BODOLAND UNIVERSITY

Syllabus for

Under Graduate Programme with Multiple Entry and Exit Options

in

PHYSICS

For Colleges Affiliated to Bodoland University

Framed According to National Education Policy (NEP 2020)

Effective from Academic Year 2023-24

Abbreviations used:

MAJ: Major

MIN: Minor

IDC: Inter Disciplinary Course

AEC: Ability Enhancement Courses

SEC: Skill Enhancement Course

VAC: Value Added Course

DIS: Dissertation

REM: Research Methodology

ADL: Advance Learning

Syllabus structure of Four Year Undergraduate Programme in Physics (based on NEP 2020)

Sem	Major Course (4 credit)	Minor Course (4 credit)	IDC (3 credit)	AEC (2 credit)	SEC (3 credit)	VAC (4 credit)	Internship *(credit 4/2)		Total credit
I	PHYMAJ1014 Mechanics	PHYMIN1014 Mechanics	PHYIDC1013 Basics of Physical Bodies	AEC1012 Language/ Regional Language	PHYSEC1013 Instrumentation Skills in Physics-I	VAC1014			20
II	PHYMAJ1024 Mathematical Physics - I	PHYMIN1024 Electricity, Magnetism and Electromagnetic Theory	PHYIDC1023 Electricity, Magnetism and Electronics	AEC1022 Language/ Regional Language	PHYSEC1023 Instrumentation Skills in Physics-II	VAC1024			20
Exit with a Certificate in Physics (40 credits and Internship of 4 credits)									
III	PHYMAJ2014 Electricity and Magnetism PHYMAJ2024 Waves and Optics	PHYMIN2014 Thermal Physics and Statistical Mechanics	PHYIDC2013 Molecules, Photons and Nuclei	AEC2012 Language/ Regional Language	PHYSEC2013 Electrical Network and Loads				20
IV	PHYMAJ2034 Mathematical Physics - II PHYMAJ2044 Thermal and Statistical Physics PHYMAJ2054 Analog systems and applications (Electronics -I)	PHYMIN2024 Waves and Optics		AEC2022 Language/ Regional Language			Internship (2)		20
Exit with a Diploma in Physics (80 credits and Internship of 4 credits)									
V	PHYMAJ3014 Classical Mechanics PHYMAJ3024 Elements of	PHYMIN3014 Mathematical Physics							20

	Modern Physics PHYMAJ3034 Digital system and applications (Electronics -II) PHYMAJ3044 Electromagnetic Theory								
VI	PHYMAJ3054 Quantum Mechanics -I PHYMAJ3064 Solid State Physics - I PHYMAJ3074 Nuclear and Particle Physics - I PHYMAJ3084 Mathematical Physics -III	PHYMIN3024 Elements of Modern Physics							20
Exit with a B.Sc. in Physics (120 credits)									
VII	PHYMAJ4014 Advanced Statistical Mechanics PHYMAJ4024 Atomic and Molecular Physics PHYMAJ4034 Quantum Mechanics –II PHYMAJ4044 Astronomy and Astrophysics (OR) PHYREM4044 Research	PHYMIN4014 Electronics and Astrophysics							20

	Methodology (For dissertation students)								
VIII	PHYMAJ4054 Laser and Non-linear Optics	PHYMIN4024 Quantum Mechanics and Solid State Physics						PHYDIS40612 Dissertation / Research Project (OR)	20
	PHYDIS40612 Dissertation / Research Project							PHYADL4014 Experimental Techniques in Physics	
								PHYADL4024 Solid State Physics -II	
								PHYADL4034 Nuclear and Particle Physics - II	
	80	32	9	8	9	6	4	12	160
Exit with B.Sc. in Physics with Honours and Research (160 credits)									

Code Explanation:
MAJ= Major; MIN= Minor; ADL= Advanced Learning; DIS= Dissertation; IDC= Interdisciplinary; AEC= Ability Enhancement Course; SEC=Skill Enhancement Course, VAC= Value Added Course,
First digit= Course level; Second and Third digit=Sl. No. of course in the category (Paper Serial Number), and Last digit= Credits, e.g. MAJ1014

Curriculum Framework for Four-Year Undergraduate Programme

Year	Objective	Nature of Courses	No. of courses	Outcome
1^{st} year (1^{st} & 2^{nd} Semesters)	Understanding and Exploration	1. Major Core Courses	1+1=2	Understanding of Disciplines, Language Competency, Exposure to discipline beyond the chosen Subject, Gaining Basic skills to pursue any vocation
		2. Minor/Related Discipline	1+1=2	
		3. Inter Disciplinary Courses	1+1=2	
		4. AEC/Languages	1+1=2	
		5. Skill Enhancement courses	1+1=2	
		6. Value Added Course	1+1=2	
***Exit option*: Certificate in Physics,** upon the successful completion of the First Year (Two Semesters) along with **internship of 4 credit**.				
2^{nd} Year (3^{rd} & 4^{th} Semesters)	Focus and Immersion	1. Major Core Courses	2+3+5	Understanding of Disciplines, Language Competency, Exposure to discipline beyond the chosen Subject, Gaining skills for employability
		2. Minor/Related Discipline	1+1=2	
		3. Inter Disciplinary Courses	1+0=1	
		4. AEC/Languages	1+1=2	
		5. Skill Enhancement courses	1+0=1	
		6. Internship	0+1=1	
***Exit option*: Diploma in Physics,** upon the successful completion of the Second Year (Four Semesters) along with **internship of 4 credit**				
3^{rd} Year - (5^{th} & 6^{th} Semesters)	Real time Learning	1. Major Core Courses	4+4=8	In depth learning of major and minor disciplines
		2. Minor/Related Discipline	4+4=8	
***Exit option*: Bachelor Degree in Physics,** upon the successful completion of the Third Year (Six Semesters) of Four-year Undergraduate Programme				
4^{th} Year - (7^{th} & 8^{th} Semesters)	Deeper Concentration	1. Major Core Courses	4+4=8	Advanced and Deeper Learning of Major Discipline
		2. Minor/Related Discipline	1+1=2	
***Exit option*: Bachelor Degree with Physics Honours**, upon the successful completion of the Fourth Year (Eight Semesters) of Four-year Undergraduate Programme				
4^{th} Year - (7^{th} & 8^{th} Semesters)	Deeper Concentration	1. Major Core Courses	3+1=4	Advanced and Deeper Learning of Major Discipline, Developing Research competencies and Foundation for pursuing Doctoral Studies
		2. Minor/Related Discipline	1+1=2	
		Research Methodology	1+0=1	
		Dissertation /Research Project	0+1=1	
***Exit option*: Bachelor Degree with Research**, upon the successful completion of theFourth Year (Eight Semesters) of Four-year Undergraduate Programme				

Curriculum Structures
for
Four Year Undergraduate Programme (FYUGP)

Total Credits= 160

SEMESTER - I							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYMAJ1014	Mechanics	4	(3+0+1)	50	30	20	100
PHYMIN1014	Mechanics	4	(3+0+1)	50	30	20	100
PHYIDC1013	Basics of Physical Bodies	3	(3+0+0)	50	00	00	50
AEC1012	Language	2	(2+0+0)	50	00	00	50
PHYSEC1013	Instrumentation Skills in Physics-I	3	(2+0+1)	40	00	10	50
VAC1014	VAC	4			30		100
Total credits		**20**					**450**

SEMESTER - II							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYMAJ1024	Mathematical Physics - I	4	(3+0+1)	50	30	20	100
PHYMIN1024	Electricity, Magnetism and Electromagnetic Theory	4	(3+0+1)	50	30	20	100
PHYIDC1023	Electricity, Magnetism and Electronics	3	(3+0+0)	50	00	00	50
AEC1022	Language	2	(2+0+0)	50	00	00	50
PHYSEC1023	Instrumentation Skills in Physics-II	3	(2+0+1)	40	00	10	50
VAC1024	VAC	4			30		100
Total credits		**20**					**450**

SEMESTER -III							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYMAJ2014	Electricity and Magnetism	4	(3+0+1)	50	30	20	100
PHYMAJ2024	Waves and Optics	4	(3+0+1)	50	30	20	100
PHYMIN2014	Thermal Physics and Statistical Mechanics	4	(3+0+1)	50	30	20	100
PHYIDC2013	Molecules, Photons and Nuclei	3	(3+0+0)	50	00	00	50
AEC2012	Language	2	(2+0+0)	50	00	00	50
PHYSEC2013	Electrical Network and Loads	3	(2+0+1)	40	00	10	50
Total credits		**20**					**450**

SEMESTER - IV							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYMAJ2034	Mathematical Physics - II	4	(3+0+1)	50	30	20	100
PHYMAJ2044	Thermal and Statistical Physics	4	(3+0+1)	50	30	20	100
PHYMAJ2054	Analog systems and applications (Electronics -I)	4	(3+0+1)	50	30	20	100
PHYMIN2024	Waves and Optics	4	(3+0+1)	50	30	20	100
AEC2022	Language	2	(2+0+0)	50	00	00	50
Internship	Internship	2					
Total credits		**20**					**500**

SEMESTER - V							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYMAJ3014	Classical Mechanics	4	(3+0+1)	50	30	20	100
PHYMAJ3024	Elements of Modern Physics	4	(3+0+1)	50	30	20	100
PHYMAJ3034	Digital System and Applications (Electronics -II)	4	(3+0+1)	50	30	20	100
PHYMAJ3044	Electromagnetic Theory	4	(3+0+1)	50	30	20	100
PHYMIN3014	**Mathematical Physics**	4	(3+0+1)	50	30	20	100
Total credits		**20**					**500**

SEMESTER - VI							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYMAJ3054	Quantum Mechanics -I	4	(3+0+1)	50	30	20	100
PHYMAJ3064	Solid State Physics - I	4	(3+0+1)	50	30	20	100
PHYMAJ3074	Nuclear and Particle Physics -I	4	(3+0+1)	50	30	20	100
PHYMAJ3084	Mathematical Physics -III	4	(3+0+1)	50	30	20	100
PHYMIN3024	**Elements of Modern Physics**	4	(3+0+1)	50	30	20	100
Total credits		**20**					**500**

SEMESTER - VII							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYMAJ4014	Advanced Statistical Mechanics	4	(3+0+1)	50	30	20	100
PHYMAJ4024	Atomic and Molecular Physics	4	(4+0+0)	70	30	00	100
PHYMAJ4034	Quantum Mechanics -II	4	(3+0+1)	50	30	20	100
PHYMAJ4044 PHYREM4044	Astronomy and Astrophysics OR Research Methodology (For dissertation students)	4	(4+0+0) (4+0+0)	70 70	30 30	00 00	100
PHYMIN4014	**Electronics and Astrophysics**	4	(3+0+1)	50	30	20	100
Total credits		**20**					**500**

SEMESTER - VIII							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYMAJ4054	Laser and Non-linear Optics	4	(4+0+0)	70	30	00	100
PHYDIS40612	Dissertation / Research Project	12	(0+0+12)	210	90	---	300
PHYMIN4024	Quantum Mechanics and Solid State Physics	4	(4+0+0)	70	30	00	100
OR							
PHYMAJ4054	Laser and Non-linear Optics	4	(4+0+0)	70	30	00	100
PHYADL4014	Experimental Techniques in Physics	4	(3+0+1)	50	30	20	100
PHYADL4024	Solid State Physics - II	4	(3+0+1)	50	30	20	100
PHYADL4034	Nuclear and Particle Physics - II	4	(3+0+1)	50	30	20	100
PHYMIN4024	Quantum Mechanics and Solid State Physics	4	(4+0+0)	70	30	00	100
Total credits		**20**					**500**

List of minor courses in physics

Semester	Paper code	Credit	Paper title
I	PHYMIN1014	3+0+1=4	Mechanics
II	PHYMIN1024	3+0+1=4	Electricity, Magnetism and Electromagnetic Theory
III	PHYMIN2014	3+0+1=4	Thermal Physics & Statistical Mechanics
IV	PHYMIN2024	3+0+1=4	Waves & Optics
V	PHYMIN3014	3+0+1=4	Mathematical Physics
VI	PHYMIN3024	3+0+1=4	Elements of Modern Physics
VII	PHYMIN4014	3+0+1=4	Electronics & Astrophysics
VIII	PHYMIN4024	4+0+0=4	Quantum Mechanics and Solid State Physics

List of SEC:

Semester	Paper code	Credit	Paper title
I	PHYSEC1013	2+0+1=3	Instrumentation Skills in Physics-I
II	PHYSEC1023	2+0+1=3	Instrumentation Skills in Physics-II
III	PHYSEC2013	2+0+1=3	Electrical Network and Loads

List of IDC:

Semester	Paper code	Credit	Paper title
I	PHYIDC1013	2+0+1=3	Basics of Physical Bodies
II	PHYIDC1023	2+0+1=3	Electricity, Magnetism and Electronics
III	PHYIDC2013	2+0+1=3	Molecules, Photons and Nuclei

Semester 1
Paper Title: Mechanics
Paper Code: PHYMAJ1014
Credit: 04 (3+0+1)
Lecture: 45

Course Objectives:

- *To give an idea of various frame of references.*
- *To give concept of work, energy, conservation laws.*
- *To offer knowledge of mechanical properties of matter.*
- *To give basic concept of theory of relativity.*

Course outcome:
On successful completion of the course students will be able to understand about the fundamental concept of dynamics, work and energy, Elasticity, motion under central force, waves & oscillations & special theory of relativity.

Unit I
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 and Laboratory frames, Principle of conservation of momentum.

(6 Lectures)

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. Law of conservation of Energy.

(3 Lectures)

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. **(7 Lectures)**

Unit II
Elasticity: Relation between Elastic constants. Twisting torque on a Cylinder or Wire.

(2 Lectures)

Fluid Motion: Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube. **(2 Lectures)**

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.

(3 Lectures)

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 of global positioning system (GPS). **(5 Lectures)**

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. **(6 Lectures)**

Unit III

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.

(4 Lectures)

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 Kinematics. **(7 Lectures)**

Reference Books:

- An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
- Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
- Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
- Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
- Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
- Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
- University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
- Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning
- Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

Paper title: Mechanics Lab
Paper code: PHYMAJ1014
Class: 30 Hrs. Lab class

A minimum of 8 experiments is to be performed by the students during the semester

1. Measurements of length (or diameter) using vernier caliper, screw gauge and traveling microscope.
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.

Semester 1
Paper Title: Mechanics
Paper Code: PHYMIN1014
Credit: 04 (3+0+1)
Lecture: 45

Course Objectives:
The objective of the course is to impart a good foundation of the concepts of vector algebra and differential equations. This course begins with Newton's Laws of Motion and ends with the Special Theory of Relativity. The students will acquire knowledge of the mechanical properties of matter in the solid. It is designed to enhance the understanding of the Concept of Gravitation, rotational motion, and central forces. They will learn about Simple Harmonic Motion and energy associated with a body executing SHM. They will have a basic idea of the Special Theory of Relativity.

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

- *Learn basics vector, vector algebra, and its Product.*
- *Learn 1^{st} and 2^{nd} order differential equations.*
- *Understand the concepts of laws of motion and their application to various dynamical situations. And their applications to the conservation of momentum, angular momentum, and energy.*
- *Understand rotational motion and associated parameters.*
- *Apply Kepler's laws to describe the motion of planets and satellites in a circular orbit.*
- *The concept of geosynchronous orbits*
- *Understand Simple Harmonic Motion and energy associated with SHM*
- *Learn mechanical properties of matter and elastic constants*
- *Concept of stress and strain and the relation between elastic constants*
- *Understand Einstein's postulates of special relativity.*
- *Apply Lorentz transformations to describe simultaneity, time dilation, and length contraction*

Unit I

Vectors: Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. **(4 Lectures)**
Ordinary Differential Equations:1^{st} order homogeneous differential equations. 2^{nd} order homogeneous differential equations with constant coefficients. **(4 Lectures)**
Laws of Motion: Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass. **(4 Lectures)**
Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy.

Motion of rockets. **(4 Lectures)**

Unit II

Rotational Motion: Angular velocity and angular momentum, Torque. Conservation of angular momentum. **(3 Lectures)**

Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). **(8 Lectures)**

Unit III

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. **(6 Lectures)**

Elasticity: Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants- Poisson's Ratio- Expression for Poisson's ratio in terms of elastic constants- Work done in stretching and work done in twisting a wire-Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion - Torsional pendulum- Determination of Rigidity modulus and moment of inertia by Searles method **(7 Lectures)**

Special Theory of Relativity: Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities. **(5 Lectures)**

Reference books:

- University Physics. FW Sears, MW Zemansky and HD Young 13/e, 1986. Addison- Wesley
- Mechanics Berkeley Physics course, Vol1: Charles Kittel, et. al. 2007, Tata Mc Graw- Hill.
- Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Paper title: Mechanics Lab

Paper code: PHYMIN1014

Class: 30 Hrs Lab class

A minimum of 8 experiments is to be performed by the students during the semester

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope
2. To determine the Height of a Building using a Sextant.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine the Young's Modulus of a Wire by Optical Lever Method.
5. To determine the Modulus of Rigidity of a Wire by Maxwell’s needle.
6. To determine the Elastic Constants of a Wire by Searle’s method.
7. To determine g by Bar Pendulum.
8. To determine g by Kater’s Pendulum.
9. To determine **g** and velocity for a freely falling body using Digital Timing Technique
10. To study the Motion of a Spring and calculate (a) Spring Constant (b) Value of g

Reference books:

- Advanced Practical Physics for students, B.L.F lintand H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4thEdition, reprinted 1985, Heinemann Educational Publishers.
- Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

Semester 1

Paper Title: Basics of Physical Bodies
Paper Code: PHYIDC1013
Paper Credit: 03 (3+0+0)
Lecture: 45

Course Objective:
To familiar the students of other discipline the concept of motion from the points of view of two observers one in inertial and other in non inertial frame of reference. The law of universal gravitation and interpretation of lunar tides and various geophysical phenomena have been incorporated. Indian space programme also highlighted.

Course Outcome:
Students are expected to learn the basic physics. They are also expected to get the holistic scientific reason for different geophysical phenomena. Also it is expected that they will be interested to learn the contribution of ISRO has made so far for building India as a self reliant nation in Space research.

Unit I

Basic concepts: The units Centimetre and the Second, Weight and Mass. The SI systems and standards of measurement. Density. The law of conservation of mass. Action and Reaction. Addition of velocities. Force is a vector. Motion in inclined plane. **(5 Lectures)**

Laws Of Motion: Different points of view about motion. The law of Inertia. The motion is relative. Celestial observer's point of view. Acceleration and Force. Rectilinear motion with constant acceleration. Path of a bullet. Circular motion. Life at g=0. Motion from an unreasonable point of view. Centrifugal forces. Coriolis forces. **(8 Lectures)**

Unit II

Conservation Laws: Recoil. The law of conservation of momentum. Jet propulsion. Motion under the action of gravity. The law of conservation of mechanical energy. Work. Units of measurement of work and energy. Power and efficiency of machines. Energy loss. Collisions.
(5 Lectures)

Oscillations: Equilibrium. Simple oscillations. Displaying (demonstration of) oscillations. Force and potential energy in oscillations. Spring vibrations. Resonance. **(5 Lectures)**

Motion of Solid Bodies: Torque. Lever. Energy loss in path. Very simple machines. Method of addition of parallel forces acting on a body. Centre of gravity and centre of mass. Angular momentum. Law of conservation of angular momentum. Angular momentum as a vector. Tops. Flexible shaft. **(7 Lectures)**

Unit III

Gravitation: What holds the Earth up!. Law of universal gravitation. Weighing the earth. Measurement of g in the service of mankind. Weight underground. Gravitational energy. How planets move. Interplanetary travel. If there were no moon! India's Space Programme. ISRO's contribution in space exploration, communication and remote sensing. **(9 Lectures)**

Pressure: Atmospheric Pressure. How Atmospheric Pressure was discovered. Atmospheric pressure and weather. Change of weather with altitude. Archimedes' principle. Extremely low pressure. Vacuum. Pressure of millions of atmosphere. Hydrostatic pressure, Hydraulic press.
(6 Lectures)

Reference:

- Physics for Everyone. (BOOK1): PHYSICAL BODIES. L D Landau, A. I. Kitaigorodsky. Mir Publishers, Moscow. Translated from the Russian by (Martin Greendlinger, D. Sc., Math)
- The Feynman Lectures on Physics (I, II & III) (Pearson Education Publication)

Semester 1
Paper Title: Instrumentation Skills in Physics-I
Paper Code: PHYSEC1013
Credit: 03 (2+0+1)
Lecture: 30

Course objective:
The objective of the course is to provide a basic understanding of electrical measurements and their applications in experimental physics. The course focuses on the principles, techniques, and instruments used for measuring and analysing electrical quantities.
Learning outcome:
Students will gain theoretical and hands-on experience on the important electronic measurements and will learn about basic circuit analysis, electronic components, multimeters, oscilloscopes, and sensors etc.

Unit I
Introduction to Instrumentation and Measurement: Importance of instrumentation in physics research, Overview of different measurement techniques, units, standards, instruments accuracy, precision, sensitivity, and resolution range. **(3 Lectures)**
Electrical Measurements: Basic components and circuit, voltage, current, and resistance measurements, colour code of resistance, Multimeters: Specifications of a multimeter and their significance. Analogue and Digital, Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Amplifier-rectifier, and rectifier- amplifier. **(6 Lectures)**
Cathode Ray Oscilloscope: Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.
(8 Lectures)
Unit II
Signal Generators and Analysis Instruments: Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis. Impedance Bridges & Q-Meters: Block diagram of bridge. working principles of basic RLC bridge. Specifications of RLC bridge. Block diagram & working principles of a Q- Meter. Digital LCR bridges. **(8 Lectures)**
Sensors and Transducers: Principles of sensor operation**,** Types of sensors (temperature, pressure, strain, etc.)**,** Selection and calibration of sensors**,** Sensor interfacing and signal conversion.
(5 Lectures)

Paper Title: Instrumentation Skills in Physics-I Lab

Paper code: PHYSEC1013

Class: 30 Hrs. Lab. Class

A minimum of 5 experiments is to be performed by the students during the semester

1. Analog voltmeters and ammeters in a simple electrical circuits to measure voltage and current.
2. Digital panel meters in electrical circuits for current and voltage measurement.
3. Identifying resistance and capacitance from colour code/item code and compare the values using digital multimeter.
4. Use soldering iron to secure an electrical connection joint.
5. Design a LED chaser circuit using IC.
6. Determine the characteristics (frequency, peak to peak voltage, rms voltage) of a continuous signal using analog (CRO) /digital (DSO) oscilloscope.
7. Use an electrical drill machine to make a hole (6mm) on a wall/wood/metal plate.

Reference Books:

- A text book in Electrical Technology; B L Theraja,
- Electronic Devices and Circuits; S. Salivahanan & N. S.Kumar,
- Electrical Measurements And Measuring Instruments; R.K. Rajput, (S. Chand)
- Electrical And Electronics Measurements And Instrumentation; R.K. Rajput, (S. Chand)
- Cathode Ray Oscilloscope: A Course for Students of Science, Medicine and Engineering; David T. Rees
- Performance and design of AC machines; M G Say
- Basic Electronics; J.B. Gupta

Semester 2
Paper Title: Mathematical Physics - I
Paper Code: PHYMAJ1024
Credit: 04 (3+0+1)
Lecture: 45

Course Objectives:
The main objective of this course is to offer the basic concepts of Calculus, differential equation, vector algebra & probability.

Course outcome:
This part of the course includes mathematics so that students could understand Calculus, Vectors & their applications in various fields of physics, Differential Equation & its application, different coordinate systems & concept of probability & error. This will be helpful to students for their higher studies.

Unit I

Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). **(2 Lectures)**

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. **(9 Lectures)**

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. **(5 Lectures)**

Unit II

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. **(3 Lectures)**

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. **(6 Lectures)**

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs). **(10 Lectures)**

Unit III

Orthogonal Curvilinear Coordinates: Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **(6 Lectures)**

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance. **(2 Lectures)**

Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing. **(2 Lectures)**

Reference books:

- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
- An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
- Differential Equations, George F. Simmons, 2007, McGraw Hill.
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
- Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
- Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
- Mathematical Physics, Goswami, 1st edition, Cengage Learning
- Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
- Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
- Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press

Paper title: Mathematical Physics - I Lab
Paper code: PHYMAJ1024
Class: 30 Hrs. Lab class

- The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.
- Highlights the use of computational methods to solve physical problems
- The course will consist of lectures (both theory and practical) in the Lab
- Evaluation done not on the programming but on the basis of formulating the problem
- Aim at teaching students to construct the computational problem to be solved Students can use any one operating system Linux or Microsoft Windows

Topics	**Description with Applications**
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
Review of C & C++/Python/Matlab/Mathematica Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, cin and cout, Manipulators for data formatting, Control statements (decision making and looping statements) (If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
Random number generation	Area of circle, area of square, volume of sphere, value of pi (π)
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving $\alpha = \tan\alpha$; $I = I_0\left(\frac{\sin\alpha}{\alpha}\right)^2$ in optics
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. sin θ, cos θ, tan θ, etc.

Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop
Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods	First order differential equation · Radioactive decay · Current in RC, LC circuits with DC source · Newton's law of cooling · Classical equations of motion Attempt following problems using RK 4 order method: · Solve the coupled differential equations $\frac{dx}{dt} = y + x - \frac{x^3}{3}$; $\frac{dy}{dx} = -x$ for four initial conditions x(0) = 0, y(0) = -1, -2, -3, -4. Plot x vs y for each of the four initial conditions on the same screen for $0 \le t \le 15$ The differential equation describing the motion of a pendulum is $\frac{d^2\nu}{dt^2} = -\sin(\nu)$. The pendulum is released from rest at an angular displacement α, i. e. υ(0)= α and $\upsilon^{/}(0)=0$. Solve the equation for α = 0.1, 0.5 and 1.0 and plot υ as a function of time in the range $0 \le t \le 8\pi$. Also plot the analytic solution valid for small υ (sin(υ)= υ

Reference Books:

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn., 2007, Cambridge University Press.
- A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
- An Introduction to Computational Physics, T. Pang, 2nd Edn., 2006, Cambridge Univ. Press
- Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

Semester 2
Paper Title: Electricity, Magnetism and Electromagnetic Theory
Paper Code: PHYMIN1024
Credit: 04 (3+0+1)
Lecture: 45

Course Objectives:
The objective is to help the students to acquire the conceptual knowledge of electricity, Electric field, potential, Capacitance, and di-electric material. The student will have an idea of magnetism ,the magnetic effect of current and magnetic materials. This course will facilitate to develop of the concept of electromagnetic induction and electromagnetic wave equations.

Course Outcomes:
At the end of this course, students will be able to
- *Enhance the idea of vector operation further.*
- *Understand the concept of electric field and electric flux.*
- *Learn to apply Gauss's theorem to find electric fields for different types of charge distribution.*
- *Will develop the concept of capacitors and How to calculate the capacity of various types of capacitors.*
- *Learn about magnetism due to current.*
- *Will grasp the idea of Magnetic materials and their properties.*
- *Understand the core concept of electromagnetic induction and Propagation of electromagnetic waves.*

Unit I
Vector Analysis: Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only). **(6 Lectures)**
Magnetism: Magnetostatics: Biot-Savart's law & its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials:Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia, para and ferro-magnetic materials.
(9 Lectures)

Unit II
Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.
(15 Lectures)

Unit III
Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual

inductance, L of single coil, M of two coils. Energy stored in magnetic field. **(6 Lectures)**

Maxwell`s equations and Electromagnetic wave propagation: Equation of continuity of current, Displacement Maxwell Equations Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization. **(9 Lectures)**

Reference books:

- Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education.
- Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.
- Electricity and Magnetism, DC Tayal, 1988, Himalaya Publishing House.
- University Physics, Ronald Lane Reese, 2003, ThomsonBrooks/Cole.
- D.J. Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings

Paper title: Electricity, Magnetism and Electromagnetic Theory LAB
Paper code: PHYMIN1024
Class: 30 Hrs. Lab class

A minimum of 8 experiments is to be performed by the students during the semester

1. To use a Multimeter for measuring (a) Resistances (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. Ballistic Galvanometer:
   i. Measurement of charge and current sensitivity
   ii. Measurement of CDR
   iii. Determine a high resistance by Leakage Method
   iv. To determine Self Inductance of a Coil by Rayleigh's Method.
3. To compare capacitances using De'Sauty's bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx).
5. To study the Characteristics of a Series RC Circuit.
6. To study the series LCR circuit and determine its (a) Resonant Frequency, (b) Quality Factor
7. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q
8. To determine a Low Resistance by Carey Foster's Bridge.
9. To verify the Thevenin and Norton theorem
10. To verify the Superposition, and Maximum Power Transfer Theorem

Reference books:

- Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

Semester 2
Paper Title: Electricity, Magnetism and Electronics
Paper Code: PHYIDC1023
Credit: 03 (3+0+0)
Lecture: 45

Course Objective:

This paper has been designed to give the students basic understanding of electricity, magnetism and electronics. The applications of electromagnetism; and it also includes Maxwell's equations which will be perfect for the students to understand the connectivity or similarity between electricity and magnetism. The paper also deals with microelectronics circuits, radio, television, radar, radio wave propagation etc.

Course Outcome:

After successful completion of this paper students of other discipline will be able to comprehend the basics of electric current and magnetism. They will have the idea of electron flow in conductor, semiconductor. The students will also be able to gain ideas of working of Radio, television and some microelectronic devices.

Unit I

Electricity: Stationary Electricity. Electric Current. What is basic? Electric Fields. Evolution of Electricity Theory. **(6 Lectures)**

Electrical Structure Of Matter: Minimum quantity of Electricity. Electron beam. Millikan's Experiment, Model of the atom. Quantizing energy. Dielectrics. Conduction in gases, Ion flow. Self maintained discharge. Matter in the Plasma State. Metals, Electron emission from metals. Thermoelectric Phenomena. Semiconductors. p-n junction. **(8 Lectures)**

Unit II

Electromagnetism: Measure of magnetic field intensity. Effect of Uniform Magnetic Field. Effect of non uniform magnetic field. Amperian currents. Electron cloud of the atom. Magnetic moments of the particles. Electromagnetic induction. Direction of induced current. Discovery of the law of electromagnetic induction. Induced Eddy Currents. Diamagnetic, Paramagnetic and Ferromagnetic materials. Earth's magnetic field. Magnetic fields of the star. **(14 Lectures)**

Unit III

Electromagnetic Fields: Maxwell's equations. Electromagnetic field. Photo-electric effect. Hertz's experiment. Mechanical model of radiation. Classification of electromagnetic radiation. **(10 Lectures)**

Radio: Some history. Vacuum tube triode and transistor. Radio transmission. Radio reception. Radio-wave propagation. J. C. Bose's contribution on wireless communication, Radar. Television. **(7 Lectures)**

Reference Books:

- Physics for Everyone. (BOOK3): ELECTRONICS. A. I. Kitaigorodsky. Mir Publishers, Moscow. Translated from the Russian by (Nicholas Weinstein)
- The Feynman Lectures on Physics (I, II & III) (Pearson Education Publication)

Semester 2
Paper Title: Instrumentation Skills in Physics-II
Paper Code: PHYSEC1023
Credit: 03 (2+0+1)
Lecture: 30

Course objective:

This course provides a scientific understanding of optical measurements and their applications in experimental physics. It explores the principles, techniques, and instruments used for optical analysis and measurements.

Course Outcome:

Students will be able to learn about the fundamental concepts of geometrical and physical optics, light sources, detectors, and fiber optic sensors. After completion of this course, students will also be able to comprehend the practical skills in setting up optical experiments, collecting and analysing data, and interpreting experimental results.

Unit I

Optical Measurements: Importance of optical measurements in physics research,Units and standards in optical measurements, Geometrical and physical optics: Reflection, refraction, and dispersion of light, Laws of geometrical optics, Optical systems: lenses, mirrors, and prisms, Ray tracing and image formation, Light sources and detectors, Interferometry and spectroscopy, Fibre optic sensors.

(9 Lectures)

Detectors and Photodetection: Principles of photodetection, Photodetector types: photodiodes, photomultiplier tubes (PMTs), etc., Photodetector characteristics: sensitivity, response time, noise, etc., Photodetection circuitry and signal amplification. **(6 Lectures)**

Unit II

Error Analysis and Measurement Uncertainty: Types of errors in measurements, Propagation of errors and error analysis, Statistical methods in data analysis, Estimation and reporting of measurement uncertainty. **(4 Lectures)**

Instrument Maintenance and safety measurements: Common issues in instrument operation, Troubleshooting techniques, Preventive maintenance and calibration schedules, Safety considerations in instrumentation. **(4 Lectures)**

Calibration and Metrology: Principles of optical metrology and precision measurements, Traceability and calibration standards, Techniques for measuring length, angle, and displacement.

(7 Lectures)

Paper Title: PHYSEC102-3: Instrumentation Skills in Physics-II Lab

Paper Code: PHYSEC1023

Class: 30 Hrs. Lab. Class

A minimum of 5 experiments is to be performed by the students during the semester

1. Using a DSO, do the fast Fourier transform (FFT) of a sinusoidal continuous signal.
2. Generate an amplitude modulated signal using DSO and signal generator.
3. Generate a frequency modulated signal using DSO and signal generator.
4. Use data storage option of the DSO to transfer the digital data to computer and reproduce the signal using any available software (MS Excel/Origin etc.)
5. Reflection, refraction and total internal reflection using laser source.
6. Diffraction of light through grating.
7. Designing a simple microscope using lenses.
8. Designing a simple telescope using lenses.

Reference Books:

- Optics; Ajay Ghatak
- Optics; Eugene Hecht and A. R. Ganesan
- Lasers and Optical Instrumentation; N. Sathyanarayana S. Nagabhushana
- Photonics: Optoelectronics, S L Kakani, S Kakani, CBS Publisher.
- A text book on light, B Ghosh and K G Mazumdar

Semester 3
Paper Title: Electricity and Magnetism
Paper Code: PHYMAJ2014
Credit: 04 (3+0+1)
Lecture: 45

Course Objectives:
The objective of this paper is to give the basic concept of electricity, dielectric properties of matter, magnetic field & magnetic properties of matter, electrical circuits etc.

Course outcome:
After completion of this paper students will be able to understand the electric & magnetic fields & their application , Electromagnetic induction, applications of Kirchhof's laws in electrical circuits.

Unit I

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. **(3 Lectures)**

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. **(4 Lectures)**

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. (**6 Lectures)**

Unit II

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. **(6 Lectures)**

Magnetic Field: Magnetic force between current elements and definition of magnetic field. 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.

(**8 Lectures)**

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. **(3 Lectures)**

Unit III

Electromagnetic Induction: Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current. **(4 Lectures)**

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.

(4 Lectures)

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.

(4 Lectures)

Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR.

(3 Lectures)

Reference Books:

- Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
- Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
- Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
- Feynman Lectures Vol. 2, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
- Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
- Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.

Paper title: Electricity and Magnetism Lab
Paper code: PHYMAJ2014
Class: 30 Hrs. Lab class

A minimum of 10 experiments is to be performed by the students during the semester

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.

- 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
- Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning.
- A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

Semester 3
Paper Title: Waves and Optics
Paper Code: PHYMAJ2024
Credit: 04 (3+0+1)
Lecture: 45

Objectives:
The main objective of the paper is to give basic concepts of Simple Harmonic Motion, Wave Motion, Vibration of strings & air column. The paper also includes the concept of wave properties of light through interference & diffraction.
Course outcome:
The outcome of the paper includes the knowledge of vibrations, propagation of waves, vibration of air column, harmonics of strings. The paper has another outcome of offering knowledge of wave properties of light & corresponding phenomena.

Unit I
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. **(4 Lectures)**
Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. **(2 Lectures)**
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. **(3 Lectures)**
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.
(4 Lectures)
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. **(6 Lectures)**

Unit II
Wave Optics: Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. **(2 Lectures)**
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); Fringees of equal thickness (Fizeau Fringes). Newton’s Rings: Measurement of wavelength and refractive index.
(7 Lectures)
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. **(3 Lectures)**
Diffraction: Kirchhoff’s Integral Theorem, Fresnel-Kirchhoff’s Integral formula. (Qualitative discussion only). **(2 Lectures)**

Unit III

Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. **(5 Lectures)**

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.

(7 Lectures)

Reference Books:

- Waves:Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
- Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
- Principles of Optics, Max Born and Emil Wolf, 7^{th} Edn., 1999, Pergamon Press.
- Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
- The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
- Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications, 2011, R. Chand Publications.

Paper title: Waves and Optics Lab
Paper code: PHYMAJ2024
Class: 30 Hrs. Lab class

A minimum of 8 experiments is to be performed by the students during the semester

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.

Semester 3
Paper Title: Thermal Physics and Statistical Mechanics
Paper Code: PHYMIN2014
Credit: 04 (3+0+1)
Lecture: 45

Course Objectives:

This course is divided into two main parts. The first part deals with Thermal Physics and the second part pertains to Statistical Mechanics. The objective of the first part of the course is to infuse ideas of Thermodynamic systems, Thermodynamic variables, Thermodynamic processes, and allied phenomenons. It is designed to familiarise students with thermodynamic potentials, the Kinetic theory of gases, and the Theory of radiation. While the second part is devoted to givinga basic introduction to Statistical Mechanics and various types of Statistics.

Course Outcomes:

Upon completion of this course, students will be able,

- To grasp the idea of 1st law of thermodynamics and its applications.
- To learn different laws of thermodynamics and their significance.
- To understand Maxwell's relations, Joule-thompson effect and Caussius-Clapeyron equation.
- To learn the derivation of Maxwell's Law of distribution of velocities, Various Transport phenomena, and also the application of the law of equipartition of energy.
- To understand Blackbody radiation and its Spectral distribution.
- To learn to derive Plank's law and also derivation other laws like Wien's distribution law, Rayleigh-Jeans law,etc from Plank's Law.
- To understand the basics of Statistical mechanics and the significance and applications of various types of statics.

Unit I

Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P & C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility & Expansion Coefficient, Reversible & irreversible processes, Second law & Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainabilityof absolute zero.

(15 Lectures)

Unit II

Thermodynamic Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations & applications - Joule-Thompson Effect, Clausius- Clapeyron Equation, Expression for (C_P – C_V), C_P/C_V, TdS equations. **(8 Lectures)**

KineticTheoryofGases: Derivationof Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gasses; mono-atomicanddiatomic gasses. **(8 Lectures)**

Unit III

Theory of Radiation: Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh- Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law. **(5 Lectures)**

Statistical Mechanics: Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann law - distribution of velocity - Quantum statistics - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law photon gas comparison of three statistics. **(9 Lectures)**

Reference books:

- Thermal Physics, S.Garg, R.Bansal and C.Ghosh,1993,Tata McGraw-Hill.
- A treatise on Heat, Meghnad Saha, and B.N. Srivastava,1969, Indian Press.
- Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
- Heat and Thermodynamics, M.W. Zemasky and R. Dittman,1981, McGraw Hill
- Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W. Sears & G.L. Salinger. 1988, Narosa
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- Thermal Physics, A. Kumar and S.P. Taneja, 2014, Rich and Publications.

Paper title: Thermal Physics and Statistical Mechanics Lab
Paper code: PHYMIN2014
Class: 30 Hrs Lab class

A minimum of 8 experiments is to be performed by the students during the semester

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barnes constant flow method.
2. Measurement of Planck's constant using black body radiation.
3. To determine Stefan's Constant.
4. To determine the coefficient of thermal conductivity of copper by Searle's Apparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
7. To determine the temperature coefficient of resistance by Platinum resistance thermometer.
8. To study the variation of thermo emf across two junctions of a thermocouple with temperature.
9. To record and analyze the cooling temperature an object as function of time using a thermocouple and suitable data acquisition system
10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-Balance Bridge

Reference books:

- Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4^{th} Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11^{th} Edition, 2011, Kitab Mahal, New Delhi.
- A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.

Semester 3
Paper Title: Molecules, Photons and Nuclei
Paper Code: PHYIDC2013
Credit: 03 (3+0+0)
Lecture: 45

Course Objective:

This paper will explain the historical development of the building block of the universe to the physics of the universe. It includes energy and its conservation, discovery of laws of thermodynamics. The paper gives the basic ideas of soft and hard electromagnetic radiations. The nuclei, the mass energy equivalence. Preliminary ideas of radioisotopes, nuclear reactions, solar energy, wind energy. The nature of the universe, expanding, stars at their different ages, cosmic rays etc.

Course Outcome:

Students are expected to understand the concept of energy and its conservation and different forms. They will also be able to understand the theory of relativity and the equivalence of mass and energy; the electromagnetic radiation, Solar energy and the thermonuclear reactions that are going on in the Star. They will also understand the Expansion of the Universe, the origin of cosmic rays etc.

Unit I

Structure of Matter: Elements. Atoms and molecules. Intermolecular Bonds. Physical and Chemical properties. Interaction of molecules. What thermal motion looks like? Crystals and their shape. Structure of crystals. Polycrystalline substances. **(6 Lecture)**

Law of Thermodynamics: Conservation of energy at the molecular level. How heat is converted into work. Entropy. Fluctuations. 1^{st} and 2^{nd} laws of thermodynamics. **(6 Lecture)**

Electromagnetic Radiation (Soft and Hard): Exchange of energy by radiation. The theory of thermal radiation. Optical spectra. Laser radiation. Luminescence. The discovery of X-rays and applications. Radiography of materials. **(10 Lecture)**

Unit II

THE STRUCTURE OF ATOMIC NUCLEI: Properties of atomic nuclei, the mass and energy of an atomic nucleus. Isotopes. Radioactivity. Radioactive decay. Nuclear reactions and the discovery of neutron. The energy of nuclear reactions. A nuclear chain reaction.

(10 Lecture)

Unit III

Energy Around Us: Sources of energy. Fuel. Electric power plants. Nuclear reactors. Thermonuclear energy. Solar energy. Power from the wind. **(6 Lecture)**

The Physics of the Universe: Measuring distance to the stars. The expanding universe. Basic theory of relativity. Life cycle of Stars: Chandrasekhar's contribution. Radio astronomy. Cosmic rays.

(7 Lecture)

Reference Books:

1. Physics for Everyone. (BOOK2): MOLECULES. L. D. Landau, A. I. Kitaigorodsky. Mir Publishers, Moscow. Translated from the Russian by (Martin Greendlinger, D. Sc., Math)
2. Physics for Everyone. (BOOK4): PHOTONS & NUCLEI . A. I. Kitaigorodsky. Mir Publishers, Moscow. Translated from the Russian by (George Yankovosky)
3. The Feynman Lectures on Physics (I, II & III) (Pearson Education Publication)

Semester 3
Paper Title: Electrical Network and Loads
Paper Code: PHYSEC2013
Credit: 03 (2+0+1)
Lecture: 30

Course objective: *The objective of this course is to provides a broad understanding on electrical networks and loads, focusing on the principles, analysis techniques, and practical applications.*

Learning outcome: *Students will be able to gain the skills necessary to analyze and design electrical networks, select appropriate loads, and understand the interplay between electrical systems and loads in various applications. Students will also acquire fundamental professional skills related to electrical wiring, splicing techniques, and shunting methods.*

Unit I

Introduction to electrical network: Introduction to electrical Power, Ohm's law. Passive and active components in electrical networks. AC and DC electricity.Understanding electrical circuits: Kirchhoff's laws and circuit analysis techniques, Series, parallel, and series-parallel combinations. Applications of series and parallel circuits in practical systems. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Three-phase power generation and transmission, Advantages and applications of three-phase systems. **(10 Lecture)**

Network Theorems: Thevenin's theorem and Norton's theorem, Superposition theorem and maximum power transfer theorem, Application of network theorems in circuit simplification and analysis, Theoretical and practical limitations of network theorems. **(5 Lecture)**

Unit II

Power, Energy and Loads: Active, reactive, and apparent power, Power factor and its significance, Energy consumption and efficiency calculations, Power measurement techniques and instruments. Types of electrical loads: resistive, inductive, capacitive, and mixed loads. Power electronic loads: rectifiers, inverters, and motor drives, Load selection and matching in practical applications.

(10 Lecture)

Power Distribution Systems: Overview of power distribution systems. Types of transformers, Distribution transformers and substations. Transmission and distribution losses, Safety considerations and protective devices in power distribution. **(5 Lecture)**

Paper Title: Electrical Network and Loads Lab
Paper code: PHYSEC2013
Class: 30 Hrs. Lab. class

1. Design a remote control ON/OFF switch for light using IR LED.
2. Design an extension board (4 nos. of 5/15 Amp socket) with switch, fuse and spike protection.
3. Design a prototype electrical connection for household AC power line distribution with circuit breakers, switches, LED tube, Led Bulb, 15/5 Amp socket.
4. Design a low pass and high pass filter circuit.
5. Measure the power consumption in a typical household AC operated load. Determine the current configuration for the main circuit breaker (MCB) for a typical laboratory hall/room when in full load.
6. Design a step-up/step-down transformer and measure the input/output voltage.

Reference Books:

1. Principles of Electronics; VK Mehta.
2. Handbook of Repair and Maintenance of Domestic Electronics Appliances, Shashi Bhushan Sinha
3. Modern Basic Electrical & House Wiring Servicing, M. Lotia
4. Performance and design of AC machines; M G Say
5. Op-Amp and Linear Integrated Circuits, R Gayakwad, Pearson Education.

Semester 4
Paper Title: Mathematical Physics - II
Paper Code: PHYMAJ2034
Credit: 04 (3+0+1)
Lecture: 45

Objectives: *The main objective of this paper to give concepts about Fourier series, method of solution of ordinary and partial differential equations, special integrals and errors.*

Course outcomes: *After successful completion of this course, students will be able to:*

1. *Expand functions in terms of Fourier series.*
2. *Solve second order ordinary differential equations using Frobenius method*
3. *Find the solutions of Legendre, Bessel, Hermite and Laguerre Differential Equations and their application in various problems related to physics.*
4. *Solve partial differential equations like Laplace's equation in various co-ordinate systems using separation of variables method.*
5. *Explain the properties of Beta and Gamma Functions and express integrals in terms of them.*

Unit I

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. **(7 Lectures)**

Unit II

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 ($J_o(x)$ and $J_1(x)$) and Orthogonality.
(20 Lectures)

Unit III

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral). **(4 Lectures)**

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.
(4 Lectures)

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 Lectures)**

Reference Books:

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
- Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
- Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

Paper Title: Mathematical Physics – II Lab
Paper Code: PHYMAJ2034
Class: 30 Hrs. Lab class

The aim of this Lab is to use the computational methods to solve physical problems. Course will consist of lectures (both theory and practical) in the Lab. Evaluation done not on the programming but on the basis of formulating the problem

Topics	**Description with Applications**
Introduction to Numerical computation softwares	Introduction to Scilab/Mathematica/Matlab/Python, Advantages and disadvantages, Scilab/Mathematica/Matlab/Python environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab/Mathematica/Matlab/Python, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab/Mathematica/Matlab/Python functions, Introduction to plotting, 2D and 3D plotting
Curve fitting, Least square fit, Goodness of fit, standard deviation	Ohms law to calculate R, Hooke's law to calculate spring constant
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	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/Mathematica/Matlab/Python	Generating and plotting Legendre Polynomials, Generating and plotting Bessel function

Solution of ODE First order Differential equation Euler, modified Euler and Runge-Kutta second order methods	First order differential equation · Radioactive decay · Current in RC, LC circuits with DC source · Newton's law of cooling · Classical equations of motion
Second order differential equation Fixed difference method	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	Partial Differential Equation: · Wave equation · Heat equation · Poisson equation · Laplace equation

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

Semester 4
Paper Title: Thermal and Statistical Physics
Paper Code: PHYMAJ2044
Credit: 04 (3+0+1)
Lecture: 45

Course Objectives:
This course is designed in view to give extensive knowledge about the relation among Heat energy , internal energy, Work done , Entropy . About different thermodynamic processes, about distribution of classical particles . This course also contains topics about the distribution of energy radiation and momentum.

Course Outcome:
After successful completion of this course students are able to understand about the first and second laws of Thermodynamics, how heat, energy and work are related , about Isothermal and adiabatic processes about specific heat . about Heat engine and its efficiency, Concept of Entropy and the change of Entropy for different thermodynamic processes.
From Maxwell's Thermodynamics student will be able to learn about the distribution of classical particles, for Ideal and real gas and the Maxwell equation in thermodynamics are set of relations which is used in deriving the dependence of thermodynamic variables as the state variables of P,V and T.
After study of Classical theory of radiation, students will learn about the time angular distribution of the radiation of energy and momentum connecting various laws like ,Kirchhoff's law , Stefan-Boltzmann's law, Rayleigh-Jean's law etc.

Unit I
Introduction to Thermodynamics: First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient. **(3 Lectures)**
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, 2^{nd} Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. **(5 Lectures)**

Unit II
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.
(7 Lectures)
Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of Cp-Cv, TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process. **(7 Lectures)**

Unit III

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.

(14 Lectures)

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. **(9 Lectures)**

Reference books:

- Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
- A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
- Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
- Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
- Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

Paper Title: Thermal and Statistical Physics Lab
Paper Code: PHYMAJ2044
Class: 30 Hrs. Lab class

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, 11^{th} Ed., 2011, Kitab Mahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4^{th} Edition, reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes,D.P.Khandelwal,1985, Vani Pub.

Semester 4
Paper Title: Analog Systems and Applications (Electronics -I)
Paper Code: PHYMAJ2054
Credit: 04 (3+0+1)
Lecture: 45

Course Objective:
This course is introduced to give knowledge about Semiconductors, Diodes, Transistors and their circuits as an application. In this course students can learn about RC-Coupled amplifiers, Feedback-amplifiers, Operational Amplifiers, Oscillators . This course will help the students to switch to Digital World.

Course Outcome:
After successful completion of this course students will learn about Semiconductor and their types P and N. About PN junction Diode, their characteristic . Application of Diode as rectifier, stabilized power supply, different types of diode, LED, Photodiode etc. Students will learn about PNP and NPN transistors, their characteristics and application as an Amplifier.
In this course students learn about different types of amplifiers RC-Coupled amplifiers and their frequency response, Feedback-amplifier-positive and negative type, Operational amplifier and their applications like, Adder, Substractor, Differentiator ,Integrator. This course also gives fear knowledge about Oscillators.

Unit I

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. Barrier Potential, Barrier width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode. **(6 Lectures)**

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. **(6 Lectures)**

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.

(4 Lectures)

Unit II

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. **(7 Lectures)**

Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response. **(3 Lectures)**

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **(3 Lectures)**

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators. **(4 Lectures)**

Unit III

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. **(4 Lectures)**

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.

(5 Lectures)

Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation). **(3 Lectures)**

Reference Books:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning
- Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
- Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
- Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
- Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
- Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
- Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

Paper Title: Analog systems and applications (Electronics -I) Lab
Paper Code: PHYMAJ2054
Class: 30 Hrs. Lab class

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 4
Paper Title: Waves and Optics
Paper Code: PHYMIN2024
Credit: 04 (3+0+1)
Lecture: 45

Course Objectives:

This paper reviews the concept of waves and optics learned at the school level from a more advanced perspective and builds new concepts. This course is divided into two main parts. The first part deals with Sound and waves. The second part pertains to optics and provides the details of interference, diffraction, and polarization.

Course Outcomes:

After the completion of this course, the students shall be able to learn the following-

- *The concept of superposition of waves and phenomena thus originated.*
- *Learn waves traveling through different mediums and parameters involved.*
- *Simple harmonic motion, superposition principle, and its application to find the resultant of superposition of harmonic oscillations.*
- *Concepts of vibrations in strings.*
- *Interference phenomenon arose out of the superposition of waves from coherent sources.*
- *Basic concepts of Diffraction: Fraunhofer and Fresnel Diffraction.*
- *Elementary concepts of the polarization of light.*
- *Michelson's Interferometer and its Applications.*

Unit I

Superposition of Two Collinear Harmonic oscillations: Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different Frequencies (Beats)

(3 Lectures)

Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.

(2 Lectures)

Waves Motion- General: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity. **(7 Lectures)**

Sound: Simple harmonic motion - forced vibrations and resonance - Fourier's Theorem - Application to sawtooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria. **(7 Lectures)**

Unit II

Wave Optics: Electromagnetic nature of light. Definition and Properties of Wavefront. Huygens Principle. **(3 Lectures)**

Interference: Interference: Division of amplitude and division of wave front. 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. **(9 Lectures)**

Unit III

Michelson's Interferometer: Idea of form fringes (no derivation needed), Determination of wavelength, Wavelength difference, Refractive Index and Visibility of fringes. **(3 Lectures)**

Diffraction: Fraunhofer diffraction: Single slit; Double Slit. Multiple slits & Diffraction grating. Fresnel Diffraction: Half-period zone Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis. **(8 Lectures)**

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization. **(3 Lectures)**

Reference books:

- Principle of optics, B.K. Mathur, 1995, Gopal Printing
- Fundamentals of Optics, FA Jenkins and HE White, 1976, McGraw-Hill Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publication
- University Physics. FW Sears, MW Zemansky and HD Young 13/e, 1986. Addison-Wesley

Paper Title: Waves and Optics Lab
Paper Code: PHYMIN2024
Class: 30 Hrs. Lab class

1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify λ^2 – T Law.
3. To study Lissajous Figures
4. Familiarization with Schuster`s focusing; determination of angle of prism.
5. To determine the Coefficient Viscosity of water by Capillary Flow Method (Poiseuille's method).
6. To determine the Refractive Index of the Material of a given Prism using Sodium Light.
7. To determine Dispersive Power of the Material of a given Prism using Mercury Light
8. To determine the value of Cauchy Constants of a prism.
9. To determine the Resolving Power of a Prism.
10. To determine wavelength of sodium light using Fresnel Biprism.
11. To determine wavelength of sodium light using Newton's Rings.
12. To determine the wavelength of Laser light using Diffraction of Single Slit.
13. To determine wavelength of (1) Sodium & (2) spectrum of Mercury light using plane diffraction Grating
14. To determine the Resolving Power of a Plane Diffraction Grating.
15. To measure the intensity using photo sensor and laser in diffraction patterns of slits.

Reference books:

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

Semester 5
Paper Title: Classical Mechanics
Paper Code: PHYMAJ3014
Credit: 04 (4+0+0)
Lecture = 60

Course Objectives:

This course will teach about the motion of bodies under the influence of forces or with equilibrium of bodies when all the forces are balanced. This course develops the concepts of virtual work, D'Alemberts principle, Hamilton's principle, Lagrange formalism will help to learn how to solve the problems related to oscillatory systems, motion of rigid body, and nonlinear dynamics.

Course Outcomes:

After learning this course, students will be able to (i) understand the basic principles of classical mechanics system using Lagrange and Hamilton's formalism (ii) apply methods of classical mechanics in solving various problems of like complicated oscillatory system, motion of rigid body, nonlinear dynamics (iii) idea of transition from classical to quantum mechanical approach.

Unit I:

Classical Mechanics of Point Particles: 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- gyro radius and gyro frequency, motion in crossed electric and magnetic fields. Constraints, classification of constraints with examples, Generalised coordinates, Generalised velocities Generalised momenta. Principle of virtual work, D' Alembert's principle and its derivation.

(**8 Lecture)**

Lagrangian formulation: Variational principle. From D' Alembert's principle Lagrange's equation for conservative and non conservative system of forces. Conception of Lagrangian. Application of Lagrange's equation for calculation of Lagrangian, derivation of equation of motion for a simple physical system, compound pendulum, simple harmonic oscillator.

(10 Lecture)

Unit II:

Hamiltonian formulation: Concepts of phase space, principle of variation. Deduction of Hamilton's canonical equation from variational principle. Concept of Hamiltonian and its physical interpretation. Deduction of Hamilton's principle from D' Alembert's principle. Canonical momenta. Basic idea of Hamiltonian in quantum mechanics, Hamiltonian of simple pendulum, compound pendulum. Deduction of Hamilton's canonical equations in above cases. Euler-Lagrange equations- one-dimensional examples of the Euler-Lagrange equations- one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity.

(17 Lecture)

Unit III:

Canonical transformations: Canonical transformation equation, conditions for canonical transformation, solution of harmonic oscillator problem using canonical equation, Generating functions, Properties of canonical transformations, Infinitesimal contact transformations, Poisson brackets, Fundamental Poison Bracket, Hamilton's equation in terms of Poisson bracket, Jacobi's identity, Liouvillie's theorem.

(12 Lecture)

Unit IV:

Rigid bodies: Rigid body dynamics, Euler's theorem, concept of infinitesimal rotation, Euler's equation of motion, symmetric top motion.

(7 **Lecture)**

Small Oscillations: Theory of small oscillations, normal coordinates, normal modes, coupled oscillations, diatomic and triatomic molecules.

(6 **Lecture)**

Reference Books:

- Classical Mechanics, H. Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.
- Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
- Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
- The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
- Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
- Classical Mechanics, P.S. Joag, N.C. Rana, Megraw Hills.
- Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
- Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
- Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press

Semester 5
Paper Title: Elements of Modern Physics
Paper Code: PHYMAJ3024
Credit: 04 (3+0+1)
Lecture = 45

Course objective:
This course going to develop quantum mechanical approach from De Broglie matter wave to Quantum Tunneling. The concepts of Uncertainty principle will give fair knowledge of uncertainty of finding position and speed of a particle and wave function related to those. This course teaches about Structure of Atomic nucleus, Mass defect, Nuclear energy, and Radioactivity .

Course outcome:
After completion of this course, students will be able to understand quantum mechanical explanation of Blackbody Radiation, matter wave, photoelectric effect which give the understanding of wave-particle duality. From Uncertainty principle students will understand the relation between position and momentum of a system. The wave equation like Schrodinger equation gives the understanding of the form of the probability waves that govern the motion of small particles. In this course, students will learn about the Scattering and Tunneling effect through the potential barrier.
This course gives fair knowledge about the structure of atomic nucleus, Radioactivity, generation of energy from Fission and Fusion, and how the energy can be regulated by Nuclear reactor.

Unit I:

Blackbody Radiation, Planck's quantum, Planck's constant and light as a collection of photons, 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. **(9 Lectures)**

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. **(7 Lectures)**

Unit II:
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; Wave amplitude and wave functions, physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension. **(8 Lectures)**

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potential barrier.

(6 Lectures)

Unit III:

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. **(4 Lectures)**

Radioactivity: 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. **(7 Lectures)**

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). **(4 Lectures)**

Note: Educational visit to the research institution and laboratories of National importance of India (eg. SINP, BARC, VECC, IUAC, CAT, ISER etc.)
A field visit report must be submitted as a part of internal evaluation.

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
- 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

Paper Title: Elements of Modern Physics Lab
Paper Code: PHYMAJ3024
Class: 30 Hrs. Lab class

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

- 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.

Semester 5
Paper Title: Digital System and Applications (Electronics -II)
Paper Code: PHYMAJ3034
Credit: 04 (3+0+1)
Lecture = 45

Course Objectives:

This course in physics curriculum is framed to introduce the concept of Boolean algebra and the basic digital electronics. In this course, students will be able to understand the working principle of CRO, Data processing circuits, Arithmetic Circuits, sequential circuits like registers, counters etc. based on flip flops. In addition, students will get an overview of microprocessor architecture and programming.

Course Outcomes:

Upon successful completion of this course, students will be able to:

- *Gain both theoretical and experimental knowledge about digital electronics.*
- *Understand computer architecture.*
- *Verify and design various logic gates.*
- *Write programs using 8085 microprocessor.*

Unit I:
Introduction to CRO: Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: Study of Waveform, Measurement of Voltage, Current, Frequency, and Phase Difference. **(3 Lectures)**

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.
(3 Lectures)

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. **(4 Lectures)**

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.
(5 Lectures)

Unit II:
Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.
(2 Lectures)

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full

Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor.

(3 Lectures)

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.

(4 Lectures)

Timers: IC 555: block diagram and applications: Astable multivibrator, Monostable and bi-stable multivibrator. **(3 Lectures)**

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). **(2 Lectures)**

Unit III:

Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

(3Lectures)

Computer Organization: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.

(4 Lectures)

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.

(6 Lectures)

Introduction to Assembly Language: 1 byte, 2 byte & 3 byte instructions. **(3 Lectures)**

Reference books:

- Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw
- Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Digital Electronics G K Kharate ,2010, Oxford University Press
- Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
- Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
- Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

Paper Title: Digital System and Applications (Electronics -II) Lab
Paper Code: PHYMAJ3034
Class: 30 Hrs. Lab class

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, 4th 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 5
Paper Title: Electromagnetic Theory
Paper Code: PHYMAJ3044
Credit: 04 (3+0+1)
Lecture = 45

Course Objective:

This course has been designed from review of Maxwell's electromagnetic equations and propagations in bound and unbound media. It also includes the phenomenon of polarization of electromagnetic waves in detail.

Course Outcome:

The students are expected to conceptualize and able to solve

1) *Problems in bound and unbound media applying Maxwell's equations.*
2) *To learn the method of production of different types of polarization of Electromagnetic waves.*
3) *The nature of Propagation of light in different crystal structures.*
4) *To understand optical rotation calculation of angle of ration.*
5) *To learn Laurent's half shade polarimeter.*

Unit I:

Maxwell 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 Lectures)

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 Lectures)**

Unit II:

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 Lectures)**

Unit III:

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. 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. **(10 Lectures)**

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. **(5 Lectures)**

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
- 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

Paper Title: Electromagnetic Theory Lab
Paper Code: PHYMAJ3044
Class: 30 Hrs. Lab class

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, 4^{th} Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11^{th} Ed., 2011, Kitab Mahal
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Semester 5
Paper Title: Mathematical Physics
Paper Code: PHYMIN3014
Credit: 04 (3+0+1)
Theory: 45 Lecture

Course Objectives:

This course is designed to involve students to learn a few essential portions of mathematics which are readily used in physics. Broadly it incorporates differential equations of various kinds, the Frobenious method and its application in differential equations, and Partial differential equations. This paper also gives the idea of the Fourier series and its application and a good portion of Complex Analysis.

Course Outcomes:

After the completion of this course, the students will be able -

- *To do partial derivatives.*
- *To expand periodic functions in a series of sine and cosine functions and be able to determine Fourier Coefficients*
- *To expand functions with arbitrary periods and also the non-periodic functions.*
- *To apply Frobenius methods in differential equations.*
- *Understand Legendre, Bessel, Hermite, and Laguerre Differential Equations.*
- *To learn Beta and Gamma functions and the relation between them.*
- *To learn to apply Laplace's equation in problems of rectangular, cylindrical, and Spherical symmetry and Finally*
- *To learn briefly complex analysis*

Unit I:

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. **(5 Lectures)**

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.

(8 Lectures)

Unit II:

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, Orthogonality. Simple recurrence relations.

(11 Lectures)

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

(3 Lectures)

Unit III:

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. **(8 Lectures)**

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.

(10 Lectures)

Reference books:

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- An Introduction to Ordinary Differential Equations, Earl A Coddington, 1961, PHI Learning.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Essential Mathematical Methods, K.F. Riley and M.P. Hobson, 2011, Cambridge University Press
- Partial Differential Equations for Scientists and Engineers, S.J. Farlow, 1993, Dover Publications.
- Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Books.

Paper Title: Mathematical Physics Lab
Paper Code: PHYMIN3014
Class: 30 Hrs. Lab class

- Highlights the use of computational methods to solve physical problems
- Useofcomputerlanguageasatoolinsolvingphysicsproblems(applications)
- The course will consist of lectures (both theory and practical) in the Computer Lab
- Evaluation done not on the programming but on the basis of formulating the problem
- Aim at teaching students to construct the computational problem to be solved
- Students can use any one operating system Linux or Microsoft Windows

Topics	**Description with Applications**
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow-emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
Review of & C++ Programming fundamentals C	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (*If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While-Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops*), Arrays (*1D&2D*) and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs: using C/C++ language	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending-descending order, Binary search
Random number generation	Area of circle, area of square, volume of sphere,value of pi (**π**)
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving $\alpha = \tan\alpha$; $I = I_0 \left(\frac{\sin \propto}{\propto}\right)^2$ in optics
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. *sinθ, cosθ, tanθ, etc.*
Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given Position with equidistant time data to calculate velocity and acceleration and vice-versa. Find the data B-H Hysteresis loop.

Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods	First order differential equation ● Radioactive decay ● Current in RC, LC circuits with DCsource ● Newton's law of cooling ● Classical equations of motion Attempt following problems using RK 4 order method: ● Solve the coupled differential equations; $\frac{dx}{dt} = y + x - \frac{x^3}{3}$; $\frac{dy}{dx} = -x$ for four initial conditions x(0) = 0, y(0) = -1, -2, -3, -4. Plot x vs y for each of the four Initial conditions on the same screen for $0 \le t \le 15$ • The differential equation describing the motion of a pendulum is $\frac{d^2\nu}{dt^2} = -\sin(\nu)$ The pendulum is released from rest at an angular displacement α, i. e. υ(0)= α and υ′(0)=0. Solve the equation for α = 0.1, 0.5 and 1.0 and plot υ as a function of time in the range $0 \le t \le 8\pi$. Also plot the analytic solution valid for small υ (sin(υ)= υ)

Reference books:

- Introduction to Numerical Analysis, S.S. Sastry, 5thEdn., 2012, PHI Learning Pvt. Ltd.
- Schaum's Outline of Programming with C++. J.Hubbard, 2000, McGraw-Hill Publications.
- Numerical Recipes in C++: The Art of Scientific Computing, W.H. Pressetal., 3rdEdn., 2007, Cambridge University Press.
- A first course in Numerical Methods, Uri M. Ascher and Chen Greif, 2012, PHI Learning
- Elementary Numerical Analysis, K.E. Atkinson, 3 rdEdn . , 2 007,Wiley India Edition.
- Numerical Methods for Scientists and Engineers, R.W. Hamming, 1973, Courier DoverPub.
- An Introduction to Computational Physics, T. Pang, 2ndEdn., 2006, Cambridge Univ.Press

Semester 6
Paper Title: Quantum Mechanics -I
Paper Code: PHYMAJ3054
Credit: 04 (3+0+1)
Lecture = 45

Course Objective:
The course has been introduced with a view to acquaint the students of physics major for smooth journey of quantum world starting from basics to applications.
Course Outcome:
At the completion of the course, students are expected to solve

I. *Time independent and time dependent Schrodinger equations and simple problems related to those for arbitrary potential and various coordinate systems.*
II. *The Eigen function and Eigen values of a wave function.*
III. *Normalization and orthogonality conditions of a given wave function.*
IV. *Hydrogen atom and similar atoms by applying Quantum Mechanical Principles.*

Unit I:
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 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.
(8 Lectures)

Unit II:
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. **(12 Lectures)**

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. **(13 Lectures)**

Unit III:
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. **(12 Lectures)**

Reference books:

- A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
- Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
- Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

Paper title: Quantum Mechanics – I Lab

Paper code: PHYMAJ3054

Class: 30 Hrs. Lab class

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:

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

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is $\approx$-13.6 eV. Take e = 3.795 $(eVÅ)^{1/2}$, ħc=1973 (eVÅ) and m = 0.511×10^6 eV/c^2.

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

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

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 = 0.511×10^6 eV/c^2, and *a* = 3 Å, 5 Å, 7 Å. In these units ħc = 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:

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

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:

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

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

$$V(r) = D\left(e^{-2\alpha r'} - e^{-\alpha r'}\right), \quad r' = (r - r_0)/r$$

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 = 940×10^6eV/C^2, D = 0.755501 eV, α = 1.44, r_o = 0.131349Å

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

Semester 6

Paper Title: Solid State Physics - I

Paper Code: PHYMAJ3064

Credit: 04 (3+0+1)

Lecture = 45

Course Objective:

The course is a building block of Solid State, it has been designed to take care of the formation, structure, electrical and magnetic, thermal properties of solids.

Course Outcome:

At the completion of the course, students are expected to:

1) *Grasps the idea of formation of a solid.*
2) *The classical explanation of specific heats of solids at high temperatures.*
3) *And conceptualize the existence of properties of magnetism in solids.*
4) *By quantum theory of solids at low temperatures.*
5) *To classify crystals, piezo and pyroelectric effects etc.*

Unit I:

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. **(12 Lectures)**

Unit II:

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 Lectures)

Unit III:

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. **(8 Lectures)**

Unit IV:

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. **(9 Lectures)**

Unit V:

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. **(6 lectures)**

Reference books:

- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
- Solid State Physics, Rita John, 2014, McGraw Hill
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications

Paper title: Solid State Physics – I Lab
Paper code: PHYMAJ3064
Class: 30 Hrs. Lab class

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.

- 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 6
Paper Title: Nuclear and Particle Physics - I
Paper Code: PHYMAJ3074
Credit: 04 (4+0+0)
Lecture = 60

Course Objective:

The goal of the course is to impart knowledge on basic nuclear properties, nuclear models, nuclear reaction and decays. It also highlights the basic principles of radiation detection, particle accelerators and fundamental concepts of particle physics.

Course Outcome:
The students are expected to
1) *Revise and retain the contents of the basic properties of nuclei.*
2) *predict nuclear stability using nuclear models.*
3) *Learn the process of radioactive decay, nuclear reactions, interaction of nuclear radiation with matter.*
4) *Learn about basic outlines of Particle Physics from conservation laws to quark model.*

Unit I:
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.
(8 Lectures)

Unit II:
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. **(10 Lectures)**

Unit III:
Radioactivity decay:(a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. (**8 Lectures)**

Unit IV:
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). **(6 Lectures)**

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.
(6 Lectures)

Unit V:
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. **(8 Lectures)**

Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. **(4 Lectures)**

Unit VI:
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. **(10 Lectures)**

Reference books:

- Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
- Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
- Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
- Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
- Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
- Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004).
- Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
- Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
- Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991)

Semester 6
Paper Title: Mathematical Physics - III
Paper Code: PHYMAJ3084
Credit: 04 (3+0+1)
Lecture = 45

Course Objectives:
The course is designed to familiarise the students with the concepts complex analysis, Fourier and Laplace transforms and their applications.

Course outcome*: Students who successfully complete the course will be able to:*
1. *Use the residue theorem to calculate complex integrals*
2. *Apply Fourier and Laplace transforms to solve differential equations.*

Unit-I
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 Integrals.

(23 Lectures)

Unit-II
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.

(10 Lectures)

Unit-III
Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1^{st} and 2^{nd} 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 2^{nd} order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1^{st} order. Solution of heat flow along infinite bar using Laplace transform.

(12 Lectures)

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3^{rd} ed., 2006, Cambridge University Press
- Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
- Complex Variables, A.S.Fokas & M.J.Ablowitz, 8^{th} Ed., 2011, Cambridge Univ. Press
- Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
- Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7^{th} Ed. 2003, Tata McGraw-Hill
- First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett

Paper title: Mathematical Physics – III Lab
Paper code: PHYMAJ3084
Class: 30 Hrs. Lab class

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

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 σ=1, 0.1, 0.01 and show it tends to 5.

3. Fourier Series: Program to Sum: Summation n=1 to infinity (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. $sin\ \theta$, 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 exp(-x^2)

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

Semester 6
Paper Title: Elements of Modern Physics
Paper Code: PHYMIN3024
Credit: 04 (3+0+1)
Theory: 45 Lecture

Course Objectives:

This paper broadly comprises of Quantum Mechanics and Nuclear Physics. It aims to set a picture of the evolution of Quantum mechanics in the minds of students. It explains how light satisfies both wave and particle nature and why the concept of wave-particle duality is adopted. It is designed to introduce the idea of matter waves and the concept of wave function. The Nuclear physics part of this paper gives a clear idea of the Nucleus and thereby explains the phenomena of radioactivity in detail.

Course Outcomes
At the end of this course, students will be able–

I. *To learn proof particle nature of light.*
II. *To learn wave is associated with moving matter.*
III. *To justify why matter waves are not easily recognisable.*
IV. *To learn the need for the concept of wavefunction.*
V. *To learn Schordingers wave equations and their importance.*
VI. *To understand the Nucleus and its various properties.*
VII. *To learn Radioactivity in detail.*
VIII. *To learn the processes of generation of Nuclear energy.*

Unit - I
Planck's quantum, Planck's constant and lights collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer Experiment
(**6 Lectures)**

Problems with Rutherford model-instability atomsan observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atom and their spectra. **(4 Lectures)**

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.
(4 Lectures)

Unit - II
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 wavefunction.
(**8 Lectures)**

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization.
(02 Lectures)

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 ofnuclear force,NZgraph.
(6 Lectures)

Unit - III

Radioactivity: stability of nucleus; Law of radioactiv e decay; Mean life & half-life; α decay; β decay - energy released, spectrum and Pauli's prediction of neutrino; γ-ray emission.

(10 Lectures)

Fission an dfusion-massdeficit relativity and generation of energy; Fission-nature of Fragments and emission of neutrons. Nuclear reactor slow neutrons interacting with Uranium235;Fusion and thermonuclear reactions. **(5 Lectures)**

Reference books:

- Concepts of Modern Physics, Arthur Beiser, 2009,McGraw-Hill
- Modern Physics, John R. Taylor, Chris D. Zafiratos, Michael A.Dubson,2009,PHI Learning
- Six Ideas that Shaped Physics: Particle Behave like Waves, Thomas A. Moore, 2003, McGrawHill
- Quantum Physics, Berkeley Physics Course Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill Co.
- Modern Physics, R.A. Serway, C.J. Moses, and C.A. Moyer, 2005, Cengage Learning
- Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill

Paper title: Elements of Modern Physics Lab
Paper code: PHYMIN3024
Class: 30 Hrs. Lab class

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine value of Planck’s constant using LEDs of at least 4 different colours.
4. To determine the ionization potential of mercury.
5. To determine the wavelength of-alpha emission line Hydrogen atom.
6. To determine the absorption lines in the rotational spectrum of Iodine vapour.
7. To study the diffraction patterns of single and double lits using laser source and measure its intensity variation using Photosensor and compare with incoherent source – Na light.
8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
9. To determine the value of e/m by magnetic focusing.
10. To set up the Millikan oil drop apparatus and determine the charge of an electron.

Reference books:

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

Semester 7
Paper Title: Advanced Statistical Mechanics
Paper Code: PHYMAJ4014
Credit: 04 (3+0+1)
Lecture = 45

Course Objective:
This course has been designed to give the students ample apatite to take up research in the field of Phase transitions, quantum fluctuations, non-equilibrium processes.

Course Outcome:
The students are expected to…

I. *Motivate to take up research in their undergraduate course in phase transitions, quantum fluctuations having acquired sound knowledge about them.*
II. *Learn in depth non-equilibrium processes.*
III. *Learn about Ising model and their applicability.*

Review of 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 `

(2 Lectures)

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 Lectures)

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.

(14 Lectures)

Fluctuations Thermodynamic fluctuations, Gaussian distribution, random walk and Brownian motion, approach to equilibrium, Fokker-Planck equation; introduction to non-equilibrium processes.

(7 lectures)

Phase transition: Formulation of the problem, the theory of Lee and Yang. First and second order phase transitions; diamagnetism, paramagnetism and ferromagnetism; Liquid Helium, Two fluid hydrodynamics, second sound, theories of Landau andFeynman.

(8 lectures)

Advanced topics: Ising model: partition function for one dimensional case; Chemical equilibrium and Saha ionisation formula. **(4 lectures)**

Reference Book:

- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
- Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
- Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
- 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
- An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

Paper title: Advanced Statistical Mechanics Lab
PHYSICS -: PHYMAJ4014
Class: 30 Hrs Lab class

Use C/C^{++}/Scilab/python and 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 C_v, 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, 3 rd Edn . 20 07, 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

Semester 7
Paper Title: Atomic and Molecular Physics
Paper Code: PHYMAJ4024
Credit: 04 (4+0+0)
Lecture = 60

Course Objective:
The course has been designed to provide idea on atomic and molecular structure, various interaction phenomena inside atoms and molecules. It also intends to provide ideas concerning various aspects of fibre optics

Course Outcome:
The students are expected to
1) *Get the evidence of stability of atoms by studying various atomic models.*
2) *use spectroscopic techniques to identify elements present in a sample*
3) *Learn about the effect of electric and magnetic fields on atoms*
4) *Learn about spectra generated due to molecular behavior*
5) *Have the idea of optical fibres, their properties and principle of propagation of electromagnetic waves through optical fibres*

Unit I
Problems with Rutherford model, Hydrogen and Alkai Spectra: Series in hydrogen, Bohr's correspondence principle, Sommerfeld model, Vector atom model, space quantization, Stern Gerlach experiment and intrinsic spin of electron. Spectra of sodium atom. Doublet structure of D lines of sodium, coupling schemes: L-S, j-j and intermediate coupling, alkali spectra, fine and hyperfine structure in alkali spectra, Magnetic moment of electron, Lande g factor, selection rules, Lande's interval rule, intensity rules, regularities in complex spectra, Pauli exclusion principle, shell structure, Hund's rule, spectral terms from two equivalent electrons. **(15 lectures)**

Unit II
Normal and anomalous Zeeman effect, Zeeman patterns of sodium and mercury, Paschen Back effects, Stark effect in hydrogen, hyperfine structure and determination of nuclear spin and nuclear g factors, radiative transition probabilities, line width: Doppler broadening, natural broadening, collision broadening and Stark broadening, X-Ray: Continuous and Characteristic X-rays, Mosley's law and its explanation from Bohr theory. **(15 lectures)**

Unit III
Rigid rotator- energy levels, spectrum, intensity of rotational lines, energy levels, eigenfunctions, transition probabilities and selection rules, spectrum, Nonrigid rotator- energy levels, spectrum, isotope effect on rotational spectra.
Born and Oppenheimer approximation, Vibration of diatomic molecules, harmonic oscillator, energy levels, anharmonicity, Rotation-vibration spectra of diatomic molecules, PQR branching, isotope effect in vibrational bands, Frank-Condon principle. **(15 lectures)**

Unit IV
classical and Quantum theory of Raman Effect, Vibrational Raman spectra, Stokes and anti-Stokes lines, rotational Raman spectra, Infra red spectra vs Raman spectra, Applications of Raman effect
Advantages of optical fibre communication, ray theory transmission, modes in planar guide, step index fibre, graded index fibre, single mode, multimode step index fibre, transmission characteristics-attenuation, material absorption loss, scattering loss, dispersion, couplers and connectors.
(15 lectures)

Reference Books:

1. Atomic Spectra: H.E. White (McGraw Hill) 1934.
2. Fundamentals of Molecular spectroscopy: Banwell and McCash (Tata McGraw Hill), 1994.
3. Physics of Atoms and Molecules, BH Bransden, CJ Joachain, Pearson, 2013
4. Atomic Spectra − JB Rajam , S Chand & Company Ltd.
5. Atomic & Molecular Spectra: Laser, Raj Kumar, Kedar Nath Ram Nath
6. Molecular Structure and Spectroscopy, G Aruldhas, PHI Learning Pvt Ltd, Delhi
7. Atomic, Molecular and Photons, Wolfgang Damtrodes (Springer), 2010.
8. Molecular Spectra and Molecular Structure I: G. Herzberg (Van-Nostrand Rein-hold), 1950.
9. Optical Fiber Communications Principles and Practice − John M. Senior, M. Yousif Jamro, Pearson

Semester 7
Paper Title: Quantum Mechanics - II
Paper Code: PHYMAJ4034
Credit: 04 (3+0+1)
Lecture = 45

Course Objective:

In this course students would be exposed to some advanced concepts in both non-relativistic and relativistic quantum mechanics and their applications to solve problems of the subatomic world.

Course outcome:

After learning this course, the learners will be able to (a) solve Schrodinger's equation for bound state problems and calculate the tunnelling probability through a potential barrier (b) use Dirac's bra-ket algebra to derive generalized uncertainty principle and solve 1D harmonic oscillator problem (c) compare the different pictures in Quantum Mechanics (d) apply various approximation methods such as time-independent perturbation theory, variational principle and WKB approximation to solve quantum mechanical problems whose exact solutions are unavailable (e) write KG equation for spinless particles.

Course Contents:

Schrödinger's Equation and its application: Wave function and its physical interpretation, time-independent and time-dependent Schrödinger's equation, applications of Schrödinger equation: Particle in a box, tunnelling through a barrier, motion in a central potential (Hydrogen atom).

(09 lectures)

Operator method in Quantum Mechanics: Introduction to linear vector space, Hilbert space, observables and operators, Dirac notations– Properties of state vectors – Ket and Bra vectors, Orthogonal and Orthonormal states. Projection Operators, Commutator Algebra, Uncertainty principle for two arbitrary operators, one dimensional linear harmonic oscillator problem by operator method.

(10 lectures)

Time evolution of states: Evolution of states, unitary time evolution operator, Schrodinger and Heisenberg pictures. Heisenberg's equation of motion, Dirac interaction picture, Ehrenfest theorem.

(6 lectures)

Approximation Methods: Time independent perturbation theory: First and second order corrections to the energy eigenvalues; First order correction to the eigenvector; Degenerate perturbation theory; Applications to Zeeman Effect, isotopic shift and Stark effect. Variational methods and its applications. Wentzel - Kramers - Brillouin (WBK) Method and its application.

(12 lectures)

Relativistic Quantum Mechanics: Concept of four-vectors in special theory of relativity and covariant forms in four dimensional Minkowski space, natural units and conversion factors; Relativistic Klein-Gordon equation, its physical significance and drawbacks. **(8 lectures)**

Reference Books:

- Introduction to Quantum Mechanics – David J Griffiths (2nd Ed. Pearson)
- Principles of Quantum Mechanics– R. Shankar (3rd Ed. Springer)
- Quantum mechanics – A. Ghatak and S. Lokanathan (Springer)

- Quantum Mechanics – Concepts and Applications N. Zettili (2nd Ed. Wiley)
- Quantum mechanics – G. Auletta, M. Fortunato, G. Parisi (Cambridge Univ. Press)
- Quatum Mechanics: An Introduction – Walter Greiner (4th Ed. Springer)
- Modern Quantum Mechanics – J .J. Sakurai (2nd Ed. Pearson)
- The Principles of Quantum Mechanics –P. A. M. Dirac (B.N. Publishing)
- The Feynman Lectures on Physics –R. Feynman, R. Leighton and M. Sands
- Quantum Mechanics –C. Cohen-Tannoudji, B. Diu, and F. Lalo. (2nd Ed., Wiley-VCH)
- Modern Particle Physics - Mark Thomson (Cambridge University Press)

Paper title: Quantum Mechanics- II Lab
Paper code: PHYMAJ4034
Class: 30 Hrs. Lab class

Scilab/ C++/Python based simulations experiments based on Quantum Mechanics problems like

1. Solve Schrodinger equation for a particle in a symmetric finite square well given by $V(x) = 0$ for $|x| \leq 5$ and $V(x) = 10$ for $|x| > 5$ and plot first five the lowest-energy Eigen functions of the particle and the corresponding density probabilities.
2. Solve Schrodinger equation for a quantum mechanical oscillator and plot first five the lowest-energy eigenfunctions of the particle and the corresponding density probabilities.

Semester 7
Paper Title: Astronomy and Astrophysics
Paper Code: PHYMAJ4044
Credit: 04 (4+0+0)
Lecture = 60

Course Objective:
The main objective of this paper is to

i) *Familiarize and appreciate the field of astronomy and Astrophysics.*
ii) *Prepare graduates with strong foundation to pursue advanced degree in Astronomy and Astrophysics.*
iii) *Give a brief idea of subject content, e.g. the classification of stars, stellar evolution, interstellar matter, galaxies, different measuring tools, physical and chemical principles involved etc.*

Course outcome:
We expect that after completion of this paper, students will:

i) *Acquire knowledge of the Astronomical scales.*
ii) *Learn about important physical quantities: luminosity, astrometry, colour, distance, spectral energy distribution, age, etc. learn to use Hertzsprung –Russell diagram.*
iii) *Learn about the Sun and Solar system.*
iv) *Attain the knowledge of evolution, classification, formation of stars, including stellar interiors and atmospheres, nucleosynthesis and late stages of stellar evolution. Learn theory of interstellar medium and their role in formation of star.*
v) *Understand the physics governing the life-cycle of stars, from initial gravitational collapse, through main-sequence nuclear fusion, and eventually to end-products such as black holes and neutron stars.*
vi) *Familiarize with the structure and population of the Milky Way galaxy, properties of galaxies and its classifications. Describe the types of galaxies that comprise the universe on large-scales, and how they develop and interact through known physical processes.*
vii) *Learn about the Active Galaxies, their behaviours and importance.*
viii) *Acquire a basic understanding about large scale structures and expanding universe*

Unit - I

Astronomical Scales: Astronomical Distance, Mass and Time, Scales, Brightness, Radiant Flux and Luminosity, Measurement of Astronomical Quantities Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature. Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars: Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell Diagram.

(12 Lectures)

Astronomical techniques: Basic Optical Definitions for Astronomy (Magnification Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of

Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of Detectors, detection Limits with Telescopes).

(4 Lectures)

Unit - II

Physical principles: Gravitation in Astrophysics (Virial Theorem, Newton versus Einstein), Systems in Thermodynamic Equilibrium, Theory of Radiative Transfer (Radiation Field, Radiative Transfer Equation), Optical Depth; Solution of Radiative Transfer Equation, Local Thermodynamic Equilibrium. **(6 Lectures)**

The sun (Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity, Basics of Solar Magnetohydrodynamics. Helioseismology). **The solar family** (Solar System: Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets. **(4 Lectures)**

Stellar spectra and classification Structure (Atomic Spectra Revisited, Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification) **(5 Lectures)**

Stellar structure: Hydrostatic Equilibrium of a Star, Some Insight into a Star: Virial Theorem, Sources of Stellar Energy, Modes of Energy Transport, Simple Stellar Model, Polytropic Stellar Model. Star formation: Basic composition of Interstellar medium, Interstellar Gas, Interstellar Dust, Formation of Protostar, Jeans criterion, Fragmentation of collapsing clouds, From protostar to Pre-Main Sequence, Hayashi Line. **(6 Lectures)**

Unit -III

Nucleosynthesis and stellar evolution: Cosmic Abundances, Stellar Nucleosynthesis, Evolution of Stars (Evolution on the Main Sequence, Evolution beyond the Main Sequence), Supernovae. Compact stars: Basic Familiarity with Compact Stars, Equation of State and Degenerate Gas of Fermions, Theory of White Dwarf, 51 Chandrasekhar Limit, Neutron Star (Gravitational Red-shift of Neutron Star, Detection of Neutron Star: Pulsars), Black Hole. The milky way: Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus.

(8 Lectures)

Galaxies: Galaxy Morphology, Hubble’s Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms, Active Galaxies. **(4 Lectures)**

Active galaxies: ‘Activities’ of Active Galaxies, How ‘Active’ are the Active Galaxies? Classification of the Active Galaxies, Some Emission Mechanisms Related to the Study of Active Galaxies, Behaviour of Active Galaxies (Quasars and Radio Galaxies, Seyferts, BL Lac Objects and Optically Violent Variables), The Nature of the Central Engine, Unified Model of the Various Active Galaxies.

(6 Lectures)

Large scale structure & expanding universe: Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble’s Law (Distance- Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter), Friedmann Equation and its Solutions, Early Universe and Nucleosynthesis (Cosmic Background Radiation, Evolving vs. Steady State Universe) **(5 Lectures)**

Note: Educational visit to the research institution and laboratories of National importance of India (eg. IUCAA, ARIES etc.)
A field visit report must be submitted as a part of internal evaluation.

Reference Books:

- Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
- Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
- The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.
- Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
- K.S. Krishnasamy, 'Astro Physics a modern perspective,' Reprint, New Age International (p) Ltd, New Delhi,2002.
- Baidyanath Basu, 'An introduction to Astro physics', Second printing, Prentice - Hall of India Private limited, New Delhi,2001.
- Text book of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

Semester 7
Paper Title: Research Methodology
Paper Code: PHYREM4044
Credit: 04 (4+0 +0)
Lecture = 45

Course Objective:
The objective of the course is to familiarise the students with the concepts of research, research design, ethics of research and consequences of plagiarism and how to write technical reports and papers.

Course Outcome:
After this course, the candidates will have basic concepts of research, research design, organize and conduct research more appropriate way and able to write research report, thesis, project proposals. The candidates will have proper idea about research ethics, plagiarism and its tools.

Unit I: Research Methodology: An introduction
Research concept, identification of research problem, Meaning of Research, Objectives of Research Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Research Process, Criteria of Good Research.
(10 Lecture)

Unit II: Research Design
Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs. **(7 Lecture)**

Unit III: Scientific Writing
Forms of scientific writing i.e. research articles, notes, report, review, monograph, dissertation/thesis, popular article etc. components of research article, writing strategy for a research article.
Communicating Research Results: Journal paper – types of available publishing services; Research proposal, Report, Thesis; Presentation in Seminar and conference; Journal abbreviations, Bibliography standards; Indices of quality assessment of publications. **(11 Lecture)**

Unit IV: Intellectual Property Right
Introduction to IPR, Patent laws, process of patenting a research finding, copyright, cyber laws.
(4 Lecture)

Unit V: Philosophy and Ethics
Introduction to philosophy: definition, nature and scope, concept, branches, Ethics: definition, moral philosophy, nature of moral judgements and reactions. **(5 Lecture)**

Unit - VI: Scientific Conduct
Ethics with respect to science and research, Intellectual honesty and research integrity, Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP), Redundant publications: duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data.
(8 Lecture)

***Reference books*:**

- Kothari, C R. *Research Methodology Methods and Techniques* (New Age International Publishers, New Delhi, 2009).
- Ackoff, Russell L. *The Design of Social Research* (Chicago Press, 1961).
- Ackoff, Russell L. *Scientific Method* (New work: John Wiley & Sons,1962).
- Bird, A. (2006). *Philosophy of Science.* Routledge.
- MacIntyre, Alasdair (1967) *A Short History of Ethics.* London.
- P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN:978- 9387480865
- Indian National Science Academy (INSA), Ethics in Science Education,
- Research and Govemance (2019), ISBN:978-81-939482-l-7
- Pruzan and Pete. Research Methodology: The Aims, Practices and Ethics of Science
- Fundamentals of Research Methodology and Statistics, Yogesh Kumar Singh (New Age International Publisher)

Semester 7
Paper Title: Electronics and Astrophysics
Paper Code: PHYMIN4014
Credit: 04 (3+0+1)
Theory: 45 Lecture

Electronics:

Course Objective:

This course offers the basic knowledge to students to design and analyse network circuit analysis and analog electronics. It gives the concept of voltage, current sources, and various electrical network theorems, the physics of semiconductor devices including junction diode, bipolar junction transistors, and unipolar devices, and their applications are discussed in detail. This also develops the understanding of amplifier and their applications.

Course Outcome:

At the end of this course, students will be able to achieve the following learning outcomes-

• To develop an understanding of the basic operation and characteristics of different types of diodes and familiarity with their working and applications.
• To be able to recognize and explain the characteristics of a PNP or NPN transistor.
• Become familiar with the load-line analysis of the BJT configurations and understand the hybrid model (h- parameters) of the BJT transistors.
• To be able to perform a small signal analysis of the Amplifier and understand its classification.
• To be able to understand the building blocks of digital electronics along with their applications.

Astrophysics:

Course Objectives:

This course is meant to introduce undergraduate students to the wonders of the Universe. Students will understand how astronomers over millennia have come to understand mysteries of the universe using laws of geometry and physics. This paper aims to give a brief idea of the different sections of astrophysics starting from the Astronomical scale and positional astronomy to the formation of stars, the Galaxy, and its types.

Course Outcome:

After completing this course, students will gain an understanding of:

- *Different types of telescopes, the diurnal and yearly motion of astronomical objects, astronomical coordinate systems and their transformations*
- *Brightness scale for stars, types of stars, their structure, and evolution on HR diagram*
- *Components of the solar system*
- *The basic structure of different galaxies and rotation of the Milky Way galaxy*
- *The process of star formation and its evolution with time.*
- *The galaxies, their types, and about the milky way*

Unit - I: Electronics:

Semiconductor Devices and Amplifiers: Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased PN Junction Diode. PN junction and its characteristics. Static and Dynamic Resistance. Principle and structures of (1) LEDs, (2) Photodiode, (3) Solar Cell.

(4 Lectures)

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 & Q-point. Active, Cutoff & Saturation regions. Voltage Divider Bias Circuit for CE Amplifier. Transistor as two port network, h-parameter Equivalent Circuit. Analysis of single-stage CE amplifier using hybrid Model. Input & output Impedance. Current, Voltage and Power gains. Class A, B & C Amplifiers. **(8 Lectures)**

Digital Circuits: Difference between Analog and Digital Circuits. Binary Numbers. Conversion from Decimal to Binary and Binary to Decimal, AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates. De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra.
(3 Lectures)

Unit - II: Astrophysics:

Astronomical Scales: Astronomical Distance, Mass and Time, Scales, Brightness, Radiant Flux and Luminosity, Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature.
(3 Lectures)

Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time: Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Determination of Distance by Parallax Method; Hertzsprung-Russell Diagram. **(6 Lectures)**

Astronomical techniques: Basic Optical Definitions for Astronomy (Magnification Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings. **(4 Lectures)**

The sun: Solar Parameters, Solar Photosphere, Solar Atmosphere, chromosphere. Corona, Solar Activity, Basics of Solar Magnetohydrodynamics. **(3 Lectures)**

Stellar structure: Hydrostatic Equilibrium of a Star, Virial Theorem, Sources of Stellar Energy, Modes of Energy Transport, Simple Stellar Model, Polytropic Stellar Model. **(4 Lectures)**

Star formation: Basic composition of Interstellar medium, Interstellar Gas, Interstellar Dust, Formation of Protostar, Jeans criterion, Fragmentation of collapsing clouds, From protostar to Pre-Main Sequence, Hayashi Line. **(4 Lectures)**

Galaxies: Galaxy Morphology, Hubble's Classification of Galaxies,The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms, Active Galaxies. **(3 Lectures)**

The milky way: Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus **(3 Lectures)**

Reference books (Electronics)

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronic devices & circuits, S. Salivahanan& N.S. Kumar, 2012, Tata Mc-Graw Hill
- Microelectronic Circuits, M.H. Rashid, 2 ndEdn., 2011, Cengage Learning.
- Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper, 1990, PHI Learning
- Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7 th Ed., 2011, Tata McGraw Hill
- Fundamentals of Digital Circuits, A. Anand Kumar, 2 nd Edition, 2009, PHI Learning Pvt. Ltd.
- OP-AMP & Linear Digital Circuits, R.A. Gayakwad, 2000, PHI Learning Pvt. Ltd.

Reference Books (Astrophysics):

- Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
- Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4 th Edition, Saunders College Publishing.
- The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.
- Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
- K.S. Krishnasamy, ‘Astro Physics a modern perspective,’ Reprint, New Age International (p) Ltd, New Delhi,2002.

Semester 7
Paper Title: Electronics and Astrophysics LAB
Paper Code: PHYMIN4014
Class: 30 Hrs. Lab class

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.

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, 4th 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 8
Paper Title: Laser and Non-linear Optics
Paper Code: PHYMAJ4054
Credit: 04 (4+0+0)
Lecture = 60

Course Objective:
The objective of the course is to familiarise the students with optical phenomena, different concepts related laser physics, ideas related to various concept of non linear optics
Course outcome:
After successfully completing the course, student will be able to:

- *Interaction of electromagnetic radiation with matter*
- *Understand the basic lasing mechanism, types of Lasers, characteristics of Laser Light,*
- *Understand and appreciate the applications of Lasers in various fields.*
- *Learn the basic principles of non linear spectroscopy*
- *Familiarize with recent developments in Laser Spectroscopy*

Unit I

Introduction to Laser: Spontaneous and Stimulated Emission, Absorption of radiation, Main features of a laser: Directionality, high intensity, monochromaticity, high degree of coherence, spatial and temporal coherence, Einstein's coefficients and possibility of amplification, Population inversion, resonant cavity, laser resonators-longitudinal and transverse cavity modes,

(10 Lectures)

Laser pumping: optical and electrical pumping Laser rate equation, Q factor, threshold condition for laser oscillation, Three and Four level lasers. **(5 Lecture)**

Unit II
Laser System: Ammonia Maser, Principle, construction & working of Ruby Laser, He-Ne Laser, Semiconductor junction Laser, N_2-Laser, CO_2 laser. Nd:YAG laser, Q-switched lasers, mode locking of lasers, Applications of lasers- in material processing (Drilling, Cutting, Welding), Industry and Military, Medical Science, communication, Atmospheric optics, industry, Holography

(10 Lectures)

Laser Raman Spectroscopy: Tunable Raman lasers, Coherent Anti-Stokes Raman Spectroscopy, (CARS), hyper Raman effect, inverse Raman scattering, Applications of Laser Raman Spectroscopy.

(5 Lectures)

Unit III:
Nonlinear Optics: Nonlinearities of the polarization, generation of second harmonic, D.C., sum and difference frequency generation, anharmonic oscillator model, Miller's rule, coupled amplitude equations. **(8 lectures)**
Phase Matching: Basic idea of phase matching, quasi-phase matching method, various methods of phase matching (angle, temperature, birefringence etc.), collinear and non-collinear phase matching, idea of tangential phase matching. **(7 lectures)**

Unit IV:

Second Harmonic Generation: Basic equation, conversion efficiency and parameters affecting doubling efficiency, various methods of enhancing conversion efficiency, second harmonic generation with Gaussian beam, intra-cavity second harmonic generation. **(9 lectures)**

Higher Order Nonlinear Processes: Four wave mixing processes-third harmonic generation, resonance enhancement of nonlinear susceptibilities, generation of tunable deep UV and IR radiation. **(6 lectures)**

Reference Books:

1. Laser, Theory & Applications, K. Thyagarajan and A.K. Ghatak, Macmillan India limited
2. Lasers and Non-Linear Optics, B.B. Laud, New Age International (P) Ltd., Publishers, New Delhi
3. Principles of Lasers, Orazio Svelto, Plenum Press
4. Elements of Laser and Non-Linear Optics, G D Baruah, Prakashan, Meerut
5. Lasers, Principles, Types and Applications, K.R. Nambiar, New Age International (P) Ltd., Publishers, New Delhi
6. Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw Hill.
7. Optical Systems and Processes, Joseph Shamir, 2009, PHI Learning Pvt. Ltd.
8. Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.
9. Optical Physics, A. Lipson, S.G. Lipson, H. Lipson, 4th Edn., 1996, Cambridge Univ. Press
10. Tunable Lasers and Applications, A. Mooradian. T. Jaeger and P. Stockseth
11. Molecular Structure and Spectroscopy, G Aruldhas, PHI Learning Pvt Ltd, Delhi

Semester 8
Paper Title: Quantum Mechanics and Solid State Physics
Paper Code: PHYMIN4024
Paper Credit: 04 (4+0+0)
Theory: 60 Lecture

Course Objective:
This paper is divided into two main parts. The first part deals with Quantum Mechanics and the second part pertains to Solid State Physics. The objective of the first part of the course is to give an elaborate idea of Schrodinger's equations and their application. It also includes the phenomena that arise on account of placing an atom in electric and magnetic fields. The second part is devoted to giving a basic idea of crystal structure, magnetic properties of materials, and Superconductivity.

Course Outcome:
Upon completion of this course, students will be able,

- *To learn Time-dependent and Time- independent Schrodinger's equations.*
- *To grasp the idea of the wavefunction, its properties, its interpretation, and the necessary conditions for the physical acceptability of the wave functions.*
- *To learn applications of Schrodinger Equation.*
- *To learn the behaviour of atoms in the presence of the electric and magnetic field.*
- *To learn to distinguish types of material and crystal structure.*
- *To learn how crystal diffracts X-rays.*
- *To learn the few laws and theories that evolved with time to describe crystal Properties like Specific heat.*
- *To learn the magnetic properties of matter.*
- *To learn about semiconductors and superconductors. The conductivity of semiconductors.*

Unit I:
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. **(10 Lectures)**

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 the spread of Gaussian wavepacket for a free particle in one dimension; wave packets. **(12 Lectures)**

Unit II:
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. **(8 Lectures**)

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons.Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. **(6 Lectures)**

Unit III:

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. **(9 Lectures)**

Elementary band theory: Kronig Penny model. Band Gaps. Conductors, Semiconductors and insulators. P and N type Semiconductors. Conductivity of Semiconductors, mobility, Hall Effect, Hall coefficient. **(9 Lectures)**

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. **(6 Lectures)**

Reference Books (Quantum Mechanics):

- A Text book of Quantum Mechanics, P.M.Mathews&K.Venkatesan, 2 nd Ed., 2010, McGraw Hill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2^{nd} Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3^{rd} Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2^{nd} Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics for Scientists and Engineers, D.A.B. Miller, 2008, Cambridge University Press

Additional Books for Reference

- Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
- Introduction to Quantum Mechanics, David J. Griffith, 2 nd Ed. 2005, Pearson Education
- Quantum Mechanics, Walter Greiner, 4^{th} Edn., 2001, Springer
- Reference Books (Solid State Physics):
- Introduction to Solid State Physics, Charles Kittel, 8 th Ed., 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 2 nd Ed., 2006, Prentice-Hall of India
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications

Semester 8
Paper Title: Experimental Techniques in Physics
Paper Code: PHYADL4014
Credit: 04 (3+0+1)
Lecture = 45

Course Objective:

The aim of this course is to implement tools and techniques used by experimental physicists in the laboratory. Students will learn to measure various error systems, industrial equipment's working principle and applications and also about the different vacuum systems.

Course Outcome:
At the successful completion of this course, students will have proper knowledge

- *In the assessment of reasonable experimental uncertainty in a variety of different measurements, and understood how to minimize that uncertainty.*
- *In analyzing experimental data using accepted error analysis methodologies to verify theoretical predictions.*
- *Acquainted with a number of common experimental techniques in physics as well as advanced experimental techniques such as utilizing vacuum technology.*

Unit I:
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. **(7 Lectures)**

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 **(6 Lectures)**

Shielding and Grounding: Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference. **(5 Lectures)**

Unit II:
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.

(12 Lectures)

Unit III:
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.

(5 Lectures)

Impedance Bridges and Q-meter: Block diagram and working principles of RLC bridge. Q-meter and its working operation. Digital LCR bridge.

(4 Lectures)

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). **(6 Lectures)**

Reference books:

- Measurement, Instrumentation and Experiment Design in Physics and Engineering, M. Sayer and A. Mansingh, PHI Learning Pvt. Ltd.
- Experimental Methods for Engineers, J.P. Holman, McGraw Hill
- Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Edition, PHI Learning Pvt. Ltd.
- Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
- Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill
- Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd.
- Electronic circuits: Handbook of design & applications, U. Tietze, Ch. Schenk, Springer

Paper Title: Experimental Techniques in Physics Lab
Paper code: PHYADL4014
Class: 30 Hrs. Lab class

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:

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

Semester 8
Paper Title: Solid State Physics -II
Paper Code: PHYADL4024
Credit: 04 (3+0+1)
Lecture = 45

Course Objective:

The objective of the course is to provide students with a comprehensive understanding of the fundamental principles and phenomena related to the behavior of matter in condensed states.

Course Outcome:

On successful completion of this course, the students will develop strong foundation on (i) free electron model which enable them to understand and analyze the electronic properties of materials, (ii) energy band theory for electrical conduction, materials and properties of semiconductors, and optical properties of solids, and (iii) principle and phenomenon of superconductivity

Unit I:

Free Electrons in Crystals: Introduction to free electron gas model. Free electron gas in one- and three-dimensional potential well, Density of states, The Fermi-Dirac distribution function. The electronic specific heat. Electrical conductivity of metals. Thermal conductivity of metals.

(8 Lectures)

Elementary band theory: The Bloch Theorem. The Kronig-Penny model. Brillouin zones. Energy vs Wave vector (E-K) diagram. Effective mass of an electron. Distinction between conductor, semiconductor and insulator. **(10 Lectures)**

Unit II:

Semiconductors: Intrinsic and Extrinsic (p-type & n-type) semiconductors. Band gap. Carrier concentration in intrinsic and extrinsic semiconductors. Fermi level. Law of mass action. Conductivity and mobility of semiconductors. Four probe method. Hall Effect. **(9 Lectures)**

Optical properties of materials: Optical constants, Drude model, dispersion relation of optical constants from Maxwell's equations, Optical absorption and emission in semiconductors, Exciton absorption, Impurity and interband transitions, Luminescence, direct and indirect luminescence Activators, Photoluminescence and thermo-luminescence. Absorption process, Photoconductivity, photoelectric and photovoltaic effect. **(8 Lectures)**

Unit III:

Superconductivity: Experimental results. Thermodynamics of superconductors: Gibbs free energy, Entropy, Specific heat. Critical temperature. Critical magnetic field. Meissner effect. Type-I and type-II Superconductors, London's Equation and Penetration Depth. Coherence length Isotope effect. Idea of BCS theory. Flux quantization. **(10 Lectures)**

Paper title: Solid State Physics -II Lab

Paper title: PHYADL4024

Class: 30 Hrs. Lab class

1. To determine the Lande g-factor of electrons by using the ESR set up.
2. To study the temperature dependence of Hall coefficient.
3. To determine magnetoresistance of the supplied material.
4. To determine the (i) Susceptibility arising due to water in the solution of $MnCl_2$ (ii)
5. magnetic moment of Mn++ ions in terms of Bohr magneton and (iii) the ionic molecular susceptibility of Mn++ ions by using Quink's method.
6. To study the I-V characteristics of the supplied solar cell and find its spectral response.
7. To determine the transition temperature of the supplied ferroelectric materials (BaTiO3).
8. To determine the power law dependence of photocurrent on intensity of illumination in a thin film sample.
9. To measure the transmission and absorption coefficients of a given liquid and a solid thin film with spectrophotometer.
10. To study the thermoluminescence of F-centres of alkalihalides.
11. To measure the dielectric constant of a supplied material.
12. To obtain the hysteresis curve (B H Curve) for a given ferromagnetic material on a CRO using solenoid and then to determine the related magnetic constants.

Reference Books

- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
- Solid State Physics, Rita John, 2014, McGraw Hill
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications

Semester 8
Paper Title: Nuclear and Particle Physics - II
Paper Code: PHYADL4034
Credit: 04 (3+0+1)
Lecture = 45

Course Objective:

The goal of the course is to impart knowledge on nuclear structure, nuclear models, nuclear decay, and nuclear reactions for better understanding of various nuclear properties. The course also aims to introduce the basic concepts and fundamental principles of particle physics.

Course Outcome:

After learning this course, the students will be able to (i) apply partial wave analysis technique to the n-p scattering problems (ii) apply the shell model to describe some basic nuclear properties, (iii) understand basics of nuclear reactions including compound nuclear reactions (iv) get familiar with the various particle accelerators and radiation detectors, (v) understand the role of symmetries in elementary particle interactions, (vi) get elementary idea of quark model and standard model of particle physics.

Unit I:

Two Nucleon System: Bound State Problem: Deuteron ground state with square well potential, electric quadrupole and magnetic dipole moments – experimental values. Scattering problem: Low energy n-p scattering, partial wave analysis, scattering length, magnitude of scattering length and strength of scattering, significance of the sign of scattering length. **(8 lectures)**

Nuclear Model: Shell Model: Evidence of shell structure, magic numbers, effective single particle potentials – square well, harmonic oscillator, Wood-Saxon with spin-orbit interaction, extreme single particle model – its successes and failures in predicting ground state spin, parity, Nordheim rule.

(7 lectures)

Unit II:

Nuclear Reactions: Different types of reactions, Conservation principles, Laboratory and CM frame of reference - energy and angle relationship for non-relativistic cases, kinematics and Q-values, exo-ergic and endo-ergic reactions, threshold energy. Basic concepts of flux and cross-sections, attenuation, the compound nucleus hypothesis and Ghoshal experiment. Direct Reaction, Kinematics of stripping and pick-up reactions, inelastic scattering. **(7 lectures)**

Nuclear beta decay: Pauli's neutrino hypothesis, Fermi's theory of beta decay, comparative half-lives and forbidden decays, Kurie plot, selection rules for Fermi and Gamow-Teller transitions, neutrino physics, Reins & Cowen experiment, Concept of double beta decay and Majorana neutrino.

(7 lectures)

Unit III:

Nuclear Radiation Detectors: General Properties of Radiation Detectors: Detector sensitivity, Energy Resolution, Detection Efficiency, Dead Time. Energy loss of charged particles: Mechanism, Stopping power and range, Bethe-Bloch formula, Bragg curve, Radiation length. Solid State Detectors: Scintillation counter, Solid State Nuclear Track Detector (SSNTD), Nuclear emulsions, Single Channel Analyzer (SCA), Multi-channel Analyzer (MCA). **(8 lectures)**

Elementary particles: Classification of fundamental forces, elementary particles and their quantum numbers (energy and momentum, charge, spin, parity, isospin, baryon number, Lepton number, strangeness, etc.), Gell-Mann--Nishijima scheme, Eightfold way, Quark Model, Properties of quarks and their classification, composition of mesons and baryons, Color degree of freedom, Elementary ideas of SU(2) and SU(3) symmetry groups, Introduction to Standard Model.

(8 lectures)

Recommended Books

- Introductory Nuclear Physics – Kenneth S Krane
- Atomic and Nuclear Physics (Vol.2) – SN Ghoshal
- Radiation Detection and Measurement - Glenn F. Knoll
- Techniques for Nuclear & Particle Physics Experiments – WR Leo
- Introduction to Nuclear & Particle Physics –A Das & T Ferbel.
- Nuclear Radiation Detectors- S.S. Kapoor & V.S. Ramamurthy
- Introduction to Elementary Particles – David Griffith
- Introduction to Particle Physics by D. J. Perkins

Paper Title: Nuclear and Particle Physics - II Lab
Paper code: PHYADL4034
Class: 30 Hrs. Lab class

1. To study the characteristics of GM tube and determine the operating voltage and percentage slope for background radiation.
2. To study the characteristics of GM tube and determine the operating voltage and percentage slope using beta/gamma source.
3. Verify the inverse square law for Gamma rays with the help of G.M. counter.
4. To study the complete spectrum of different gamma sources and to locate the corresponding photo peak, Compton edge, using NaI (Tl) scintillation counter and single channel analyzer (SCA) and draw calibration curve.

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