,	T1 T2				
	L12-L13			nature of nuclear forces, excited state of deuteron,	T1-T2				
	L14-L15			spin dependence of nuclear force,	T1 T2				
	L-16			meson theory of nuclear force	T1 T2				
	L17-L20			Scattering, Cross section, differential cross section, scattering cross section,	T1 T2 R1				

	L20-L24			nucleon nucleon scattering, proton-proton and neutron-neutron scattering at low energies	T1 T2 R1				
	L25-L28			Interaction of radiation with matter, Interaction of charged particles with matter,	T1 R1				
	L29-L32			stopping power of heavy charged particles, energy loss of electrons, absorption of gamma rays, photoelectric effect, Compton effect and pair production	T1 R1				
	L33-L35			Classification of elementary particle,	T1 T3				
	L36-L38			Eightfold way, Baryon octate and meson octate, Quark model, Baryon Decuplet, meson nonlet, Intermediate vector Boson	T1 T3				
	L39-L40			Strong electromagnetic and week interactions, standard model, lepton classification and quark classification.	T1 T3				

COURSE INFORMATION SHEET

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
Name of Teacher:

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. Quantum Mechanics by L. I. Schiff. (Tata McGraw Hill, New Delhi)

References:

1. Quantum Mechanics by L. D. Landau and E. M. Lifshitz (Pergamon, Berlin)
2. Quantum Mechanics by A. K. Ghatak and S. Lokanathan (McMillan India)
3. A Textbook of Quantum Mechanics by P. T. Mathews (Tata McGraw Hill)

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus: NA
Topics beyond syllabus/Advanced topics/Design: NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√	√	
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
A	H	L	M	M	L
B	L	H	L	L	L
C	M	L	H	M	L
D	M	L	M	H	L
E	L	L	L	L	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	B	c	d	e	f		h	i	j	k	l
1	H	H	**H**	M	H	H						
2	H	H	**H**	M	H	H						
3	H	H	**H**	M	H	H						
4	H	H	H	M	L	H						
5	H	H	H	M	M	H						

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 No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology Used	Remarks by faculty if any
1	L1-L6			Perturbation theory, time-independent perturbation theory (non-degenerate and degenerate) and applications.	T1-T2-R1				
	L7-L9			Stark effect and other simple cases. Relativistic perturbation to hydrogen atom.	T1-T2_R1				
	L10-L12			Energy levels of hydrogen including fine structure, Lamb shift and hyperfine splitting	T1 T2 R1				
	L13-L15			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)**	T1 T2 R1				
	L16-L20			Quantum mechanics of molecules, Born-Oppenheimer approximation	T1 T3 R1				
	L21-L24			Time-dependent perturbations, first order transitions, Semi-classical theory of interaction of atoms with field.	T1 T3 R1				
	L25-L28			Quantization of radiation field. Hamiltonian of field and atom,	T1 T2 R1				
	L29-L30			Fermi golden rule, the Einstein's A & B coefficients.	T1 T2				
	L31-L34			Atom field interaction, density matrix equation,	T1 T2				
	L35-L38			closed and open two-level atoms, Rabi oscillations.	T1 T2 T3				
	L39-L44			Relativistic wave equations: Klein-Gordon equation for a free	T1 T2 T3				

				particle and particle under the influence of an electromagnetic potential,					
	L44-L50			, Dirac's relativistic Hamiltonian, Dirac's relativistic wave equation, positive and negative energy states, significance of negative energy states.	T1 T2 T3				

COURSE INFORMATION SHEET

Course code: PH 503
Course title: Lasers Physics and Applications
Pre-requisite(s): Waves and Optics
Co- requisite(s):
Credits: 3 L: 3 T: 1 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: IX / III
Branch: PHYSICS
Name of Teacher:

Code: PH 503	Title: Lasers Physics and Applications	L-T-P-C [3-1-0-4]

Course Objectives

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
E	To illustrate various applications of laser e.g. holographic non-destructive testing.

Course Outcomes

After the completion 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.

Module-1	Interaction of radiations with atoms and ions: Spontaneous and Stimulated emissions, Stimulated absorption. Population inversion, gain oscillation, gain saturation, threshold, rate equation, 3 and 4 level systems, laser line shape, hole burning, Lamb dip, output power. Properties of laser: coherence, monochromaticity, divergence.	**[15]**
Module-2	Theory of resonator. Stable and unstable resonator, Optical cavities, Cavity modes, longitudinal and transverse modes of the cavity.	**[10]**
Module-3	Continuous wave, Pulsed, Q- switched and Modelocked lasers.	**[5]**
Module-4	Different type of lasers, design (in brief) and functioning of different lasers - Ruby laser, Nd: YAG laser, He-Ne laser, CO_2 laser, Argon ion laser, Dye laser, Excimer laser. Free electron laser	**[10]**
Module-5	Measurement with laser, alignment, targeting, tracking, velocity measurement, surface quality measurement. 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.	**[10]**

<u>**Book:**</u>

T1: O. Svelto; Principles of Lasers, Springer (2004)
T2: Laser Fundamentsls: William T. Silfvast, Cambridge University Press (1998)
R1 K. Shimoda, Introduction to laser Physics, Springer Verlag, Berlin (1984)
R2: Laser Electronics: J.T.Verdeyen, 3rdEd, Prentice Hall (1994)
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

POs met through Gaps in the Syllabus : NA

Topics beyond syllabus/Advanced topics/Design : NA

POs met through Topics beyond syllabus/Advanced topics/Design

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	0
End Sem Examination Marks	60
Quiz	15+15
Teacher's assessment	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√	√	
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
A	H	M	M	L	M
B	M	H	M	L	L
C	L	L	H	L	L
D	-	L	L	H	L
E	L	M	L	L	H

Mapping of Course Outcomes onto Program Outcomes

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

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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	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			Spontaneous and Stimulated emissions, Stimulated absorption. Population inversion, 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 INFORMATION SHEET

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

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.
7. To determine the Kerr constant of the liquid (Nitro Benzene)
8. Study of hydrogen spectrum using grating and spectrometer.
9. To find the velocity of ultrasonic wave in a liquid using ultrasonic diffraction apparatus.

I.M.Sc. X / M.Sc. IV Semester

PE- VI & VII Two papers from the same Group A or B or C or E
Project from the same Group A or B or C or E

PE-V

Group A- <u>Theoretical and Computational Physics:</u>

1. Numerical Methods for Physicists
2. Theory of Solids

COURSE INFORMATION SHEET

Course code: PH 504
Course title: Numerical Methods for Physicists
Pre-requisite(s): Mathematical Physics
Co- requisite(s):
Credits: L: 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 1**

Code: PH 504	**Title: Numerical Methods for Physicists** Theory &Programming using C for solving problems on following topics:	**L-T-P-C [4- 0-0- 4]**

Course Objectives
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

Course Outcomes
After 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** Golden Section Search, Brent's Method, Methods Using Derivative, Minimization in Several Dimensions, Quasi-Newton Methods, Direction Set Methods, Linear Programming	**[10]**
Module-2	**Functional Approximations** 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	**[10]**
Module-3	**Algebraic Eigenvalue Problems** Introduction,Power Method, Inverse Iteration, Eigenvalue Problem for a Real Symmetric Matrix , QL Algorithm for a Symmetric Tridiagonal Matrix, Algebraic Eigenvalue Problem	**[10]**
Module-4	**Integral Equations** 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	**[10]**

Module-5	**Partial Differential Equations** 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	**[10]**

References

1. "Numerical methods for Scientists and Engineers" by H. M. Antia, Springer Science and Business Media.
2. "Numerical Recipes in C" by William H. Press, Saul A. Teukolsky, William T. Vetterling & Brian P. Flannery, Cambridge University Press.
3. "Programming in C# A Primer" by E Balagurusamy, McGraw Hill Education.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

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
A	H	L	-	-	-
B	M	H	L	-	M
C	M	L	H	-	M
D	M	L	L	H	M
E	M	L	L	L	H

Course Outcome #	**Program Outcomes**					
	a	**b**	**c**	**d**	**e**	**f**
1	**L**	**M**	**M**	**M**	**L**	**M**
2	**L**	**M**	**M**	**M**	**L**	**M**
3	**L**	**H**	**M**	**M**	**L**	**M**
4	**L**	**H**	**M**	**M**	**H**	**M**
5	**L**	**H**	**M**	**M**	**H**	**M**

Lecture wise Lesson planning Details.

Week No.	**Lect No.**	**Tentative Date**	**Ch. No.**	**Topics to be covered**	**Text Book / References**	**Cos mapped**	**Actual Content covered**	**Methodologyused**	**Remarks by faculty if any**
1	L1-L3			Golden Section Search, Brent's Method, Methods Using Derivative	T1,T2,T3	1		Board, Computers	

2	L4-L6			inimization in Several Dimensions, Quasi-Newton Methods	T1,T2,T3	1		Board, Computers	
3	L7-L9			Direction Set Methods, Linear Programming	T1,T2,T3	1		Board, Computers	
4	L10-L12			Choice of Norm and Model, Linear Least Squares, Nonlinear Least Squares	T1,T2,T3	2		Board, Computers	
5	L13-L15			Discrete Fourier Transform, Fast Fourier Transform (FFT),	T1,T2,T3	2		Board, Computers	
6	L16-L18			FFT in Two or More Dimensions, Functional Approximations	T1,T2,T3	2		Board, Computers	
7	L19-L21			Introduction,Power Method, Inverse Iteration,	T1,T2,T3	3		Board, Computers	
8	L22-L24			Eigenvalue Problem for a Real Symmetric Matrix , QL Algorithm for a Symmetric Tridiagonal Matrix	T1,T2,T3	3		Board, Computers	
9	L25-L27			Algebraic Eigenvalue Problem	T1,T2,T3	3		Board, Computers	
10	L28-L30			Introduction, Fredholm Equations of the Second Kind, Expansion Methods	T1,T2,T3	4		Board, Computers	
11	L31-L33			Eigenvalue Problem, Fredholm Equations of the First Kind	T1,T2,T3	4		Board, Computers	
12	L34-L36			Volterra Equations of the Second Kind, Volterra Equations of the First Kind	T1,T2,T3	4		Board, Computers	
13[T1,T2,T3]	L37-L39			Wave Equation in Two Dimensions, General Hyperbolic Equations, Elliptic Equations	T1,T2,T3	5		Board, Computers	
14	L40-L42			Successive Over-Relaxation Method, Alternating Direction Method, Fourier Transform Method	T1,T2,T3	5		Board, Computers	
15	L43-L45			Finite Element Methods, Algorithms for Vector and Parallel Computers	T1,T2,T3	5		Board, Computers	

COURSE INFORMATION SHEET

Course code: PH 505
Course title: Theory of Solids
Pre-requisite(s): Condensed Matter Physics
Co- requisite(s):
Credits: L: 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: PH 505	Title: Theory of Solids	L-T-P-C [4-0-0-4]

Course Objectives : This course enables the students

A.	To become familiar with classification of solids using band theory.
B.	To be familiarized with the change in density of states as a function of physical dimension of solids.
C.	To become familiar with the electrical behaviour of dielectric materials and understand the field charge induced by dielectrics.
D.	To become familiar with the theory behind the magnetic properties of materials.
E.	To understand the different optical processes and photophysical properties of solids.

Course Outcomes : 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 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** Review of Concepts: (Bloch theorem and Bloch function, Kronig Penney model), 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.	**[8]**
Module-2	**Electron Statistics** 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.	**[6]**
Module-3	**Dielectrics** 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^{nd} and relaxor kind), Hysteresis loop, Recoverable energy, Piezoelectricity and transducers.	**[10]**
Module-4	**Magnetism** Magnetic interactions, Exchange interaction, Direct exchange, Indirect exchange, Double exchange, Helical order, Frustration, Spin glasses, Landau theory of ferromagnetism, 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.	**[8]**

Module-5	**Optical properties** 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.	**[8]**

Text book

1. Introduction to Solid State Physics 8th Edition , 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).

Gaps in the syllabus (to meet Industry/Profession requirements)
POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

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
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz (s)	20
Teacher's Assessment	05

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					
	a	b	c	d	e	f
1	H	M	M	L	M	L
2	H	M	M	L	L	L
3	M	H	H	L	M	M
4	H	H	H	L	M	M
5	M	H	H	L	M	M

Course Outcome #	Course Objectives				
	a	b	c	d	e
1	H	M	L	L	M
2	M	H	L	L	L
3	L	L	H	L	M
4	L	L	L	H	L
5	M	L	M	M	H

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			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Module No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1-L2		I	Review of Concepts: (Bloch theorem and Bloch function,	T1, T2	1, 2		PPT Digi Class/Chalk -Board	
1	L3			Kronig Penney model)Construction of Brillouin zones (1 and 2 dimensions)	T1, T2			PPT Digi Class/Chalk -Board	
1	L4-L5			Extended, reduced and periodic zone scheme	T1, T2			PPT Digi Class/Chalk	

				Effective mass of an electron,				-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 method,Pseudo-potential method	T1, T2			PPT Digi Class/Chalk -Board	
3	L10			Classification of conductor, semiconductor and insulators	T1, T2			PPT Digi 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, Classification of solids (0D, 1D, 2D, 3D) on the basis of density of states	T1, T2			PPT Digi Class/Chalk -Board	
5	L17			k-space	T1, T2			PPT Digi Class/Chalk -Board	
6-7	L18-20			Effect of temperature on Fermi distribution function.	T1, T2			PPT Digi Class/Chalk -Board	
	L21		III	Matter in a.c. field, Propagation of e.m. wave in matter on the basis of Maxwell's equation	T1, T2			PPT Digi Class/Chalk -Board	
	L22			Relaxations and resonances	T1, T2			PPT Digi Class/Chalk -Board	
	L23			Kramer's-Kronig relation, Mechanical analogue of relaxation	T1, T2			PPT Digi Class/Chalk -Board	
	L24			Debye relation, Argand diagram	T1, T2			PPT Digi Class/Chalk -Board	
	L25			Influence of local field and d.c. conductivity and multiple relaxation times	T1, T2			PPT Digi Class/Chalk -Board	
	L26			Special diagram (cole-cole arc), Heterogeneous dielectrics (Maxwell-Wagner effect)	T1, T2			PPT Digi Class/Chalk -Board	
	L27			Ferroelectricity, Microscopic	T1, T2			PPT Digi Class/Chalk	

				theory of Ferroelectricity				-Board	
	L28			Phase transition of ferroelectrics (1st, 2nd and relaxor kind),	T1, T2			PPT Digi Class/Chalk -Board	
	L29			Hysteresis loop, Recoverable energy,	T1, T2			PPT Digi Class/Chalk -Board	
	L30			Piezoelectricity and transducers.	T1, T2			PPT Digi Class/Chalk -Board	
	L31		IV	Magnetic interactions, Exchange interaction	T1, T2, R2			PPT Digi Class/Chalk -Board	
	L32			Direct exchange, Indirect exchange	T1, T2, R2			PPT Digi Class/Chalk -Board	
	L33-34			Double exchange, Helical order, Frustration, Spin glasses	T1, T2, R2			PPT Digi Class/Chalk -Board	
	L35			Landau theory of ferromagnetism,	T1, T2, R2			PPT Digi Class/Chalk -Board	
	L36-37			Heisenberg and Ising models, Excitations,	T1, T2, R2			PPT Digi Class/Chalk -Board	
	L38			Magnons, Bloch $T^{3/2}$ law,	T1, T2, R2			PPT Digi Class/Chalk -Board	
	L39			Measurement of spin waves	T1, T2, R2			PPT Digi Class/Chalk -Board	
	L40			Spin density waves, Kondo effect.	T1, T2, R2			PPT Digi Class/Chalk -Board	
	L41		V	Classification of optical process, optical coefficient	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L42			complex refractive index, propagation of light in a dense optical medium	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L43			atomic oscillator, vibrational oscillator	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L44-45			free electron oscillator, dipole oscillator model	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L46			inter band absorptions,excitons, concept of excitons, free excitons, free excitons in external field	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L47			luminescence, light emission	T1, T2,			PPT Digi Class/Chalk	

				from solids	R1			-Board	
	L48			interband luminescence, photoluminescence	T1, T2, R1			PPT Digi Class/Chalk -Board	
	L49			electroluminescence,luminescence 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: 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 Option A)

COURSE INFORMATION SHEET

Course code: PH 506
Course title: Functional Materials
Pre-requisite(s): Condensed Matter Physics
Co- requisite(s):
Credits: L: 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 : B

Code: PH 506	**Title: Functional Materials**	**L-T-P-C [3-1-0-4]**
Module-1	Introduction to Metals, Alloys, Ceramics, Polymers and Composites, Phase rules Fe-C phase diagram, Steels, cold, hot working of metals, recovery, recrystallization and grain growth, Structure, properties.	**[8]**
Module-2	Processing and applications of ceramics. Classification of polymers, polymerization, structure, properties, additives, products, processing and applications. Quasicrystals, Conducting Polymers; Properties and applications composites.	**[12]**
Module-3	Advanced Materials: Smart materials, ferroelectric, piezoelectric, biomaterials (some basic information),superalloys, aerospace materials, shape memory alloys, optoelectronic materials, Materials for photodiode, light emitting diode (LED), Photovoltaic/Solar cell and meta materials	**[10]**
Module-4	Nanostructured Materials: Nanomaterials classification (Gleiter's Classification)–property changes done to size effects, Quantum dot, wire and well, synthesis of nanomaterials, ball milling.	**[8]**
Module-5	Liquid state processing -Sol-gel process, Vapour state processing –CVD, MBE, Aerosol 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.	**[12]**

Text books:

1. T1: Structure and properties of engineering materials, fifth edition, Henkel and Pense, McGraw Hill, 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

Gaps in the syllabus (to meet Industry/Profession requirements)
POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

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
Quizes	30
Assignment	10
End Sem Examination Marks	60

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

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					
	a	b	c	d	e	f
1	H	H	H	L	M	L
2	M	H	H	L	L	L
3	H	M	M	M	M	M
4	M	H	M	M	H	M
5	H	H	H	L	H	L

Course Outcome #	Course Objectives				
	A	B	C	D	E
1	H	M	M	M	M
2	L	H	L	L	M
3	L	M	H	M	M
4	H	L	H	H	L
5	H	M	M	L	H

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			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Module. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		I	Introduction to Metals, Alloys	T1			PPT Digi Class/Chalk-Board	
1	L2			Ceramics	T1, T2			PPT Digi Class/Chalk-Board	
1	L3-L4			Polymers and Composites, Phase rules	T1, T2			PPT Digi Class/Chalk-Board	
2	L5			Fe-C phase diagram	T1			PPT Digi Class/Chalk-Board	
2	L6-L8			Steels, cold, hot working of metals, recovery, recrystallization and grain growth, Structure, properties.	T1			PPT Digi Class/Chalk-Board	
2	L9-L10		II	Processing and applications of ceramics.	T1			PPT Digi Class/Chalk-Board	
3	L11-L13			Classification of polymers, polymerization, structure, properties	T1			PPT Digi Class/Chalk-Board	
3	L14-L16			additives, products, processing and applications.	T1			PPT Digi Class/Chalk-Board	
3	L17-L18			Quasicrystals	T1			PPT Digi Class/Chalk-Board	
4	L19-L20			Conducting Polymers; Properties and applications composites.	T1			PPT Digi Class/Chalk-Board	
4	L21-22		III	Advanced Materials: Smart materials,	T1			PPT Digi Class/Chalk-Board	
5	L23-24			Ferroelectric, piezoelectric,	T1			PPT Digi Class/Chalk-Board	
5	L25-L26			Biomaterials (some basic information), superalloys,	T2			PPT Digi Class/Chalk-Board	
6	L27-L28			Aerospace materials, shape memory alloys,	T1			PPT Digi Class/Chalk-Board	
6-7	L29-L30			Optoelectronic materials, Materials for photodiode, light emitting diode (LED), Photovoltaic/Solar cell and meta materials	T1			PPT Digi Class/Chalk-Board	
	L31-		IV	Nanostructured Materials:	T1			PPT Digi	

	L32			Nanomaterials classification (Gleiter's Classification)				Class/Chalk-Board	
	L33-L35			Property changes done to size effects,	T1			PPT Digi Class/Chalk-Board	
	L36-L38			Quantum dot, wire and well,	T1			PPT Digi Class/Chalk-Board	
	L39-L40		V	synthesis of nanomaterials, ball milling.	T2			PPT Digi Class/Chalk-Board	
	L41-L43			Liquid state processing -Sol-gel process, electronic properties of tubules, applications	T1, T2			PPT Digi Class/Chalk-Board	
	L44-L46			Vapour state processing –CVD, MBE	T1			PPT Digi Class/Chalk-Board	
	L47-L48			Aerosol processing, fullerene and tubules,	T1			PPT Digi Class/Chalk-Board	
	L49-L50			Formation and characterization of fullerenes and tubules, single wall and multiwall carbon tubules	T1			PPT Digi Class/Chalk-Board	

Group C – Photonics:

1. Fiber and Integrated Optics
2. Quantum & Nonlinear Optics

COURSE INFORMATION SHEET

Course code: PH 507
Course title: Fiber and Integrated Optics
Pre-requisite(s): Waves and Optics
Co- requisite(s):
Credits: 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 : 1**

Code: PH 507	Title: Fiber and Integrated Optics	L-T-P-C [3-1-0-4]

Course Objectives : This course enables the students:

A.	To understand the light propagation phenomenon through fiber optic cable
B.	To understand various loss mechanism of signal while travelling through an optical fiber.
C.	To understand the basic working principle of waveguides and its design parameters.
D.	To identify waveguides for applications in fiber optics communication systems
E	To understand the principle of working of fiber based sensors for various application purposes.

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

1.	Able to illustrate the principle of fiber optics communications.
2.	Able to distinguish between various loss mechanism in fiber optics communication system.
3.	Able to utilize the idea of waveguide for different application purpose.
4.	Able to categorise different waveguides for the utilization in optics communication system
5.	Able to interpret different fiber sensors and their respective application and can recommend this technique for other new application.

Module-1	Principle of light propagation in fibers, step-index and graded index fibers; single mode, multimode and W-profile fibers. Ray optics representation, meridional and skew rays. Numerical aperture and acceptance angle.	**5**
Module-2	Dispersion, combined effects of material and other dispersions - RMS pulse widths and frequency response, birefringence. Attenuation in optical fibers. Material dispersion and waveguide dispersion in single-mode fibers, Inter and intramodal dispersion in graded-index fibers. .	**10**
Module-3	Theory of optical waveguides, planar, rectangular, symmetric and asymmetric waveguides, channel and strip loaded waveguides. Anisotropic and segmented waveguides. Step-index and graded index waveguides, guided and radiation modes. Arrayed waveguide devices. Fabrication of integrated optical waveguides and devices.	**12**
Module-4	Wave guide couplers, transverse couplers, grating couplers, tapered couplers, prism couplers, fiber to waveguide couplers. Multilayer planar waveguide couplers, dual channel directional couplers, Butt coupled ridge waveguides, Branching waveguide couplers. Directional couplers, optical switch; phase and amplitude modulators, filters, etc. Y-junction, power splitters.. .	**13**
Module-5	Fiber optics sensors, intensity modulation, phase modulation sensors, fiber Bragg grating sensors. Measurement of current, pressure, strain, temperature, refractive index, liquid level etc. Time domain and frequency domain dispersion measurement, fibre lasers and fibre gyroscope.	**12**

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:

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus: NA
Topics beyond syllabus/Advanced topics/Design: NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√	√	
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
A	H	M	M	M	L
B	M	H	M	M	--
C	M	M	H	M	L
D	L	M	H	H	M
E	M	M	H	H	H

Mapping of Course Outcomes onto Program Outcomes

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

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			

Lecture wise Lesson planning Details.

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

				in graded-index fibers					
	L16-L19			Theory of optical waveguides, planar, rectangular, symmetric and asymmetric waveguides, channel and strip loaded waveguides	T1, T2	CO3		PPT Digi Class/Chock-Board	
	L20-L23			Anisotropic and segmented waveguides. Step-index and graded index waveguides, guided and radiation modes	T1, T2	CO3		PPT Digi Class/Chock-Board	
	L24-L27			Arrayed waveguide devices. Fabrication of integrated optical waveguides and devices.	T1, T2	CO3		PPT Digi Class/Chock-Board	
	L28-L31			Wave guide couplers, transverse couplers, grating couplers, tapered couplers, prism couplers, fiber to waveguide couplers	T1, T2	CO4		PPT Digi Class/Chock-Board	
	L32-L35			Multilayer planar waveguide couplers, dual channel directional couplers , Butt coupled ridge waveguides , Branching waveguide couplers	T1, T2	CO4		PPT Digi Class/Chock-Board	
	L36-L39			Directional couplers optical switch; phase and amplitude modulators	T1, T2	CO4		PPT Digi Class/Chock-Board	
	L40			filters, Y-junction, power splitters	T1, T2	CO4		PPT Digi Class/Chock-Board	
	L41-L44			Fiber optics sensors, intensity modulation, phase modulation sensors, fiber Bragg grating sensors	T3	CO5		PPT Digi Class/Chock-Board	
	L45-L48			Measurement of current, pressure, strain, temperature, refractive index, liquid level etc.	T3	CO5		PPT Digi Class/Chock-Board	
	L49-L52			Time domain and frequency domain dispersion measurement, fibre lasers and fibre gyroscope.	T3	CO5		PPT Digi Class/Chock-Board	

COURSE INFORMATION SHEET

Course code: PH 508
Course title: Quantum and Nonlinear Optics
Pre-requisite(s): Waves and Optics
Co- requisite(s):
Credits: 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**

Code: PH 508	**Titles: Quantum and Nonlinear Optics**	**L-T-P-C [3-1-0-4]**

This course enables the students:

A.	To identify the phenomenon of the nonlinear optical interaction of light with matter
B.	To examine higher harmonic generations, two-photon absorption and stimulated scattering phenomenon
C.	To formulate nonlinear optics in two-level approximations
D.	To analyse intensity dependent phenomenon
E	To identify nonlinear optical phenomenon for applications in optical devices

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

1.	Able to judge non-linear optical phenomenon
2.	Apply knowledge of nonlinear optical phenomena in higher harmonic generations, two-photo absorption and stimulated scattering phenomenon
3.	To solve nonlinear optical interaction problem in two-level system
4.	To evaluate intensity dependent material properties like refractive indices and self-focussing
5.	To design non-linear optical devices

Module-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	**10**
Module-2	Manley-Rowe relations, phase matching of SHG, quasi phase matching, electric field induced SHG (EIFISH), optical parametric amplification, third harmonic generation, two-photon absorption. Stimulated Raman scattering and stimulated Brillouin scattering.	**10**
Module-3	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, dressedatomic state, optical wave mixing in two level systems, photon echo, self-induced transparency, optical nutation, free induction decay.	**10**
Module-4	tensity 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. .	**12**
Module-5	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	**8**

Book:

T1. Fundamentals of Nonlinear Optics; P.E.Powers, CRC Press Francis and Taylor (2011)
T2. Principles of Nonlinear Optics; Y.R.Shen
T3. Nonlinear Optics: Robert Boyd, Academic press
R1. Physics of Nonlinar Optics: Guang- Sheng –He and Song-Hao Lin; World scientific.
R2. Two Level Resonances in Atoms; Allen and J.H. Emberly, John Wiley.

POs met through Gaps in the Syllabus: NA

Topics beyond syllabus/Advanced topics/Design: NA

POs met through Topics beyond syllabus/Advanced topics/Design

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	0
End Sem Examination Marks	60
Quiz	15+15
Teacher's assessment	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√	√	
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
A	H	M	M	L	M
B	M	H	M	L	L
C	L	L	H	L	L
D	-	L	L	H	L
E	L	M	L	L	H

Mapping of Course Outcomes onto Program Outcomes

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

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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No	Topics to be covered	Text Book / RefereNces	COs mapped	Actual Content covered	Methodology used	Remarks 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	

				SHG (EIFISH), optical parametric amplification, third harmonic generation, two-photon absorption. Stimulated Raman scattering and stimulated Brillouin scattering.				-Board	
	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 – Electronics:

1. **Instrumentation and Control**
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: 3 T: 1 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 **Option 1**

Code: PH 509	**Title: Instrumentation and Control**	**L-T-P-C** 3-1-0-4

Course Objectives

This course enables the students:

A.	Course on *Instrumentation and control* intends to impart knowledge of measurement, data acquisition and control for experiments.
B.	The first module of the course addresses basics of measurements like range, 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.
D.	The techniques of signal conditioning and noise reductions for acquired data are subject of Module-3.
E.	Last two units covers working and theory of different types of correction and regulating elements used in control systems.

Course Outcomes

After the completion of this course, students will be:

1.	Learners would develop understanding of various experimental parameters of 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:** Range, resolution, linearity, hysteresis, reproducibility and drift, calibration, accuracy and precision.	5
Module-2	**Sensors** Sensor Systems, characteristics, Instrument Selection, Measurement Issues and Criteria, Acceleration, Shock and Vibration Sensors,	10

	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** 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	15
Module-4	**Actuators** Correction and regulating elements used in control systems, pneumatic, hydraulic and electric correction elements.	4
Module-5	**Control System** 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.	16
Text books: T1. Electronic Instrumentation -H. S. Kalsi, Tata McGraw-Hill Education, 2010 T2. Electronic Instrumentation -W. Bolton T3. Instrumentation: Electrical and Electronic Measurements and Instrumentation -A. K. Sawhney, T4. Modern Electronic Instrumentation & Measurement Techniques -Helfrick & Cooper		

Reference books: R1: Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	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
Quiz	15+15
Assignment	10
End Sem Examination Marks	60

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I	√	√	√		
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
A	H	H	H	H
B	H	H	L	L
C	H	H	H	L
D	H	L	H	L
E	H	H	H	L
F	H	L	L	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	a	b	c	d	e	f
1	H	H	H	L	H	H
2	H	H	H	L	H	H
3	H	H	H	L	H	H
4	H	H	H	L	H	M

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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch No	Topics to be covered	Text Book / References	Cos mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1			**Measurement basics:** Range, resolution, linearity,	T1, T4				
	L2				T1, T4				
	L3			hysteresis, reproducibility	T1, T4				
	L4			drift, calibration,	T1, T4				
	L5			accuracy and precision.	T1, T4				
	L6			**Sensors** Sensor Systems, characteristics,	T1, T4				
	L7			Instrument Selection, Measurement Issues and Criteria,	T1, T4				
	L8			Acceleration, Shock and Vibration Sensors, Interfacing and Designs,	T1, T4				
	L9			Capacitive and Inductive Displacement Sensors, Magnetic Field Sensors,	T1, T4				
	L10			Flow and Level Sensors, Load Sensors, Strain gauges, Humidity Sensors, Accelerometers,	T1, T4				
	L11			Photosensors, Thermal Infrared Detectors,	T1, T4				
	L12			Contact and Non-contact Position sensors, Motion Sensors,	T1, T4				
	L13			Piezoresistive and Piezoelectric	T1, T4				
	L14			Pressure Sensors, Sensors for Mechanical Shock,	T1, T4				
	L15			Temperature Sensors (contact and non-contact)	T1, T4				
	L16			**Signal conditioning** Types of signal conditioning, Amplification, Isolation,	T1, T4				
	L17				T1, T4				
	L18				T1, T4				
	L19				T1, T4				
	L20			Filtering, Linearization,	T1, T4				
	L21			Classes of signal conditioning, Sensor Signal Conditioning,	T1, T4				
	L22			Conditioning Bridge Circuits,	T1, T4				
	L23			D/A converters	T1, T4				
	L24			and A/D converters for signal conditioning,	T1, T4				
	L25			Signal Conditioning for high	T1, T4				

				impedance sensors Grounded and floating signal sources,					
	L26			single-ended and differential measurement,	T1, T4				
	L27			measuring grounded signal sources, ground loops, signal circuit isolation,	T1, T4				
	L28			measuring ungrounded signal sources,	T1, T4				
	L29			system isolation techniques, errors, noise and interference in measurements,	T1, T4				
	L30			types of noise, noise minimization techniques	T1, T4				
	L31			**Actuators** Correction and regulating	T1, T4				
	L32			elements used in control systems,	T1, T4				
	L33			pneumatic, hydraulic and electric correction elements.	T1, T4				
	L34				T1, T4				
	L35			**Control System** Open loop and closed loop (feedback) systems	T1, T4				
	L36			stability analysis of these systems,	T1, T4				
	L37			Signal flow graphs and their use in determining transfer functions of systems;	T1, T4				
	L38			transient and steady state analysis of linear time invariant (LTI) control systems and frequency response.	T1, T4				
	L39				T1, T4				
	L40			Tools and techniques for LTI control system analysis: root loci, Routh-Hurwitz criterion	T1, T4				
	L41				T1, T4				
	L42				T1, T4				
	L43			Bode and Nyquist plots.	T1, T4				
	L44				T1, T4				
	L45			Control system compensators: elements of lead and lag compensation,	T1, T4				
	L46				T1, T4				
	L47				T1, T4				
	L48			elements of Proportional-Integral-Derivative (PID) control.	T1, T4				
	L49				T1, T4				
	L50			State variable representation and solution of state equation of LTI control systems.	T1, T4				

COURSE INFORMATION SHEET

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

Option 2

Code: PH 510	Title: Physics of Low dimensional Semiconductors Devices	L-T-P-C 3-1-0=4

Course Objectives

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 of various Low-dimensional Semiconductors.
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 gas (2-DEG) would enable them to grasp the pace of advancing field of 2D-Semiconductors and their applications for ultrathin devices.

Module-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** Infinite deep square well, square well of finite depth, parabolic well, triangular well, Low-dimensional systems, Occupation of subbands, Quantum wells in hetrostructures.	**12**
Module-4	**Tunneling transport and Quantum Hall effect** 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	**12**
Module-5	**Two-Dimensional electron gas (2DEG)** 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	**12**

Text Book

[T1] John H. Davies, The Physics of Low-Dimensional Semiconductors an Introduction, Cambridge University Press.

[T2] Thomas Heinzel, Mesoscopic electronics in solid state nanostructures, Wiley-VCH

[T3] Jan G. Korvink, Andreas Greiner, Semiconductors for micro and Nanotechnology – An Introduction for Engineers. Wiley-VCH

Reference books: R1: Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	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
Quiz	15+15
Assignment	10
End Sem Examination Marks	60

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

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**
A	H	H	H	H	H
B	H	H	H	L	L
C	H	H	L	H	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	**Program Outcomes**					
	a	b	c	d	e	f
1	H	H	H	M	H	H
2	H	H	H	M	H	H
3	H	H	H	M	H	H

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		-	-

Lecture wise Lesson planning Details.

Week No.	**Lect. No.**	**Tentative Date**	**Ch. No.**	**Topics to be covered**	**Text Book / References**	**Cos mapped**	**Actual Content covered**	**Methodology used**	**Remarks by faculty if any**
1	L1 L2		Ch 1	**Introduction to Semiconductor Nanostructures** Introduction, Semiconductor quantum dot and quantum wire,	T1, T2, T3				
	L3 L4			Density of states for 0-D, 1D and 2D nanostructures.	T1, T2, T3				

	L5 L6			Two-dimensional semiconductors.	T1, T2, T3				
	L7		Ch 2	**Hetrostructures** General properties and growth of hetrostructures	T1, T2, T3				
	L8			Band engineering	T1, T2, T3				
	L9			Layered structures	T1, T2, T3				
	L10			Quantum wells and barriers	T1, T2, T3				
	L11			Doped hetrostructures, Wires and dots	T1, T2, T3				
	L12			Optical confinement,	T1, T2, T3				
	L13 L14			Effective mass approximation and Effective mass theory in hetrostructures.	T1, T2, T3				
	L15 L16		Ch 3	**Quantum wells and Low-Dimensional Systems** Infinite deep square well,	T1, T2, T3				
	L17			square well of finite depth,	T1, T2, T3				
	L18 L19			parabolic well,	T1, T2, T3				
	L20 L21			triangular well,	T1, T2, T3				
	L22 L23 L24			Low-dimensional systems, Occupation of subbands,	T1, T2, T3				
	L25 L26			Quantum wells in hetrostructures.	T1, T2, T3				
	L27		Ch 4	**Tunneling transport and Quantum Hall effect** Potential step	T1, T2, T3				
	L28			T-Matrices	T1, T2, T3				
	L29			Resonant tunneling	T1, T2, T3				
	L30			Superlattices and minibands	T1, T2, T3				

	L31 L32			Coherent transport in many channels	T1, T2, T3				
	L33 L34			Tunneling in hetrostructures	T1, T2, T3				
	L35 L36			Schrodinger equation with electric and magnetic fields	T1, T2, T3				
	L37 L38			Quantum hall effect	T1, T2, T3				
	L39		Ch 5	**Two-Dimensional electron gas (2DEG)** Revision of approximate methods					
	L40 L41			scattering rates: the golden rule	T1, T2, T3				
	L42 L43			Absorption in a quantum well	T1, T2, T3				
	L44 L45			Electronic structure of a 2DEG, Optical properties of quantum wells: Kane model	T1, T2, T3				
	L46			bands in a quantum well	T1, T2, T3				
	L47 L48			Interband and intersubband transitions in a quantum well	T1, T2, T3				
	L49 0			Optical gain and lasers, Excitons	T1, T2, T3				

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: 3 T: 1 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	**Title: Introduction to Plasma Physics**	**L-T-P-C [3-1-0-4]**

Module	**Course Objective:**
1.	To impart the knowledge about the fundamental and basics of Plasma Physics.
2.	To learn about the charged particle motion in electric and magnetic field.
3.	To provide the knowledge about the ionization process and diffusion.
4.	To learn about the basic Plasma Diagnostic Methods.
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).
2.	Will be able to visualize the motion of charged particles in electric and magnetic field.
3.	Will have knowledge about the ionization and diffusion of Plasma.
4.	Will be able to measure the different plasma parameters.
5.	Will be familiar with different applications of Plasma.

Module-1	The fourth state of matter, collective behavior, charge neutrality, space and time scale, concept of plasma temperature, Classification of Plasma, Debye shielding, Debye length, plasma frequency, plasma parameters and criteria for plasma state.	**[8]**
Module-2	Single particle dynamics, charged particle motion in electric field, magnetic field and in combined electric and magnetic field, Basics of $E \times B$ drift, Drift of guiding centre, gradient drift, curvature drift and magnetic mirror.	**[8]**
Module-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.	**[8]**
Module-4	Basic plasma diagnostics, Single probe method, Double probe method, Optical emission spectroscopy (basic idea), Abel inversion.	**[8]**
Module-5	Controlled Thermonuclear fusion, Tokamak, Laser Fusion, MHD Generator, Industrial applications of plasma.	**[8]**

References:

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.
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

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus: NA
Topics beyond syllabus/Advanced topics/Design: NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√	√	
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
A	H	M	L	M	L
B	M	H	L	L	L
C	M	L	H	L	L
D	M	L	L	H	L
E	L	L	L	L	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	B	C	d	e	f	g	h	I	j	k	l
1	M	H	M	M	M	H						
2	M	H	M	M	M	H						
3	M	H	M	M	M	H						
4	M	H	M	M	M	H						
5	M	H	L	M	M	H						

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

				probe method,					
	L29-L32			Optical emission spectroscopy (basic idea), Abel inversion	T2 R1				
	L33-L36			Controlled Thermonuclear fusion, Tokamak,	T1 R1				
	L37-L40			Laser Fusion, MHD Generator, Industrial applications of plasma.	T1 R1				

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

Course Objectives
This course enables the students to:

A.	Defineplasma and its parameters
B.	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 Outcomes
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 various types of reactions involved in a plasma.
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, etc., and their associated techniques such as, sputtering, nitriding, etc.
5.	Illustrate arc plasma based applications like, plasma spraying, plasma waste processing, plasma cutting, etc.

Module-1	Plasma-the fourth state of matter, Plasma Parameters, Debye length, Plasma oscillations & 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.	**[8]**
Module-2	Design principles and construction of plasma torches and thermal plasma reactors, Efficiency of plasma torches in converting electrical energy in to thermal energy, Designing aspects of low pressure plasma reactors.	**[8]**
Module-3	Measurements of Plasma parameters, Electrical probes, Single and double Langmuir probe, Magnetic probe, Calorimetric measurements, Enthalpy Probes, Spectroscopic techniques.	**[8]**
Module-4	Plasma Etching Anisotropic etching, plasma cleaning, surfactants removal, plasma ashing, plasma polymerization, Plasma sputtering and PECVD Thin film coatings, magnetron sputtering, RF PECVD, MW PECVD, plasma nitriding.	**[15]**
Module-5	Module 5:Plasma Spraying Non-transferred plasma torches, powder feeder, optimization of spraying processes, spherodization, Arc plasmas, Plasma torches, plasma waste processing, Synthesis of materials and metallurgy in arc plasmas, Plasma cutting and Welding.	**[6]**

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

Gaps in the syllabus (to meet Industry/Profession requirements)
POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

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 Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	60
Quiz	15
Teachers Assessment	5

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 Outcome #	Program Outcomes					
	a	b	c	d	e	f
1	H	H	H	L	M	L
2	H	H	M	L	L	L

3	H	M	M	L	L	L
4	H	M	M	L	L	L
5	H	H	H	L	H	L

Course Outcome #	Course Objectives				
	a	b	c	d	e
1	H	M	M	M	L
2	M	H	M	M	L
3	M	M	H	L	L
4	M	M	H	L	L
5	M	M	L	L	H

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			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	ModuleNo.	Topics to be covered	Text Book / References	Cos mapped	Actual Content covered	Methodology used	Remarks byfaculty if any
1-2	L1-2		I	Plasma-the fourth state of matter, Plasma Parameters, Debye length	T2	CO-1		PPT Digi Class/Chalk-Board	
	L3-4			Plasma oscillations & frequency, Plasma Sheath, Interaction of electromagnetic wave with plasma, Concept about plasma equilibrium	T2	CO-1		PPT Digi Class/Chalk-Board	
2	L5			Industrial Plasmas, Cold and thermal plasma,	T1	CO-1		PPT Digi Class/Chalk-Board	
2-3	L6			Plasma Chemistry, Homogeneous and Heterogeneous reaction	T1	CO-1		PPT Digi Class/Chalk-Board	
3	L7-8			Reaction rate coefficients, Plasma Surface interaction		CO-1		PPT Digi Class/Chal	

								k-Board	
4	L9-12		II	Design principles and construction of plasma torches and thermal plasma reactors	T3	CO-2		PPT Digi Class/Chalk-Board	
5	L13-14			Efficiency of plasma torches in converting electrical energy in to thermal energy	T1	CO-2		PPT Digi Class/Chalk-Board	
5-6	L15-16		III	Measurements of Plasma parameters	T1	CO-3		PPT Digi Class/Chalk-Board	
7	L17-18			Electrical probes, Single and double Langmuir probe		CO-3		PPT Digi Class/Chalk-Board	
8	L19-20			Magnetic probe, Calorimetric measurements Enthalpy Probes,	T2	CO-3		PPT Digi Class/Chalk-Board	
8-9	L21-22			Spectroscopic techniques.	T1, T2,	CO-3		PPT Digi Class/Chalk-Board	
9-10	L23-25		IV	Plasma Etching Anisotropic etching	T1, T2,	CO-4		PPT Digi Class/Chalk-Board	
10-11	L26-28			plasma cleaning, surfactants removal	T1, T2,	CO-4		PPT Digi Class/Chalk-Board	
11-12	L29-31			plasma ashing, plasma polymerization	T1, T2,	CO-4		PPT Digi Class/Chalk -Board	
12	L32-33			Plasma sputtering and PECVD Thin film coatings	T1, T2,	CO-4		PPT Digi Class/Chalk-Board	
13	L34-35			magnetron sputtering	T1, T2,	CO-4		PPT Digi Class/Chalk-Board	
13	L36			, RF PECVD, MW PECVD	T1, T2,	CO-4		PPT Digi Class/Chalk-Board	
14	L37			plasma nitriding	T1, T2,	CO-4		PPT Digi Class/Chalk-Board	
14	L40		V	Plasma Spraying Non-transferred plasma torches	T1, T2,	CO-5		PPT Digi Class/Chalk-Board	
14	L41			powder feeder, optimization of spraying processes	T2	CO-5		PPT Digi Class/Chalk-Board	

15	L42			spherodization, Arc plasmas, Plasma torches	T1, T2,	CO-5		PPT Digi Class/Chalk-Board	
15	L43-44			plasma waste processing, Synthesis of materials and metallurgy in arc plasmas	T2	CO-5		PPT Digi Class/Chalk-Board	
16	L45			Plasma cutting and Welding	T2	CO-5		PPT Digi Class/Chalk-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 513
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**

Code: PH 513	Title: Theoretical and Computational Fluid Dynamics Theory &Programming using C for solving problems on following topics:	L-T-P-C [2- 0-4- 4]

Course Objectives

This course enables the students:

A.	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 and equilibrium averages.

Module-1	Model systems and interaction potentials: Atomic systems, Molecular systems, Lattice systems, Calculating the potential, Constructing an intermolecular potential, Studying small systems: periodic and spherical boundary conditions.	**[11]**
Module-2	Statistical Mechanics: Statistical ensembles, Transformation between ensembles, Fluctuations, Time correlations, Transport coefficients.	**[9]**
Module-3	Molecular dynamics: Finite difference methods, Verlet algorithm, Linear and nonlinear molecules, Checks on accuracy.	**[7]**
Module-4	Monte Carlo methods: Monte Carlo integration, Importance sampling, Metropolis method, Molecular liquids.	**[9]**
Module-5	Analyzing results: Time correlation functions, Fast Fourier transform, Estimation of errors in equilibrium averages and fluctuations, Errors in time correlation functions.	**[9]**

References:

1. "Computer Simulation of Liquids" by Allen and Tildesley, Oxford Science Publications .
2. "The Art of Molecular Dynamics Simulation" by D. C. Rappaport, Cambridge University Press.

Gaps in the syllabus (to meet Industry/Profession requirements)
POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

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
A	H	M	M	M
B	M	H	M	M
C	M	L	H	M
D	L	M	H	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	a	b	c	d	e	f
1	H	H	M	M	H	M
2	L	H	M	M	H	M
3	L	H	H	M	H	M
4	L	H	H	M	H	M

Lecture wise Lesson planning Details.

Week No	Lect. No.	Tentative Date	Ch. No	Topics to be covered	Text Book / References	Cos mapped	Actual Content covered	Methodology used	Remarks 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-L15			Transformation between ensembles, Fluctuations	T1,T2	2			
6	L16-L18			Time correlations, Transport coefficients.	T1,T2	2			

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

<u>COURSE INFORMATION SHEET</u>

Course code: PH 515
Course title: Theoretical and Computational Condensed Matter Physics
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 **<u>Option 2</u>**

Code: PH 515	**Title: Theoretical and Computational Condensed Matter Physics** Theory &Programming using C for solving problems on following topics:	L-T-P-C [2- 0-4- 4]

Course Objectives:
The course aims to give students the basic concepts of condensed matter physics and to prepare them to formulate the problems in condensed matter physics so that these can be solved on a computer. The main objectives of the course are

1. To teach how Monte-Carlo techniques can be used to solve various physical systems.
2. To give concepts of first order phase transitions, second order phase transitions and mean field theory using Ising model.
3. To teach the equilibrium properties and time evolution of simple fluids.
4. To provide the concept on computation of free energies of solids and how to obtain them numerically.
5. To introduce the method of dissipative particle dynamics.

Program Outcomes:
After taking the course the student should be able to

1. Use Monte-Carlo simulation to obtain the equilibrium configuration of a physical system.
2. Differentiate between first order and second order phase transitions and appreciate the efficiency of mean field theory.
3. Calculate transport coefficients and space-time correlation function of simple fluids.
4. Compute the free energy of perfect or imperfect solids numerically.
5. Understand the fundamentals of dissipative particle dynamics technique.

Module-1	**Random Systems** 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	**[10]**
Module-2	**Statistical Mechanics, Phase Transitions, and the Ising Model** 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	**[10]**
Module-3	**Equilibrium and Dynamical properties of simple fluids** Thermodynamic measurements, Structure, Packing studies, Cluster analysis, Transport coefficients Measuring transport coefficients, Space-time correlation functions	**[10]**
Module-4	**Free Energies of Solids** Thermodynamic Integration, Free Energies of Solids, Free Energies of Molecular Solids, Vacancies and Interstitials, Numerical Calculations	**[10]**
Module-5	**Dissipative Particle Dynamics** Justification of the Method, Implementation of the Method, DPD and Energy Conservation	**[10]**

Text books:
T1: “Computation Physics” by Nicholas J. Giordano, Pearson Addison-Wesley
T2: “The Art of Molecular Dynamics Simulation” by D. C. Rappaport, Cambridge University Press.

Reference books:
R1: “Understanding Molecular Simulation” by Daan Frenkel, Academic Press.

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design : NA

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	Y

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Quiz (s)	30
End Sem Examination Marks	60
Assignment /	10

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	c	d	e
1	H	L	L	L	L
2	L	H	L	L	L
3	L	L	H	L	L
4	L	L	L	H	L
5	L	L	L	L	H

Mapping of Course Outcomes onto Program Outcomes

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

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			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1-3	L1-L10			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	T1, T2	1		PPT Digi Class/Chock -Board	
3-5	L11-L20			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	T1, R1	2			
6-8	L21-L30			Thermodynamic measurements, Structure, Packing studies, Cluster analysis, Transport coefficients Measuring transport	T1, T2, R1	3			

				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 INFORMATION SHEET

Course code: PH 516
Course title: Nonlinear Dynamics and Chaos
Pre-requisite(s): Classical Dynamics
Co- requisite(s):
Credits: L: 4 T: 0 P: 0
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 [3- 0-2- 4]
Course Objectives: The objective of the course is to 1. Train students to calculate fixed points and do stability analysis of various systems motivated from physics/biology. 2. Give a clear concept of bifurcation and some examples of the phenomenon. 3. Teach them to plot limit cycles of various differential equations on computer using C language. 4. Teach properties of limit cycles taking examples from physics. 5. Train students to solve problems on coevolution and the impact of environment on population growth using concepts from physics. **Course Outcomes**: The student should be able to 1. Model physical or biological systems computationally and obtain their fixed points, saddle points, attractors, etc. 2. Compute the evolution of phase space as various parameters are changed. 3. Visualize limit cycles of various nonlinear systems graphically. 4. Solve problems related to oscillators, viz., relaxation oscillators, weakly nonlinear oscillators, etc. 5. Solve simple models of population growth of multiple-species on computer.		
Module-1	**Flows on the Line & Circle** 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	**[12]**
Module-2	**Bifurcations** Saddle-Node Bifurcation, Transcritical Bifurcation, Laser Threshold, Pitchfork Bifurcation, Overdamped Bead on a Rotating Hoop, Imperfect Bifurcations and Catastrophes, Insect Outbreak, Chaos	**[10]**
Module-3	**Phase Plane** Phase Portraits, Existence, Uniqueness, and Topological Consequences, Fixed Points and Linearization, Rabbits versus Sheep, Conservative Systems, Reversible Systems, Pendulum, Index Theory	**[10]**
Module-4	**Limit Cycles** Ruling Out Closed Orbits, Poincare-Bendixson Theorem, Lienard Systems, Relaxation Oscillators, Weakly Nonlinear Oscillators	**[8]**
Module-5	**Population Dynamics** Multispecies model: limit cycles and time delays, Randomly Fluctuating Environment, Niche Overlap and Limiting Similarity	**[10]**
Text books: T1: Nonlinear dynamics and Chaos: with applications to physics, biology, chemistry, and engineering by Steven H. Strogatz, CRC Press. T2: “Stability and Complexity in Model Ecosystems” by Robert M May, Princeton University Press.		

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design : NA

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	Y

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Quiz (s)	30
End Sem Examination Marks	60
Assignment /	10

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	c	d	e
1	H	L	L	L	L
2	L	H	L	L	L
3	L	L	H	L	L
4	L	L	L	H	L
5	L	L	L	L	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	a	b	c	d	e	f
1	H	H	H	M	H	H
2	H	H	H	M	H	H
3	H	H	H	M	H	H

4	H	H	H	M	H	H
5	H	H	H	M	H	H

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			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1-3	L1-L12			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	T1, T2	1		PPT Digi Class/Chock -Board	
4-6	L13-L22			Saddle-Node Bifurcation, Transcritical Bifurcation, Laser Threshold, Pitchfork Bifurcation, Overdamped Bead on a Rotating Hoop, Imperfect Bifurcations and Catastrophes, Insect Outbreak, Chaos	T1, T2	2			
6-8	L23-LL32			Phase Portraits, Existence, Uniqueness, and Topological Consequences, Fixed Points and Linearization, Rabbits versus Sheep, Conservative Systems, Reversible Systems, Pendulum, Index Theory	T1,T2	3			
9-10	L33-L40			Ruling Out Closed Orbits, Poincare-Bendixson Theorem,	T1,T2	4			

				Lienard Systems, Relaxation Oscillators, Weakly Nonlinear Oscillators					
11-14	L41-L50			Multispecies model: limit cycles and time delays, Randomly Fluctuating Environment, Niche Overlap and Limiting Similarity	T1, T2	5			

COURSE INFORMATION SHEET

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: L: 3 T: 1 P: 0
Class schedule per week:4
Class: I.M.Sc./ M.Sc.
Semester / Level: X/IV
Branch: Physics
Name of Teacher:

Group : B **Option 1**

Code: PH 517	**Title: Nonconventional Energy Materials**	**L-T-P-C [3-1-0-4]**

Course Objectives

This course enables the students:

A.	Todefine the current scenario of the conventional sources of energy and importance of sustainable energy sources.
B.	To explain the basic of PN Junction solar cell.
C.	To define the solar cell characterization.
D.	To illustrate the various solar cell technologies.
E.	To explain the other nonconventional energy sources

Course Outcomes

After the completion 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 generation of photo-voltage and photo-current of PN Junction solar cell.
3.	Demonstrate the measurement of solar cell parameters and solar cell design for high Isc, design for high Voc, design for high FF.
4.	Explain the fabrication of wafer based solar cells, thin film solar cell, organic solar cells, dye-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.

Module-1	Energy sources and their availability, conventional sources of energy: Fossil fuel, Hydraulic energy, Nuclear energy: nuclear fission, nuclear fusion, Environmental impact of conventional sources of energy, Need for sustainable energy sources, Nonconventional energy sources, Current status of renewable energy sources.	**[5]**
Module-2	Structure of solar cell materials, direct and indirect band gap semiconductor, carrier concentration and distribution, drift and diffusion current densities, P-N Junction: space charge region, energy band 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.	**[10]**
Module-3	Solar Cell Characteristics and Cell parameters: Short circuit current, open circuit voltage, fill factor, efficiency; losses in solar cells, Solar Cell Design: design for high Isc, design for high 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.	**[10]**
Module-4	Wafer-based Si solar cell fabrication: saw damage removal and surface texturing, P-N Junction 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	**[15]**

	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 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.	**[10]**

Text/Reference 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.

Gaps in the syllabus (to meet Industry/Profession requirements) : NA

POs met through Gaps in the Syllabus : NA

Topics beyond syllabus/Advanced topics/Design : NA

POs met through Topics beyond syllabus/Advanced topics/Design

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 I and Quiz II	10+10
Teacher's assessment	5

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

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 Objectives	Course Outcomes 1	2	3	4	5
A	H	L	L	L	L
B	M	H	M	M	L
C	M	M	H	L	L
D	M	L	L	H	L
E	M	L	L	L	H

Mapping of Course Outcomes onto Program Outcomes

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

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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	Cos mapped	Actual Content covered	Methodology used	Remarks by faculty if any
	L1			World energy status, current energy scenario in India, environmental aspects of energy utilization, Classification of energy, Energy Resources, need of renewable energy, non-conventional energy sources.	R1				
	L2, L3			An overview of developments in Offshore	R1				

				Wind Energy, Tidal Energy, Wave energy systems, Ocean energy,					
	L4, L5			Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity. Energy conservation and storage.	R1				
	L6-L10			Solar energy, its importance, storage of solar energy, 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	R1, R2 T1				
	L11-L15			absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems	R1, R2 T1				
	L16-L19			Wind Energy: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.	R1, R2				
	L20-L22			Ocean Energy, Potential against Wind and Solar, Wave Characteristics, Wave Energy Devices.	R1, R2				
	L23-L25			Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.	R1, R2				
	L26-L30			Biomass energy, resources, conversion, gasification, liquefaction, production, energy farming,	R1, R2				
	L31-L33			Geothermal Energy: Geothermal Resources, Geothermal Technologies.	R1, R2				
	L34, L35			small hydro resources. Layout, water turbines, classifications, generators, status.	R1, R2				

	L36-L38			Direct Energy conversion: Thermoelectric effects, generators, Thermionic generators, magneto hydro dynamics generators, Fuel cells	R1, R2				
	L39, L40			photovoltaic generators, electrostatic mechanical generators, Thin film solar cells, nuclear batteries.	R1, R2				

COURSE INFORMATION SHEET

Course code: PH 518
Course title: Cryogenic Physics
Pre-requisite(s):
Co- requisite(s):
Credits: 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: PH 518	Title: Cryogenic Physics	L-T-P-C [4-0-0-4]

Course Objectives : This course enables the students

A.	To become familiar with low temperature and the principles and methods to produce low temperature.
B.	To acquire basic understanding of the macroscopic manifestations of quantum phenomenon at low temperatures like superfluidity of He^4, He^3 and superconductivity.
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 in the physical properties.
E	Become conversant with the principles and methods to produce low temperature.

Course Outcomes : After 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 temperatures.
3.	Able to summarize and apply the knowledge of the behaviour of various physical properties at low temperature.
4.	Able to discuss and compare various special phenomena observed at low temperatures.
5.	Compare different methods of producing low temperature.

Module-1	**Quantum Fluids:** Introduction to low temperature physics; cryo-liquids; helium-general properties; superfluid ^4He, experimental observation, two-fluid model and Bose-Einstein condensation; normal-fluid and superfluid ^3He; mixtures of ^3He and ^4He.	**[8]**
Module-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.	**[8]**
Module-3	**Solids at Low Temperature (Magnetic Moments, Spins):** Paramagnetic systems-isolated spins, magnetic contribution to specific heat, Schottky anomaly; spin waves-magnons, ferromagnets, anti-ferromagnets.	**[8]**
Module-4	**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; Shubnikov-de Haas (SdH) oscillations, quantization of Bloch electrons in a uniform magnetic field; colossal magnetoresistance (CMR).	**[8]**
Module-5	**Refrigeration:** Liquefaction of gases, expansion engines, Joule-Thomson expansion; closed cycle refrigerators, Gifford Mc-Mahon coolers; simple-helium bath cryostats; ^3He-^4He dilution refrigerator; Pomeranchuk cooling; refrigeration by adiabatic demagnetization of a paramagnetic salt and adiabatic nuclear demagnetization.	**[8]**

Textbooks:

1. Low-Temperature Physics, Christian Enss and Siegfried Hunklinger, Springer 2005.
2. Matter 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)

Gaps in the syllabus (to meet Industry/Profession requirements)
POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

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 Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	60
Quiz	10
Teachers Assessment	5

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 Outcome #	Program Outcomes					
	a	b	c	d	e	f
1	L	H	H	L	H	M
2	M	H	H	L	H	M
3	M	H	H	L	H	M
4	L	H	H	L	H	M
5	L	H	H	L	H	M

Course Outcome #	Course Objectives				
	a	b	c	d	e
1	H	H	H	L	L
2	M	H	M	M	L
3	M	M	H	M	L
4	M	M	H	H	L
5	M	L	L	L	H

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, CD4,CD5 and CD8
CD2	Tutorials/Assignments		CO2	CD1, CD2, CD4,CD5 and CD8
CD3	Seminars		CO3	CD1, CD2, CD4,CD5 and CD8
CD4	Mini projects/Projects		CO4	CD1, CD2, CD4,CD5 and CD8
CD5	Laboratory experiments/teaching aids		CO5	CD1, CD2, CD4,CD5 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			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Module No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodologyused	Remarks byfaculty if any
1-2	L1		I	Introduction to low temperature physics, course objectives, grading scheme	T1-T2	CO-1		PPT Digi Class/Chalk-Board	
	L2-L5			Cryoliquids, general properties of He, Superfluid ^{4}He, Experimental Observation, Two fluid model, Bose Einstein Condensation	T1-T2	CO-1		PPT Digi Class/Chalk-Board	
2	L6-7			Superfluid and Normal Fluid ^{3}He.	T1-T2	CO-1		PPT Digi Class/Chalk-Board	
2	L8			Mixtures of ^{3}He and ^{4}He.	T1-T2	CO-1		PPT Digi Class/Chalk-Board	
3	L9-		II	Solids at Low	T1-T2	CO-2		PPT Digi	

	L10			Temperature: Phonons and electrons, specific heat of Phonons, Debye model				Class/Chalk-Board	
3	L11			Specific heat of conduction electrons in simple metals	T1-T2	CO-2		PPT Digi Class/Chalk-Board	
3-4	L11-L13			Electrical conductivity, relaxation-time approximation, Matthiessen's rule, electron-phonon scattering, electron-magnon scattering	T1-T2	CO-2		PPT Digi Class/Chalk-Board	
4	L13-16			Thermal conductivity of metals; Kondo effect; Heavy Fermion Systems	T1-T2	CO-2		PPT Digi Class/Chalk-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		PPT Digi Class/Chalk-Board	
6	L21-24			Spin waves-magnons, ferromagnets, anti-ferromagnets	T1-T2	CO-3		PPT Digi Class/Chalk-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		PPT Digi Class/Chalk-Board	
8	L29-32			Shubnikov-de Haas (SdH) oscillations, quantization of Bloch electrons in a uniform magnetic field; colossal magnetoresistance	T1-T2, R1-R2	CO-4		PPT Digi Class/Chalk-Board	

				(CMR).					
9	L33-34		V	Refrigeration: Liquefaction of gases, expansion engines, Joule-Thomson expansion	T1-T2	CO-5		PPT Digi Class/Chalk-Board	
9	L35-36			Closed cycle refrigerators, Gifford Mc-Mahon coolers; simple-helium bath cryostats	T1-T2	CO-5		PPT Digi Class/Chalk-Board	
10	L37-40			^3He-^4He dilution refrigerator; Pomeranchuk cooling; refrigeration by adiabatic demagnetization of a paramagnetic salt and adiabatic nuclear demagnetization.	T1-T2	CO-5		PPT Digi Class/Chalk-Board	

COURSE INFORMATION SHEET

Course code: PH 519
Course title: Physics of Thin Films
Pre-requisite(s):
Co- requisite(s):
Credits: L: 03 T: 00 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 PH 519	Title: Physics of Thin Films	L-T-P-C [3 1 0 4]

Course Objectives
This course enables the students to:

A.	Definevacuum and compare various vacuum pumps and gauges.
B.	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.

Course Outcomes
After the completion 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.

Module-1	**Vacuum Science & Technology:** 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.	**[8]**
Module-2	**Basic Thermodynamics of Thin Films** 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 thin films	**[8]**
Module-3	**Mechanisms of Film Formation** 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 films, Theories of epitaxy, role of interfacial layer, epitaxial film growth, super lattice structures	**[8]**
Module-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**: Deposition rate, Film thickness and uniformity, Structural properties: Crystallographic properties, defects, residual stresses, adhesion, hardness, ductility, electrical properties, magnetic properties; optical properties.	**[6]**

Text books:

1. The Material Science of Thin Films by Milton Ohring, Academic Press, Inc., 1992.
2. Handbook of Thin Films by Maissel and Glang
3. Thin Film Phenomena by K. L. Chopra (McGraw Hill, 1969)

Reference books:

1. Thin Film Deposition: Principles & Practice by Donald L. Smith (McGraw Hill, 1995)
2. Coating Technology Handbook by D. Satas, A. A. Tracton, Marcel Dekkar Inc. USA.
3. Arc Plasma Technology in Material Science, P. A. Gerdeman and N. L. Hecht, Springer Verlag, 1972.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

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 Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	60
Quiz	15
Teachers Assessment	5

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 Outcome #	Program Outcomes					
	a	b	c	d	e	f
1	H	H	H	L	M	L
2	H	H	M	L	L	L
3	H	M	M	L	L	L
4	H	M	M	L	L	L
5	H	H	H	L	H	L

Course Outcome #	Course Objectives				
	a	b	c	d	e
1	H	M	M	M	L
2	M	H	M	M	L
3	M	M	H	L	L
4	M	M	H	L	L
5	M	M	L	L	H

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			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Module No.	Topics to be covered	Text Book / References	Cos mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1-2	L1-2		I	Classification of vacuum ranges, Kinetic theory of gases	T2	CO-1		PPT Digi Class/Chalk-Board	

	L3-4			gas transport and pumping, Conductance and Throughput	T2	CO-1		PPT Digi Class/Chalk -Board	
2	L5			Classification of vacuum pumps, single stage and double stage rotary pump, diffusion pump, turbomolecular pump,	T1	CO-1		PPT Digi Class/Chalk-Board	
2-3	L6			cryopump and Classification of gauges, Mechanical gauges: McLeod gauge	T1	CO-1		PPT Digi Class/Chalk-Board	
3	L7			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.	T3	CO-2		PPT Digi Class/Chalk-Board	
4	L9		II	Solid surface, interphase surface	T3	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, calculation of diffusion coefficient, interdiffusion and diffusion in thin films	T1, T2, T3	CO-2		PPT Digi Class/Chalk-Board	
7	L17-18		III	Stages of thin film formation: Nucleation, Adsorption, Surface diffusion	T1	CO-3		PPT Digi Class/Chalk-Board	
7-8	L19-20			capillarity theory of nucleation, statistical theory of nucleation, growth and coalescence of islands		CO-3		PPT Digi Class/Chalk-Board	
8	L21-22			grain structure and microstructure of thin films, diffusion during film growth	T2	CO-3		PPT Digi Class/Chalk-Board	
9	L23			polycrystalline and amorphous films, Theories of epitaxy	T1, T2,	CO-3		PPT Digi Class/Chalk-Board	
9	L24			role of interfacial layer, epitaxial film growth, super lattice structures	T2, T3	CO-3		PPT Digi Class/Chalk-Board	
9-10	L25-26		IV	Vacuum evaporation-Hertz-Knudsen equation, evaporation from a	T1	CO-4		PPT Digi Class/Chalk-Board	

				source and film thickness uniformity					
10	L27-28			Glow discharge and plasmas- Plasma structure, DC, RF and microwave excitation	T1	CO-4		PPT Digi Class/Chalk-Board	
11	L29-30			Sputtering processes- Mechanism and sputtering yield, Sputtering of alloys	T2	CO-4		PPT Digi Class/Chalk-Board	
11-12	L31-32			magnetron sputtering, Reactive sputtering	T2	CO-4		PPT Digi Class/Chalk-Board	
12	L33-34			vacuum arc: cathodic and anodic vacuum arc deposition. Chemical vapour deposition	T2	CO-4		PPT Digi Class/Chalk-Board	
13	L35-36			Thermodynamics of CVD, gas transport, growth kinetics, Plasma chemistry	T2	CO-4		PPT Digi Class/Chalk-Board	
14	L37-39			plasma etching mechanisms; etch rate and selectivity, orientation dependent etching; PECVD	T2	CO-4		PPT Digi Class/Chalk-Board	
14	L40		V	Deposition rate, Film thickness and uniformity	T2	CO-5		PPT Digi Class/Chalk-Board	
15	L41			Structural properties: Crystallographic properties, defects	T2	CO-5		PPT Digi Class/Chalk-Board	
15	L42			residual stresses, adhesion, hardness, ductility	T2	CO-5		PPT Digi Class/Chalk-Board	

15	L43			electrical properties	T2	CO-5		PPT Digi Class/Chalk-Board	
16	L44			magnetic properties;	T2	CO-5		PPT Digi Class/Chalk-Board	
16	L45			optical properties	T2	CO-5		PPT Digi Class/Chalk-Board	

COURSE INFORMATION SHEET

Course code: PH 520
Course title: Theory of Dielectrics and Ferroics
Pre-requisite(s):
Co- requisite(s):
Credits: 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 4**

		L T C P
Code: PH 520	**Title: Theory of dielectrics and ferroics**	3-1-0=4

Course Objectives
This course enables the students:

A.	To become familiar with the concept of polarisation in ideal and non-ideal dielectrics.
B.	To be familiarized with electrochemical impedance spectroscopy.
C.	To 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 types of magnetic ordering.
E.	To become familiar with the concept of multiferroics and different types of mechanisms by which multiferroics can be formed.

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

1.	Able to differentiate between different type of dielectrics, ferroelectrics and able to interpret the experimental results with different theoretical models.
2.	Able to apply the concept of relaxation, resonance and dispersion in dielectrics using frequency and time domain method.
3.	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 their origin.

Module-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]**
Module-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.	**[10]**
Module-3	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]**
Module-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]**

Textbooks:

1. Applied Electromagnetism and Materials by Andre Moliton, Springer, 2007
2. Magnetism in Condensed Matter, Oxford Master Series in Condensed Matter Physics 4, Stephen Blundell, Oxford University Press, 2001.
3. Multiferroic Materials: Properties, Techniques and Applications, Junling Wang, CRC Press, Taylor and Francis group, 2017.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

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
Mid Sem Examination Marks	25
End SemExamination Marks	50
Quiz (s)	20
Teacher's Assesment	05

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 Outcome #	Program Outcomes					
	a	b	c	d	e	f
1	M	H	H	L	L	M
2	L	H	H	L	L	M
3	M	H	H	L	L	L
4	H	M	M	L	L	L
5	M	H	H	H	L	L

Course Outcome #	Course Objective				
	a	b	c	d	e
1	H	M	M	L	M
2	M	H	M	L	M
3	M	M	H	L	M
4	L	L	L	H	H
5	M	M	M	H	H

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			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

Lecture wise Lesson planning Details.

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

2	L6			Temperature coefficient of dielectrics, dielectric losses.	T1			PPT Digi Class/Chalk -Board	
2	L7-8			The double well potential model for polarization and determination of depth of potential wells.	T1			PPT Digi Class/Chalk -Board	
4	L9-10		II	Dielectric spectroscopy: introduction to impedance spectroscopy,	T1			PPT Digi Class/Chalk -Board	
4	L11			physical models for equivalent circuit elements	T1			PPT Digi Class/Chalk -Board	
5	L12-13			dielectric relaxation in materials with single time constant, distribution of relaxation time,	T1			PPT Digi Class/Chalk -Board	
5	L14-15			interface and boundary conditions, grain boundary effects.	T1			PPT Digi Class/Chalk -Board	
6	L16			Elementary idea of measurement technique in frequency and time domain methods.	T1			PPT Digi Class/Chalk -Board	
	L17		III	Ferroelectricity: Ferroelectricity, Microscopic theory of Ferroelectricity,	T1			PPT Digi Class/Chalk -Board	
	L18			Landau primer of ferroelectricity,	T1			PPT Digi Class/Chalk -Board	
	L19			Phase transition of ferroelectrics (1^{st}, 2^{nd} and relaxor kind),	T1			PPT Digi Class/Chalk -Board	
	L20			soft optical phonons, hysteresis loop,	T1			PPT Digi Class/Chalk -Board	
	L21-24			Recoverable energy, Piezoelectricity and energy harvesting, transducer	T1			PPT Digi Class/Chalk -Board	
	L25		IV	Ferromagnetism: Weiss model of a ferromagnet,	T2			PPT Digi Class/Chalk -Board	
	L26			magnetic susceptibility,effect of a magnetic field,	T2			PPT Digi Class/Chalk -Board	
	L27			origin of the molecular field, Weiss model of antiferromagnet, magnetic susceptibility	T2			PPT Digi Class/Chalk -Board	

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

COURSE INFORMATION SHEET

Course code: PH 515
Course title: Theoretical and Computational Condensed Matter Physics
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 : B **Option 5**

Same Given As above(in Group A)

Group C- Photonics:	
1. Photonic and Optoelectronic Devices 2. Holography and Applications 3. Quantum photonics and applications	4. Introduction to Nanophotonics

COURSE INFORMATION SHEET

Course code: PH 521
Course title: Photonics and Optoelectronic Devices
Pre-requisite(s):
Co- requisite(s):
Credits: L: 4 T: 0 P: 0
Class schedule per week:
Class: I.M.Sc.
Semester / Level: VI / VII
Branch: PHYSICS
Name of Teacher:

Group : C **Option 1**

Code: PH 521	Title: Photonics and Optoelectronic Devices	L-T-P-C [3 1 0 4]

Course Objectives This course enables the students:

	To explain the properties of optoelectronic material and optical processes in semiconductor.
B.	To understand underlying principle & working of liquid crystal displays, optical modulator, and switches.
C.	To understand principle & working of light sources and photodetectors.
D	To know the working of optical nonlinear devices and understand its significance for optical computing.
E	To acquire the knowledge of the function and working of photonic switches and interconnects

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

1.	Able to identify suitable optoelectronic materials and explain optical phenomena occurring in semiconductor
2.	Able to recognize parameters for optimizing the performance of liquid crystal displays, optical modulator, and switches & solve related numerical problems.
3.	Able to identify the parameters for optimizing the performance of light sources and detectors.
4.	To define the role of different nonlinear optical devices in optical computing.
5.	To select appropriate photonic switch and interconnect for different operations under different working condition.

Module-1	**Optical processes in semiconductors:** Electron-hole pair formation and recombination, Direct and indirect bandgap semiconductors, structural property of crystalline, polycrystalline, amorphous materials, optoelectronic materials, Liquid crystals, compound semiconductors, absorption in semiconductors, Stark effects in quantum well structures, Absorption and emission spectra, excitonic effects.	**10**
Module-2	**Displays, optical modulators, and switches:** Liquid crystal cells (principle), Passive and Active matrix liquid crystal displays, Electro-optic modulator, Magneto-optic modulator, Acousto-optic modulator. Electro-absorption modulators, Mach-Zehnder Electrorefraction (Electro-optic) modulators, optical switches.	**8**
Module-3	**Optical sources and detectors:** Light emitting diodes, surface- and edge- emitting configuration. Injection laser diodes, gain and index guided lasers, PIN and avalanche photodiodes, Photoconductors, Phototransistors, noise in photodetector. Solar cells (spectral response, conversion efficiency), Charge-coupled devices, Characteristics and applications.	**12**
Module-4	**Optical computing:** Digital optical computing: Nonlinear devices, optical bistable devices, SEED devices, Optical phase conjugate devices, integrated devices, spatial light modulators (SLM), Optical Memory: Holographic data storage	**10**
Module-	**Photonic switching and interconnects:** Kerr gates, Nonlinear Directional couplers, Nonlinear optical	**10**

5	loop mirror (NOLM), Soliton logic gates, Free-space optical interconnects, wave-guide interconnects, holographic inteconnections.	

References

1. Essentials of optoelectronics, Alan Rogers, 1st Ed., Chapman & Hall.
2. Introduction to Fiber Optics, Ghatak & Thyagarajan, Cambridge University press.
3. Optoelectronics: An Introduction to Materials and Devices, Jasprit Singh, The McGraw-Hill Companies.
4. Semiconductor Optoelectronics Devices, P. Bhattacharya, PHI.
5. Optoelectronics and Photonics, principles and practices S. O. Kasap, Prentice Hall
6. Photonic switching and Interconnects; Abdellatif Marrakchi, Marcel Dekker, Inc.
7. Optical Computing, an Introduction, Mohammad A. Karim and Abdul A. S Awwal, John Wiley & Sons Inc

Gaps in the syllabus (to meet Industry/Profession requirements): NA
POs met through Gaps in the Syllabus: NA
Topics beyond syllabus/Advanced topics/Design: NA
POs met through Topics beyond syllabus/Advanced topics/Design: NA

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 (s)	10+10
Teacher's assesment	5

AssessmentCompoents	CO1	CO2	CO3	CO4	CO5
Quiz 1	√	√			
Quiz 2			√	√	
Mid Sem Examination Marks	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Assignment	√	√	√	√	√

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 Objective	Course Outcomes				
	1	2	3	4	5
A	H	H	H	H	H

B	L	H	M	M	L
C	M	H	H	M	H
D	M	M	H	H	H
E	M	H	H	H	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes					
	a	b	c	d	e	f
1	H	H	H	-	H	M
2	H	H	H	-	H	H
3	M	H	H	-	H	H
4	M	H	M	-	H	H
5	L	H	M	-	H	H

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
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			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		1	Electron-hole pair formation and recombination	R3, R4, R5	1, 2		CD1, CD2	
	L2			Direct and indirect bandgap semiconductors	R3, R4, R5	1		CD1, CD2	
	L3			structural property of crystalline, polycrystalline, amorphous materials,	R3, R4	1		CD1, CD2	
	L4			optoelectronic materials	R3, R4, R5	1		CD1, CD2	
2	L5			Liquid crystals,	R3	1		CD1, CD2	
	L6			compound semiconductors	R4	1		CD1, CD2	
	L7			absorption in	R3, R4,	1		CD1,	

				semiconductors	R5			CD2	
	L8			Stark effects in quantum well structures	R3, R4, R5	1		CD1, CD2	
3	L9			Absorption and emission spectra	R3, R4, R5	1		CD1, CD2	
	L10			excitonic effects	R4	1		CD1, CD2	
	L11		2	Liquid crystal cells (principle)	R3	2		CD1, CD2	
	L12			Passive and Active matrix liquid crystal displays	R3	2		CD1, CD2	
4	L13			Electro-optic modulator	R3, R4, R5	1,2		CD1, CD2	
	L4			Magneto-optic modulator	R3, R4, R5	1,2		CD1, CD2	
	L15			Acousto-optic modulator	R3, R4, R5	1,2		CD1, CD2	
	L16			Electro-absorption modulators	R3, R4, R5	1,2		CD1, CD2	
5	L17			Mach-Zehnder Electrorefraction (Electro-optic) modulators	R3, R4, R5	1,2		CD1, CD2	
	L18			optical switches	R4	1,2		CD1, CD2	
	L19		3	Light emitting diodes	R3, R4, R5	1,3		CD1, CD2	
	L20			Surface- emitting configuration	R3, R4, R5	1,3		CD1, CD2	
6	L21			edge- emitting configuration	R3, R4, R5	1,3		CD1, CD2	
	L22			Injection laser diodes	R3, R4, R5	1,3		CD1, CD2	
	L23			gain and index guided lasers	R3, R4, R5	1,3		CD1, CD2	
	L24			PIN photodiodes	R3, R4, R5	1,3		CD1, CD2	
7	L25			Avalanche photodiodes	R3, R4, R5	1,3		CD1, CD2	
	L26			Photoconductors	R3, R4, R5	1,3		CD1, CD2	
	L27			Phototransistors	R3, R4, R5	1,3		CD1, CD2	
	L28			Noise in photodetector	R3, R4, R5	1,3		CD1, CD2	
8	L29			Solar cells (spectral response, conversion efficiency)	R3, R4, R5	1,3		CD1, CD2	
	L30			Charge-coupled devices, Characteristics and applications	R3, R4, R5	1,3		CD1, CD2	

	L31		4	Digital optical computing	R6, R7	3,4		CD1, 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 INFORMATION SHEET

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: **PH 522**	**Title: Holography and Applications**	**L-T-P-C** [3 1 0 4]

Course Objectives This course enables the students:

A.	To understand the basics of holograms and able to differentiate between holography and photography
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 elements can be utilized.

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

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.

Module-1	**Basics of Holography:** Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms, In line Hologram, off axis hologram, Fourier Hologram, Lenses Fourier Hologram, Image Hologram, Fraunhofer Hologram. Holographic interferometer, double exposure hologram, real-time holography, digital holography, holographic camera.	**[10]**
Module-2	**Theory of Hologram:** Coupled wave theory, Thin Hologram, Volume Hologram, Transmission Hologram, Reflection Hologram, Anomalous Effect.	**[8]**
Module-3	**Recording Medium:** Microscopic Characteristics, Modulation transfer function, Diffraction efficiencies, Image Resolution, Nonlinearities, S/N ratio, Silver halide emulsion, Dichromated gelatin, Photoresist, Photochrometics, Photothermoplastics, photorefractive crystals.	**[13]**
Module-4	**Applications**: Microscopy, interferometry, NDT of engineering objects, particle sizing, holographic particle image velocimetry; imaging through aberrated media, phase amplification by holography; Optical testing; Information storage.	**[13]**
Module-5	Holographic Optical Elements (HOE): multifunction, holographic lenses, holographic mirror, holographic beam splitters, polarizing, diffuser, interconnects, couplers, scanners; Optical data processing, holographic solar connectors; antireflection coating, holophotoelasticity;	**[8]**

Text books:

T1: Optical Holography, Principle Techniques and applications: P. Hariharan, Cambridge University Press

T2: Holographic Recording materials; H.M.Smith, Springer Verlag

Reference books: R1: Lasers and Holography P C Mehta and V V Rampal, World Scientific

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus: NA
Topics beyond syllabus/Advanced topics/Design: NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I	√	√			
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
A	H	M	L	H	
B	H	H	M	M	L
C	H	H	H	M	M
D		M	M	H	H
E	L	M	M	H	H

Mapping of Course Outcomes onto Program Outcomes

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

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Deliver 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			

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No	Topics to be covered	Text Book / References	Cos mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1-L2			Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves	T1, R1	CO1		PPT Digi Class/Chock-Board	
	L3-L6			Point source holograms, In line Hologram, off axis hologram, Fourier Hologram, Lenses Fourier Hologram, Image Hologram	T1, R1	CO1		PPT Digi Class/Chock-Board	
	L7-L10			Fraunhofer Hologram. Holographic interferometer, double exposure hologram, real-time holography, digital holography	T1, R1	CO1		PPT Digi Class/Chock-oard	
	L11-			Theory of Hologram:	T1, R1	CO2		PPT Digi Class/Ch	

	L14			Coupled wave theory, Thin Hologram, Volume Hologram				ock-Board	
	L15-L18			Transmission Hologram, Reflection Hologram, Anomalous Effect.	T1, R1	CO2		PPT Digi Class/Chock-Board	
	L19-L22			Recording Medium: Microscopic Characteristics, Modulation transfer function, Diffraction efficiencies,	T2, R1	CO3		PPT Digi Class/Chock-Board	
	L23-L26			Image Resolution, Nonlinearities, S/N ratio, Silver halide emulsion	T2, R1	CO3		PPT Digi Class/Chock-Board	
	L27-L31			Dichromated gelatin, Photoresist, Photochrometics, Photothermoplastics, photorefractive crystals.	T2, R1	CO3		PPT Digi Class/Chock-Board	
	L32-L35			Applications: Microscopy, interferometry, NDT of engineering objects, particle sizing,	T1, R1	CO4		PPT Digi Class/Chock-oard	
	L36-L39			holographic particle image velocimetry; imaging through aberrated media	T1, R1	CO4		PPT Digi Class/Chock-Board	
	L40-L44			phase amplification by holography; Optical testing; Information storage	T1, R1	CO4		PPT Digi Class/Chock-oard	
	L45-L46			Holographic Optical Elements (HOE): multifunction, holographic lenses, holographic mirror	T1, R1	CO5		PPT Digi Class/Chock-Board	
	L47-L50			holographic beam splitters, polarizing, diffuser, interconnects, couplers, scanners	T1, R1	CO5		PPT Digi Class/Chock-Board	
	L51-L52			Optical data processing, holographic solar connectors; antireflection coating, holophotoelasticity	T1, R1	CO5		PPT Digi Class/Chock-Board	

COURSE INFORMATION SHEET

Course code: PH 523
Course title: Quantum photonics 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 3**

Code: PH 523	Title: Quantum photonics and applications	L-T-P-C [3 1 0 4]

Course Objectives : This course enables the students:

A.	To assess light-matter interaction at the nanoscale (1-100 nm) in terms of photon statistics for identification of single photon sources.
B.	To Identify various plasmonic nanoantenna (nanoparticles, nanorods) for enhanced electromagnetic interaction
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 technology

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-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-2	Plasmonic nanoantennas, fabrications, characterizations and applications in quantum communications devices	**8**
Module-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-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	**10**

Reference:

1. Michler, P. (Ed.). (2009). Single semiconductor quantum dots (Vol. 28). Berlin: Springer.
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 ,

POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	0
End Sem Examination Marks	60
Quiz	15+15
Teacher's assessment	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√	√	
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
A	H	M	M	L	M
B	M	H	M	L	L
C	L	L	H	L	L
D	-	L	L	H	L
E	L	M	L	L	H

Mapping of Course Outcomes onto Program Outcomes

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

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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
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/Chock -Board	
	L11-L12			Photon detection and correlation function.Single-Photon Pulses and Indistinguishability of Photons..		1,2,3		Digi Class/Chock-Board	
	L13-L20			Plasmonic nanoantennas, fabrications,		1,2		DigiClass /Chock	

				characterizations and applications in quantum communications devices.				-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 test).		1		Digi Class/Chock -Board	
	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/Chock -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/Chock -Board	

COURSE INFORMATION SHEET

Course code: PH 524
Course title: Introduction to Nanophotonics
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 4**

Code: PH 524	**Title: Introduction to Nanophotonics**		**L-T-P-C [3 1 0 4]**

Course Objective: Course enables the students:

A	To identify optical phenomenon and tools to understand physics at nanoscales.
B.	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.
E	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:

1.	To solve problems of optical confinement at nanoscales.
2.	To evaluate light-matter interaction in Nano-systems (quantum dots, well etc).
3.	To design theoretical models for photonic crystals.
4.	To design (theoretically) different types of microstructure fibres and photonic crystal fibre devices
5.	To assess the field enhancement in metal nanoparticles and its application in surface plasmon waveguides. Further he/she will be able to apply knowledge of light confinement in microcavity for microcavity lasers.

Module-1	Foundations for Nanophotonics: similarities and differences of photons and electrons and their 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	**10**
Module-2	Quantum wells, quantum wired, quantum dots, quantum rings and superlattices. Quantum 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	10
Module-3	Photonic Crystals: basics concepts, features of photonic crystals, wave propagation, photonic band-gaps, light guiding. Theoretical modeling of photonic crystals. Methods of fabrication. Photonic crystal optical circuitry. Nonlinear photonic crystals. Applications of photonic crystals. Microstructure fibers: photonic crystal fiber (PCF), photonic band gap fibers (PBG), band gap guiding, single mode and multi-mode, dispersion engineering, nonlinearity engineering, PCF devices. .	12
Module-4	Plasmonics: Metallic nanoparticles, nanorods and nanoshells, local field enhancement. Collective modes in nanoparticle arrays, particle chains and arrays. surface plasmons, plasmon waveguides. Applications of metallic Nanostructures	8
Module-5	Nanophotonic Devices: Quantum well lasers: resonant cavity quantum well lasers and light emitting diodes, Fundamentals of Cavity QED, strong and weak coupling regime, Purcell factor, Spontaneous emission control, Application of microcavities, including low threshold lasers, resonant cavity LED. Microcavity-based single photon sources.	10

References:

T1. Nanophotonics, Paras N Prasad, John Wiley & Sons (2004)
T2 . Fundamentals of Photonic Crystal Fibers; Fredric Zolla- Imperial College Press.
T3. Photonic 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)

POs met through Gaps in the Syllabus: NA
Topics beyond syllabus/Advanced topics/Design: NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	0
End Sem Examination Marks	60
Quiz	15+15
Teacher's assessment	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√	√	
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
A	H	M	M	L	M
B	M	H	M	L	L
C	L	L	H	L	L
D	-	L	L	H	L
E	L	M	L	L	H

Mapping of Course Outcomes onto Program Outcomes

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

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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1-L4		1	Foundations for Nanophotonics: similarities and differences of photons and electrons and their confinement. Propagation through a classically forbidden zone: tunneling. Localization under a periodic potential: Band gap.	T1, T2,	1,2		PPT Digi Class/Chock -Board	
	L3-L7			Cooperative effects for photons and electrons. Nanoscale optical interactions, axial and lateral nanoscopic localization, scanning near-field optical		1,		Digi Class/Chock -Board	

				microscopy.					
	L8-L10			Nanoscale confinement of electronic interactions: Quantum confinement effects, nanoscale interaction dynamics, nanoscale electronic energy transfer. Cooperative emissions		1,2		Digi Class/Chock -Board	
	L11-L12			Quantum wells, quantum wired, quantum dots, quantum rings and superlattices. Quantum confinement, density of states, optical properties...		1,2,3		Digi Class/Chock -Board	
	L13-L15			Quantum confined stark effect. Dielectric confinement effect, Core-shell quantum dots and quantum-dot-quantum wells.		1,2		Digi Class/Chock -Board	
	L16-L20			Quantum confined structures as lasing media. Organic quantum-confined structures		3		Digi Class/Chock -Board	
	L21-L25			Photonic Crystals: basics concepts, features of photonic crystals, wave propagation, photonic band-gaps, light guiding. Theoretical modeling of photonic crystals. Methods of fabrication		3		Digi Class/Chock -Board	
	L26-L30			Photonic crystal optical circuitry. Nonlinear photonic crystals. Applications of photonic crystals. Microstructure fibers: photonic crystal fiber (PCF), photonic band gap fibers (PBG), band gap guiding, single mode and multi-mode, dispersion engineering, nonlinearity engineering, PCF devices. .		3			

	L31-L35			Plasmonics: Metallic nanoparticles, nanorods and nanoshells, local field enhancement. Collective modes in nanoparticle arrays, particle chains and arrays. surface plasmons, plasmon waveguides. Applications of metallic Nanostructures		4			
	L36-L50			Nanophotonic Devices: Quantum well lasers: resonant cavity quantum well lasers and light emitting diodes, Fundamentals of Cavity QED, strong and weak coupling regime, Purcell factor, Spontaneous emission control, Application of microcavities, including low threshold lasers, resonant cavity LED. Microcavity-based single photon sources.		5			

Group D- Electronics:	
1. Microprocessor and Microcontroller Applications **2.** Integrated Electronics	**3.** Microwave Electronics

COURSE INFORMATION SHEET

Course code: PH 525
Course title: Microprocessor and Microcontroller 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:PE VI / VII
Branch: PHYSICS
Name of Teacher:
Group : D **Option 1**

Code: PH 525	**Title: Microprocessor and Microcontroller Applications**	**L-T-P-C** **3-1-0-4**

Course Objectives

This course enables the students:

A.	The first module introduces architecture of 8085 and 8086 Microprocessor.
B.	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 4th 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.	The course intends to impart knowledge of Microprocessors and microcontrollers to enable learners gain 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 AVR RISC microcontroller architecture. This would enable learners to understand fundamentals of microcontrollers and implement it to design / use microcontroller for new environments.

Module-1	**8086 Architecture** Introduction to 8085 Microprocessor, 8086 Architecture-Functional diagram. Register Organization, Memory Segmentation. Programming Mode!. Memory addresses. Physical memory organization. Architecture of 8086, signal descriptions	[15]

	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:** 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, IEEE-4-88, Prototyping and trouble shooting	[14]
Module-3	**Introduction to Microcontrollers:** Overview of 8051 microcontroller. Architecture. I/O Ports. Memory organization, addressing modes and instruction set of 8051, simple program	[6]
Module-4	**8051 Real Time Control:** Interrupts, timer/ Counter and serial communication, programming Timer Interrupts, programming external hardware interrupts, programming the serial communication interrupts, programming 8051 timers and counters.	[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	[7]

TEXT BOOKS:

1 D. V. Hall. Micro processors and Interfacing, TMGH. 2'1 edition 2006.
2 Kenneth. 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 2006.
2 The 8051 Microcontrollers, Architecture and programming and Applications -K.Uma Rao, Andhe Pallavi,,Pearson, 2009.
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

Gaps in the syllabus (to meet Industry/Profession requirements) : NA

POs met through Gaps in the Syllabus : NA

Topics beyond syllabus/Advanced topics/Design : NA

POs met through Topics beyond syllabus/Advanced topics/Design

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
Quiz	15+15
Assignment	10
End Sem Examination Marks	60

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I	√	√			
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	Course Outcomes				
	1	2	3	4	5
A	H	M	M	L	H
B	M	H	M	M	H
C	L	L	H	M	L
D	M	L	L	H	H
E	H	M	L	L	H

Mapping of Course Outcomes onto Program Outcomes

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

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, 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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / Refere nces	Cos mapped	Actual Content covered	Methodol ogy used	Remarks by faculty if any
1	L1-L2		1	Introduction to 8085 Microprocessor, 8086 Architecture-Functional diagram.	T1, R3	CO1		CD1, CD2	
	L3-L5			Register Organization, Memory Segmentation. 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-			Introduction to DOS and	T2	CO2		CD1,	

	22			BIOS interrupts, Interfacing Interrupt Controller 8259 DMA Controller 8257 to 8086.				CD2	
7	L23-25			Communication interface: Serial communication standards, Serial data transfer schemes.	T2	CO2		CD1, CD2	
	L26-27			8251 USART architecture and interfacing, RS-232, IEEE-4-88,	T2	CO2		CD1, CD2	
8	L28-29			Prototyping and trouble shooting	T2	CO2		CD1, CD2	
	L30-31		3	Overview of 8051 microcontroller. Architecture.	T2	CO3		CD1, CD2	
9	L32-33			I/O Ports. Memory organization,	T2	CO3		CD1, CD2	
	L33-L34			addressing modes and instruction set of 8051,	T2	CO3		CD1, CD2	
	L35			simple program	T2	CO3		CD1, CD2	
10	L36-37		4	Interrupts, timer/ Counter and serial communication,	T2, R2	CO4		CD1, CD2	
	L38-39			programming Timer Interrupts, programming external hardware interrupts	T2, R2	CO4		CD1, CD2	
11	L40-41			programming the serial communication interrupts	T2, R2	CO4		CD1, CD2	
	L42			programming 8051 timers and counters	T2, R2	CO4		CD1, CD2, and CD8	
	L43		5	Introduction	R4	CO5		CD1, CD2, and CD8	
	L44-45			AVR Family architecture, Register File, The ALU.	R4	CO5		CD1, CD2, and CD8	
12	L46-47			Memory access and Instruction execution.	R4	CO5		CD1, CD2, and CD8	
	L48-49			Timers. UART. Interrupt Structure	R4	CO5		CD1, CD2, and CD8	

COURSE INFORMATION SHEET

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: **PH 526**	Title: **Integrated Electronics**	**L-T-P-C** **3-1-0-4**

Course Objectives

This course enables the students:

A.	First module of the course contains information about various type of circuitry to achieve logic processing for digital devices.
B.	The second module of the course would introduce the learners to the processes currently being followed in foundry for fabrication of Integrated devices.
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.

Module-1	**Logic Families** Diode Transistor Logic, High Threshold Logic, Transistor-transistor Logic, Resistor-transistor Logic, Direct Coupled Transistor Logic, Comparison of Logic families	5
Module-2	**Integrated Chip Technology** 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	20

	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, molecular beam epitaxy. Design rules and Scaling, BICMOS ICs: Choice of transistor types, pnp transistors, Resistors, capacitors, Packaging: Chip characteristics, package functions, package operations	
Module-3	**Nanoelectronic devices** Effect of shrinking the p-n junction and bipolar transistor; field-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.	15
Module-4	**Nano-Optoelectronic devices** Direct and indirect band gap semiconductors, QWLED, QWLaser, Quantum Cascade Laser Integrated Micromachining Technologies for Transducer Fabrication	5
Module-5	**Applications of Functional Thin Films and Nanostructures** Functional Thin Films and Nanostructures for Gas Sensing, Chemical Sensors, Applications of Functional Thin Films for Mechanical sensing, Sensing Infrared signals by Functional Films.	5

References

Textbooks and Reference Books:

1 Herbert Taub, Donald L. Schilling, Digital Integrated Electronics, McGraw-Hill, 1977
2 S.M. Sze, Ed, Modern Semiconductor Device Physics, Wiley, New York
3 S.M. Sze 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 Streetman, B.G. Solid State Electronic Devices, Prentice Hall, Fifth Edition, 2000
7 R. D. Doering and Y. Nishi, Handbook of Semiconductor Manufacturing Technology, CRC Press, Boca Raton.
8 W. R. Fahrner (Editor), Nanotechnology and Nanoelectronics, Materials, Devices, Measurement Techniques
9 Anis Zribi, Jeffrey Fortin (Editors), Functional Thin Films and Nanostructures for Sensors Synthesis, Physics, and Applications

Gaps in the syllabus (to meet Industry/Profession requirements) : NA

POs met through Gaps in the Syllabus : NA

Topics beyond syllabus/Advanced topics/Design : NA

POs met through Topics beyond syllabus/Advanced topics/Design

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
Quiz	15+15
Assignment	10
End Sem Examination Marks	60

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

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	Course Outcome				
	1	**2**	**3**	**4**	**5**
A	H	L	M	M	M
B	M	H	H	H	H
C	L	M	H	H	M
D	L	M	M	H	H
E	L	M	H	H	H

Mapping of Course Outcomes onto Program Outcomes

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

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	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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1-L2		1	Diode Transistor Logic, High Threshold Logic, Transistor-transistor Logic	R2, R3, and R6			CD1, CD2	
	L3-L4			Resistor-transistor Logic, Direct Coupled Transistor Logic,	R2, R3, and R6			CD1, CD2	
	L5			Comparison of Logic families	R2, R3, and R6			CD1, CD2	
	L6-7		2	Overview of semiconductor industry, Stages of Manufacturing, Process and product trends	R1,R4, R5			CD1, CD2	
	L8-9			Crystal growth, Basic wafer fabrication operations, process yields, semiconductor material preparation,	R1, R4, R5			CD1, CD2	
	L9			yield measurement, contamination sources, clean room construction,	R1, R4, R5			CD1, CD2	
	L10-12			substrates, diffusion, oxidation and photolithography, doping and depositions, implantation, rapid thermal processing, metallization.	R1, R4, R5			CD1, CD2	
	L13-14			patterning process, Photoresists, physical properties of photoresists,	R1, R4, R5			CD1, CD2	
	L15-16			Storage and control of photoresists, photo masking process, Hard bake, develop inspect,	R1, R4, R5			CD1, CD2	
	L17-18			Dry etching Wet etching, resist stripping,	R1, R4, R5			CD1, CD2	
	L19-20			Doping and depositions: Diffusion process steps, deposition, Drive-in oxidation, Ion implantation,	R1, R4, R5			CD1, CD2	
	L21-22			CVD basics, CVD process steps, Low pressure CVD systems, Plasma enhanced	R1, R4, R5			CD1, CD2	

				CVD systems, Vapour phase epitoxy, molecular beam epitaxy.					
	L23-24			Design rules and Scaling, BICMOS ICs: Choice of transistor types, pnp transistors, Resistors, capacitors	R1, R4, R5			CD1, CD2	
	L25			Packaging: Chip characteristics, package functions, package operations	R1, R4, R5			CD1, CD2	
	L26-27		3	Effect of shrinking the p-n junction and bipolar transistor; field-effect transistors, MOSFETs,	R8, R9			CD1, CD2, and CD8	
	L28-29			Introduction, CMOS scaling, the nanoscale MOSFET, vertical MOSFETs	R8, R9			CD1, CD2, and CD8	
	L30-31			electrical characteristics of sub-100 nm MOS transistors, limits to scaling, system integration limits (interconnect issues etc.)	R8, R9			CD1, CD2, and CD8	
	L32-33			heterostructure and heterojunction devices, ballistic transport and high-electron-mobility devices,	R8, R9			CD1, CD2, and CD8	
	L34-L35			HEMT, Carbon Nanotube Transistor, single electron effects, Coulomb blockade.	R8, R9			CD1, CD2, and CD8	
	L36-38			Single Electron Transistor, Resonant Tunneling Diode, Resonant Tunneling Transistor	R8, R9			CD1, CD2, and CD8	
	L39-40			applications in high frequency and digital electronic circuits and comparison with competitive devices	R8, R9			CD1, CD2, and CD8	
	L41		4	Direct and indirect band gap semiconductors	R8, R9			CD1, CD2, and CD8	
	L42-43			QWLED, QWLaser, Quantum Cascade Laser	R8, R9			CD1, CD2, and CD8	
	L44-45			Integrated Micromachining Technologies for Transducer Fabrication	R8, R9			CD1, CD2, and CD8	

	L46-48		5	Functional Thin Films and Nanostructures for Gas Sensing, Chemical Sensors	R9			CD1, CD2, and CD8	
	L49-50			Applications of Functional Thin Films for Mechanical sensing, Sensing Infrared signals by Functional Films	R9			CD1, CD2, and CD8	

COURSE INFORMATION SHEET

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 527	**Title: Microwave Electronics**	**L-T-P-C [3-1-0-4]**

Course Objectives

This course enables the students:

A.	Module-1 contains information about Transmission lines and wave-guides.
B.	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 Network analysis.
D.	Knowledge about Micro-wave passive components and methods to measure various microwave parameters are planned to be covered in Module-IV.
E.	Module-V contains information about design, fabrication and working of microwave integrated circuit technology.

Course Outcomes

After the completion of this course, students will be:

1.	Leaner would gain knowledge about working, design and application of microwave frequency 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

Module-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** 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.	7

Module-3	**Stripline and microstrip lines and Network analysis** 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 matrix, 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.	11
Module-4	**Microwave Passive Components and measurements** 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	14
Module -5	**Microwave Integrated Circuit Technology** 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).	6

RECOMMENDED BOOKS:

1 Electromagnetic Waves and Radiating Systems – E.C. Jordan & K.G. Balmain, Prentice Hall, Inc.
2 Microwave Devices and Circuits -S. Y. LIAO, PHI
3 Introduction to Microwave Theory and Measurements – L. A. Lance, TMH
4 Transmission lines and Networks – Walter C. Johnson, McGraw Hill, New Delhi
5 Networks Lines and Fields – John D. Ryder
6 Microwave Engineering: Passive Circuits -Peter A. Razi, Prentice Hall of India Pvt. Ltd, New Delhi.
7 Waveguides – H.R.L. Lamont, Methuen and Company Limited, London
8 Foundations for Microwave Engineering – Robert E. Collin, McGraw Hill Book Company, New Delhi
9 Microwave Engineering – Annapurna Das, TMH, New Delhi

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus : NA
Topics beyond syllabus/Advanced topics/Design : NA
POs met through Topics beyond syllabus/Advanced topics/Design

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
Quiz	15+15
Assignment	10
End Sem Examination Marks	60

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

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	Course Outcomes				
	1	2	3	4	5
A	H	M	M	L	H
B	H	H	M	L	H
C	M	L	H	L	L
D	H	L	L	H	H
E	L	M	L	L	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes					
	a	b	c	d	e	f
1	H	M	H	M	H	H
2	H	H	H	M	H	H
3	H	L	M	M	L	M
4	H		H	M	M	M
5	M	H	H	M	H	H

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, 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		-	-

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1-L2		1	Introduction of Microwaves and their applications.	R1, R4, and R7	CO1		CD1, CD2	
	L3-L5			Types of Transmission lines, Characterization in terms of primary and secondary constants, Characteristic impedance	R1, R4, and R7	CO1		CD1, CD2	
2	L6			General wave equation, Loss less propagation, Propagation constant, Wave reflection at discontinuities,	R1, R4, and R7	CO1		CD1, CD2	
	L7			Voltage standing wave ratio, Transmission line of finite length,	R1, R4, and R7	CO1		CD1, CD2	
	L8			The Smith Chart, Smith Chart calculations for lossy lines,	R1, R4, and R7	CO1		CD1, CD2	
3	L9			Impedance matching by Quarter wave transformer, Single and double stub matching.	R1, R4, and R7	CO1		CD1, CD2	
	L10-12			Rectangular Waveguides: TE and TM wave solutions, Field patterns, Wave impedance and Power flow.	R1, R4, and R7	CO1		CD1, CD2	
4	L13-14		2	Microwave Linear-Beam (O type) and Crossed-Field tubes (M type), Limitations of conventional tubes at microwave frequencies,	R2	CO2		CD1, CD2	
	L15			Klystron, Multicavity Klystron Amplifiers, Reflex Klystrons	R2	CO2		CD1, CD2	
5	L16-17			Helix Travelling-wave tubes, magnetron Oscillators.	R2	CO2		CD1, CD2	
	L18			Tunnel diode, TED ¬Gunn diode,	R2	CO2		CD1, CD2	
	L19			Avalanche transit time devices IMPATT (also TRAPAT) and parametric devices.	R2	CO2		CD1, CD2	
6	L20-21		3	Dominant mode of	R4, R5	CO1,		CD1, CD2	

				propagation, Field patterns, Characteristic impedance,		CO3			
	L22			Basic design formulas and characteristics.	R4, R5	CO1, CO3		CD1, CD2	
	L23			Parallel coupled striplines and microstrip lines-Even-and odd-mode excitations.	R4, R5	CO1, CO3		CD1, CD2	
	L24			Slot lines and Coplanar lines. Advantages over waveguides	R4, R5	CO1, CO3		CD1, CD2	
7	L25-27			Microwave Network Analysis: Impedance and Admittance matrices, Scattering matrix,	R4, R5	CO1, CO3		CD1, CD2	
	L28			Parameters of reciprocal and Loss less networks, ABCD Matrix,	R4, R5	CO1, CO3		CD1, CD2	
8	L29			Scattering matrices of typical two-port, three-port and four-port networks,	R4, R5	CO1, CO3		CD1, CD2	
	L30			Conversion between two-port network matrices.	R4, R5	CO1, CO3		CD1, CD2	
	L31-32		4	Waveguide Components: E-plane and H-plane Tees, Magic Tee, Shorting plunger, Directional couplers, and Attenuator.	R6, R8	CO4		CD1, CD2	
9	L33-34			Stripline and Microstrip line Components: Open and shorted ends.	R6, R8	CO4		CD1, CD2	
	L35-36			Half wave resonator, Lumped elements (inductors, capacitors and resistors) in microstrip.	R6, R8	CO4		CD1, CD2	
10	L37-38			Ring resonator, 3-dB branchline coupler, backward wave coupler, Wilkinson power dividers and rat-race hybrid ring.	R6, R8	CO4		CD1, CD2	
	L39			Low pass and band pass filters.	R6, R8	CO4		CD1, CD2	
11	L40-42			Microwave Measurements: Detection of microwaves, Microwave power measurement, Impedance measurement, Measurement of reflection loss (VSWR), and transmission loss in components.	R6, R8	CO4		CD1, CD2	
	L43-44			Passive and active circuit measurement & characterization using network analyser, spectrum analyser and noise	R6, R8	CO4		CD1, CD2	

				figuremeter					
12	L45		5	Substrates for Microwave Integrated Circuits (MICs) and their properties.	R9	CO5		CD1, CD2	
	L46-47			Hybrid technology – Photolithographic process, deposited and discrete lumped components.	R9	CO5		CD1, CD2, and CD8	
	L48			Microwave Monolithic Integrated Circuit (MMIC) technology-Substrates	R9	CO5		CD1, CD2, and CD8	
	L49-50			MMIC process, comparison with hybrid integrated circuit technology (MIC technology).	R9	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: 4 T: 0 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: PH 528	**Title: Theory of Plasmas**	**L-T-P-C [4-0-0-4]**
Plasma Theory **Course Objective** 1. To learn about the similarity of plasma with fluid. 2. To learn about the diffusion and mobility of plasma. 3. To learn about the resistivity and single fluid MHD equation of plasma. 4. To learn about the Boltzmann and the Vlasov equation. 5. To learn about the different type of discharges. **Course Outcome** 1. Be familiar about the method by which plasma can be treated as a fluid. 2. Be familiar with the diffusion and mobility process. 3. Be able to derive the set of single fluid MHD equation. 4. Be able to describe plasma with Boltzmann and Vlasov equation. 5. Be familiar with the different type of electrical discharges.		
Module-1	Relation of plasma physics to ordinary electromagnetic field, Fluid equation of motion, Fluid drifts perpendicular to B, Fluids drifts parallel to B, Plasma approximation.	**[8]**
Module-2	Diffusion and mobility in weakly ionized gases, Decay of a plasma by diffusion, steady state solution, Recombination, diffusion across a magnetic field, collision in fully ionized plasma.	**[8]**
Module-3	Mechanics of coulomb collisions, Physical meaning of resistivity, Numerical value of resistivity, Single fluid MHD equations, Diffusion in fully ionized plasma, Bohm diffusion and Neoclassical diffusion.	**[8]**
Module-4	Concepts of elementary kinetic theory of plasmas, The meaning of distribution function, Boltzmann and Vlasov equation	**[8]**
Module-5	Electrical discharges, Electrical breakdown in gases, glow discharge, Self sustained discharges, Paschen curve, High frequency electrical discharge in gases, electrode less discharge, capacitively and Inductively coupled plasmas, ECR Plasmas, Electrical arcs .	**[8]**
References 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		

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus: NA
Topics beyond syllabus/Advanced topics/Design: NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√	√	
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
A	H	L	L	L	L
B	M	H	L	L	L
C	M	M	H	L	L
D	M	L	L	H	L
E	L	L	L	L	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	B	C	d	E	f	g	H	i	j	K	l
1	M	H	M	M	M	H						
2	M	H	L	M	M	H						
3	M	H	H	M	M	H						
4	M	H	H	M	M	H						
5	M	H	L	M	M	H						

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 No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / Refere Nces	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1-L5			Relation of plasma physics to ordinary electromagnetic field, Fluid equation of motion,	T2 T3 R1				
	L6-L10			Fluid drifts perpendicular to B, Fluids drifts parallel to B, Plasma approximation	T2 T3 R1				
	L11-L15			Diffusion and mobility in weakly ionized gases, Decay of a plasma by diffusion,	T2 T3 R1				
	L16-L20			steady state solution, Recombination, diffusion across a magnetic field, collision in fully ionized plasma.	T2 T3 R1				
	L21-L25			Mechanics of coulomb collisions, Physical meaning of resistivity, Numerical value of resistivity,	T2 T3 R1				
	L26-L30			Single fluid MHD equations, Diffusion in fully ionized plasma, Bohm diffusion and Neoclassical diffusion.	T2 T3 R1				
	L31-L35			Concepts of elementary kinetic theory of plasmas,	T2 T3 R1				
	L36-L40			The meaning of distribution function, Boltzmann and Vlasov equation	T2 T3 R1				
	L41-L45			Electrical discharges, Electrical breakdown in gases, glow discharge,	T1 R1				

				Self sustained discharges, Paschen curve,					
	L46-L50			High frequency electrical discharge in gases, electrode less discharge, capacitively and Inductively coupled plasmas, ECR Plasmas, Electrical arcs .	T1 R1				

COURSE INFORMATION SHEET

Course code: PH 529
Course title: Plasma Confinement
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 2**

Code: PH 529	**Title: Plasma Confinement**	**L-T-P-C [3-1-0-4]**

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, Controlled thermonuclear fusion and fusion reactor, Lawson criterion, Ignition, Fuel resources, Reactor economics, Plasma confinement schemes, Magnetic confinement, Inertial confinement, Laser-Fusion .	**[8]**
Module-2	Magnetic confinement: Larmor orbits, particle drifts, Magnetic mirror, Z-pinch, 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.	**[8]**
Module-3	Collisional Transport: Classical transport – minimal dissipation, diffusion, random walk estimate, heat conductivity, Fluid evolution in a torus – transport closure, radial fluxes, neoclassical transport, Surface flows, Axis symmetric fluxes.	**[8]**
Module-4	Plasma-surface interaction: Plasma surface interactions, Boundary layer, Recycling, Atomic and molecular processes, Desorption and wall cleaning, Sputtering, Arcing, Limiters, Divertors, Heat flux, Evaporation and heat transfer, Tritium inventory. Radiation from Plasma	**[8]**
Module-5	MHD Generator: Magnetohydrodynamic Generator, Basic theory, Principle of working, The fuel in MHD, Magnet in MHD Generator.	**[8]**

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

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus: NA
Topics beyond syllabus/Advanced topics/Design: NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√	√	
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
A	H	M	L	L	L
B	M	H	L	L	L
C	L	L	H	L	L
D	L	M	M	H	L
E	L	M	L	L	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes										
	a	b	c	d	E	f	g	H	I	j	k	l
1	M	H	M	M	H	H						
2	M	H	M	M	H	H						
3	M	H	M	M	H	H						
4	M	H	M	M	H	H						
5	M	H	M	M	H	H						

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

				beta, Aspect-ratio,					
	L16-L20			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.					
	L21-L25			Collisional Transport: Classical transport – minimal dissipation, diffusion, random walk estimate, heat conductivity,					
	L26-L30			Fluid evolution in a torus – transport closure, radial fluxes, neoclassical transport, Surface flows, Axis symmetric fluxes					
	L31-L35			Plasma-surface interaction: Plasma surface interactions, Boundary layer, Recycling, Atomic and molecular processes,					
	L36-L40			Desorption and wall cleaning, Sputtering, Arcing, Limiters, Divertors, Heat flux, Evaporation and heat transfer, Tritium inventory. Radiation from Plasma					
	L41-L45			MHD Generator: Magnetohydrodynamic Generator, Basic theory,					
	L46-L50			Principle of working, The fuel in MHD, Magnet in MHD Generator.					

<u>**COURSE INFORMATION SHEET**</u>

Course code: PH 530
Course title: Waves and Instabilities in Plasma
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 : E <u>**Option 3**</u>

Code: PH 530	**Title: Waves and Instabilities in Plasma**	**L-T-P-C [4-0-0-4]**
Course Objective 1. To learn the fundamental and basics of Plasma waves. 2. To learn about the electromagnetic waves. 3. To learn about the Landau Damping. 4. To learn about the different type of instabilities. 5. To learn about the MHD stability. **Course outcome:** 1. Will be familiar with the plasma waves. 2. Be able to handle electromagnetic waves mathematically. 3. Be able to derive mathematically Landau damping related concept. 4. Will be familiar with the different type of instabilities. 5. Be able to handle MHD stability mathematically.		
Module-1	Representations of waves, group velocity, Plasma Oscillations, Electron plasma waves, sound waves, ion waves, validity of plasma approximations, comparison of ion and electron waves, electrostatic electron oscillations perpendicular to B.	**[8]**
Module-2	Electrostatic ion waves perpendicular to B, The lower hybrid frequency, electromagnetic waves with B=0, Experimental applications, electromagnetic waves perpendicular to B, Cutoffs and resonances, electromagnetic waves parallel to B, Whistler mode, Faraday rotation.	**[8]**
Module-3	Hydromagnetic waves, Magnetosonic waves, Alfven waves, Plasma oscillations and Landau damping, A physical derivation of Landau damping.	**[8]**
Module-4	Equilibrium and stability, Hydromagnetic equilibrium, Diffusion of magnetic field into a plasma, Classification of instabilities, two stream instability, The gravitational instability, Resistive drift waves.	**[8]**
Module-5	MHD stability, Energy principle, Kink instability, Internal kink, tearing modes, Resistive layer, Tearing stability, Mercier criterion, Ballooning modes, Beta limit.	**[8]**
<u>**References**</u> 1. Tokamaks, J Wessons, 1987, Oxford Science Publication. 2. Introduction to Plasma Physics f F Chen. 3. The theory of plasma waves, T H Stix, 1962, McGraw-Hill New York. 4. Fundamental of Plasma Physics, J, A. Bittencourt, Springer-Verlag New York Inc., 2004		

Gaps in the syllabus (to meet Industry/Profession requirements) : NA
POs met through Gaps in the Syllabus: NA
Topics beyond syllabus/Advanced topics/Design: NA
POs met through Topics beyond syllabus/Advanced topics/Design

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	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Quiz I			√	√	
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
A	H	M	L	L	L
B	M	H	L	L	L
C	M	M	H	L	L
D	L	L	L	H	M
E	L	L	L	M	H

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	C	D	E	f	g	H	i	j	k	l
1	M	H	M	M	H	H						
2	M	H	M	M	H	H						
3	M	H	H	M	H	H						
4	M	H	M	M	H	H						
5	L	H	L	M	H	H						

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

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: I.M.Sc.
Semester / Level: PE VI / VII
Branch: PHYSICS
Name of Teacher: Dr. Sanat Mukherjee

Group : E **Option 4**

Same given as above (in Group B)

Generic Elective Papers offered to I. M.Sc. Programmes of other Departments

PH 109 Physics- I 50 Lectures

Course Objectives: This course enables the students

1.	To know the basic theories of Electrostatics and Magnetostatics.
2.	To get the basic knowledge of Electromagnetic theory.
3.	To gather a general information of Nuclear Physics.
4.	To make acquainted with the theories of Physical Optics.
5.	To have some basic knowledge of the Special Theory of Relativity.

Course Outcomes

After the completion of this course, students will be:

1.	Able to implement the theories of Electrostatics and Magnetostatics for different physical problem.
2.	Able to understand the practical and theoretical approaches of Electromagnetic theory.
3.	Understanding about the Nuclear Reactor, Source of Sun Energy etc.
4.	Acquainted with the theories of Physical Optics and its relevant results observed in practice.
5.	Acquainted with the Special Theory of Relativity and its applications.

Code: PH 109	**Title: Physics- I**	**L-T-P-C 3-1-0-4**
Module I	**Electromagnetic Theory I:** Gauss's law and its applications, electric potential, relation between **E** and V, capacitance, energy density of an electric field, dielectrics, dielectric constant, dielectric polarization, three electric vectors **E, D, P,** boundary conditions for **E** and **D** at interface between two dielectrics	**[10]**
Module II	**Electromagnetic Theory II:** Ampere's law, Biot-Savart law, inductance, energy density of a magnetic field, Gauss's law in magnetism, three magnetic vectors H**, B, M,** boundary conditions for **B** and H, Faraday's Law, Displacement current, Maxwell's equations in free space, plane electromagnetic waves in free space, Poynting vector, pressure and momentum of EM waves	**[10]**
Module III	**Nuclear physics** Nuclear forces, binding energy, liquid drop model, fission, nuclear reactors, fusion, energy processes in stars, controlled thermonuclear reactions.	**[5]**
Module IV	**Physical Optics:** Huygen's construction for propagation of a wavefront, superposition principle, conditions for interference of light, coherence, Young's double-slit experiment, Newton's rings, Diffraction, Fraunhofer diffraction by a single slit, diffraction grating (qualitative), Polarization, polarizers, Malus' Law, Brewster's Law, Double Refraction	**[15]**
Module V	**Special Theory of Relativity:** Postulates, Galilean transformations, Lorentz transformation, length contraction, time dilation, velocity addition, mass change and Einstein's mass energy relation, Application os Relativity in GPS system.	**[10]**

Text Books:

Modules 1 and 2: E.M. theory

1. Halliday, Resnick, Walker , Fundamentals of Physics, 6th Edition, John Wiley & Sons, 2004
2. D. J. Griffith, Introduction to Electrodynamics, 3rd Edition.
3. Mathew N.O. Sadiku, Elements of Electromagnetics, 4th Edition, Oxford University Press, (2012).

Modules 4:

1. Halliday, Resnick, Walker , Fundamentals of Physics, 6th Edition, John Wiley & Sons, 2004
2. Ajoy Ghatak , Optics, 5th Edition, Tata McGraw Hill, 2012
3. Jenkins and White: Fundamentals of Optics

Module 3 and 5: Relativity

1. Arthur Beiser, Concept of Modern Physics, 6th Edition, Tata McGraw Hill, 2009

PH110 Physics- I Lab

PH 111 Physics II (50 lectures)

Course Objectives: This course enables the students

1.	To get the basic knowledge of Thermodynamics and Statistical Physics
2.	To know the basic theories of Quantum mechanics
3.	To gather a general information of Laser Physics.
4.	To have some basic knowledge of dielectric materials.
5.	To have some basic knowledge of magnetic materials.

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

1.	Able to understand the practical and theoretical approaches of Thermodynamics and Statistical Physics.
2.	Able to implement the theories of Quantum mechanics for microscopic particles and the concerned nanoscience.
3.	Understanding about the Laser source, Optical fibres, holography etc.
4.	Acquainted with the properties and applications of dielectric materials.
5.	Acquainted with the properties and applications of magnetic materials.

Code: PH 111	**Title: Physics II**	**L-T-P-C 3-1-0-4**
Module I	**Thermodynamics and Statistical Physics** Zeroth law, first law, second law, entropy, heat transfer, steady state one-dimensional heat conduction. Elementary ideas, comparison of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics.	**[12]**
Module II	**Quantum mechanics** Planck's theory of black-body radiation, Compton effect, wave particle duality, De Broglie waves, Davisson and Germer's experiment, uncertainty principle, physical interpretation of wave function and its normalization, expectation value. Schrodinger equation in one dimension, solutions of time-independent Schrodinger equation for free particle, particle in an infinite square well, potential barrier and tunneling.	**[10]**
Module III	**Lasers and applications** Emission of light by atoms, spontaneous and stimulated emission, Einstein's A and B coefficients, laser: population-inversion, properties of laser radiation, Ruby & He-Ne lasers, applications of lasers, elementary ideas of holography and fiber optics.	[10]
Module IV	**Dielectrics properties** Dielectric constant and polarization of dielectric materials. Types of polarization. Equation for internal field in liquids and solids (one dimensional). Ferro and Piezo electricity. Frequency dependence of dielectric constant. Important applications of dielectric materials.	**[10]**
Module V	**Magnetic properties** Classification of dia, para and ferro-magnetic materials. Hysterisis in ferromagnetic materials. Soft and hard magnetic materials, Applications.	**[8]**
Text Books: 1. Perspective of Modern Physics, A. Beiser (AB), Mc Graw Hill Int. Ed. 2002 2. Physics for Engineers, M. R. Srinivasan, New Age International, 1996. 3. Fundamentals of Thermodynamics, 6th Ed., Sonntag, Borgnakke & Van Wylen, John Wiley & Sons.		

Open Elective Papers offered for Minor in Engineering Physics of B.Tech. Programme

	PE	Subjects	L-T-P-C
		Theory Papers	
Odd Semester	**PE-I**	• Advanced Mathematical Physics • Nano Materials and Applications	3-0-0-3 3-0-0-3
Odd Semester	**PE-II**	• Computational Physics • Materials Science and Nanotechnology • Experimental Technique	3-0-0-3 4-1-0-5 3-0-0-3
Even Semester	**PE-III**	• Nonconventional Sources of Energy • Introduction to Nuclear and Particle Physics • Nuclear Hazard and Waste Managements	3-0-0-3 4-1-0-5 4-1-0-5
Even Semester	**PE-IV**	• Atmospheric Physics • Advanced Experimental Technique	3-0-0-3 3-0-0-3
		Lab Papers	
Odd Semester	**PE-I**	• Advanced Mathematical Physics • Nano Materials and Applications	0-0-2-2 0-0-2-2
Odd Semester	**PE-II**	• Computational Physics • Experimental Technique	0-0-2-2 0-0-2-2
Even Semester	**PE III**	• Nonconventional Sources of Energy	0-0-2-2
Even Semester	**PE-IV**	• Atmospheric Physics • Advanced Experimental Technique	0-0-2-2 0-0-2-2