ST. JOSEPH'S UNIVERSITY

Bengaluru - 27

Syllabus for

B.Sc./B.Sc. (Honors) Physics

I-VI SEMESTER

2022-2026

Department of Physics

School of Physical sciences

St. Joseph's university

Bengaluru - 560027

Structure of the physics course for I-IV semesters of BSc(honors) degree

The BSc honors degree course is a four year program divided into 8 semesters, each semester will consist of 14 weeks of instruction for theory and 11 weeks of instructions for practicals. In Physics there will be 8 discipline core papers and 8 practical papers from semester I-IV. The theory papers, continuous internal assessments(CIA) is given 40 % weightage and end semester examination (ESE) is given 60 % weightage. The practical internal assessment (PIA) is given 40% weightage and the end semester examination is given 60 % weightage. CIA is based on written tests, problem solving, assignments, quiz etc. End semester theory examination is for 2 hours duration (60 marks). Practical examination is for 3 hours and 30 marks.

Semester	Code number	Title of the paper	no of hours of teaching per week
I	PH 121	Mechanics and Properties of Matter	4
	PH1P1	Physics practical	4
II	PH 221	Electricity and Magnetism	4
	PH 2P1	Physics practical	4
III	PH 322	Oscillations, Waves and Optics	4
	PH 3P1	Physics practical	4
	PH 422	Thermal Physics and Electronics	4
IV	PH 4P1	Physics practical	4

Marks allotments and credits for each paper .

Semester	Code number	no of credits	Continuous internal assessment marks	end semester examination marks	Total marks
I	PH 121	4	40	60	100
	PH1P1	2	20	30	50
II	PH 221	4	40	60	100
	PH 2P1	2	20	30	50
III	PH 322	4	40	60	100
	PH 3P1	2	20	30	50
IV	PH 422	4	40	60	100
	PH 4P1	2	20	30	50

Detailed Syllabus for Semester I

Course Content Semester – I

Paper Code – PH121

Course Title: **Mechanics and Properties of Matter**	Course Credits:4
Total Contact Hours: 52+ 8 (Self Study)	Duration of ESA: 2 hours
Continuous Assessment Marks: 40	End Semester Exam Marks: 60

Course Outcomes (COs):

At the end of the course, the student should be able to:

1. will learn fixing units, tabulation of observations, analysis of data (graphical/analytical)
2. will learn about accuracy of measurement and sources of errors, importance of significant figures.
3. will know how g can be determined experimentally and derive satisfaction.
4. will see the difference between simple and torsional pendulum and their use in the determination of various physical parameters.
5. will come to know how various elastic moduli can be determined.
6. will measure surface tension and viscosity and appreciate the methods adopted.
7. will get hands-on experience of different equipment.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs)

Course Outcomes (COs) / Program Outcomes (POs)	1	2	3	4	5	6
1. will learn fixing units, tabulation of observations, analysis of data (graphical/analytical)	x	x				
2. will learn about accuracy of measurement and sources of errors, importance of significant figures.	x	x				
3. will know how g can be determined experimentally and derive satisfaction.	x					
4. will see the difference between simple and torsional pendulum and their use in the determination of various physical parameters.	x					
5. will come to know how various elastic moduli can be determined.	x					
6. will measure surface tension and viscosity and appreciate the methods adopted.	x					
7. will get hands-on experience of different equipment.	x					

Course Articulation Matrix relates course outcomes of course with the corresponding program outcomes whose attainment is attempted in this course. Mark 'X' in the intersection cell if a course outcome addresses a particular program outcome.

Unit – 1

1.Units and measurements: System of units (CGS and SI), measurement of length, mass and time, dimensions of physical quantities, dimensional formulae. Minimum deviation, errors.

Coordinate system:

Cartesian co-ordinate system - Vectors and scalars, addition of vectors, multiplication of vectors - dot product, cross product, Geometrical interpretation of dot and cross product.

resolution of vectors, unit vectors in the plane polar co-ordinate system ($\hat{r}$, $\hat{\theta}$, $d\hat{r}/d\theta$, $d\hat{\theta}/d\theta$). Velocity ($\vec{v} = \vec{v}_r + \vec{v}_\theta$) and acceleration ($\vec{a} = \vec{a}_r + \vec{a}_\theta$) in polar coordinate system. Uniform circular motion-centripetal acceleration. Velocity and acceleration in the Cartesian coordinate system.

(7 hours)

Self Study: Fictitious forces. Coriolis force. **(1Hour)**

2. Momentum and Energy: Newton's Laws of motion. Work and energy. Conservation of energy with examples. Linear momentum, law of conservation of linear momentum, expression for impulse. Centre of mass, velocity and acceleration of centre of mass. Total linear momentum about the centre of mass, system of two particles, equation of motion of centre of mass, and rocket propulsion-single stage, multistage.

(6hours)

Self Study: Collision- elastic and inelastic. Perfectly inelastic collision in one dimension - decrease in energy(qualitative). **(1Hour)**

Suggested Activities

1. Activity: i). Students can measure diameters of small balls of different size and estimate their volumes. ii). Students can measure lengths of nails of different size.
   iii). Students can measure volume of a liquid
   iv). Students can measure distances and put the result both in CGS and SI units in 2, 3 and 4 significant figures. Ask them to mention the precession of the measurement.
   v). Students can estimate standard deviations wherever possible.
   vi). Students can use smart phone to measure centripetal acceleration.
2. Activity: Students can try and understand conservation of energy in every day examples. For example:
   i) What happens in solar conservation panels
   ii)Pushing an object on the table it moves
   iii)Moving car hits a parked car causes parked car to move.

In these cases, energy is conserved. How? Understand and verify if possible.

iv) Students can build water rocket and Hero's machine.

Unit – 2

3. Special theory of relativity: Frames of reference – Inertial & Non-inertial. Newtonian principle of relativity, Galilean transformation.

Constancy of speed of light. Postulates of Special Theory of Relativity. Lorentz transformation equations (no derivation). Length contraction. Time dilation. Relativistic addition of velocities.

(5 hours)

Self Study: Paradoxes in length contraction and time dilation **(1hour)**

4. Dynamics of Rigid bodies:

Rotational motion about an axis, moment of inertia and physical significance, angular momentum, torque on a rigid body, law of conservation of angular momentum. Rotational energy. Similarity between translatory and rotatory motion, theorems of perpendicular and parallel axes. M I of rectangular Lamina, circular disc, and solid cylinder. Flywheel. Theory of compound pendulum and determination of g.

(8hours)

Self Study: examples of conservation of angular momentum **(1hour)**

Suggested Activities

Activity:

Moment of inertia is an abstract concept. It simply gives a measure of rotational inertia of a rigid body and it is proportional to the product of the square of radius, r of the body and its mass, m. Students by referring to websites, can construct and perform simple experiments to verify that MI α mr^2.

Reference : www.khanacademy.org, www.pinterest.com, www.serc.cerleton.edn

Activity:

Prepare suitable charts and give seminar talks in the class.

Reference : Weblink/Youtube/Book

Unit - 3

5. Elasticity:

Rigid bodies & elastic bodies, Concept of stress & strain, stress – strain diagram for metallic wire, elastic limit, Hooke's law, elastic moduli –Young's modulus, rigidity modulus & bulk modulus, Poisson's ratio, Mention the relation between them, limiting values of Poisson's ratio. Work done in stretching a wire(derivation), Bending of beams – concept of neutral surface and neutral axis, bending moment(derivation), theory of single cantilever. Torsion of a cylinder - couple required to twist a uniform solid cylinder. Torsional pendulum-Determination of rigidity modulus and moment of inertia - q, η and σ by Searle's method.

(9 hours)

Self Study: I-section girders and its applications. **(1hour)**

6.Viscosity: Streamline flow, turbulent flow, critical velocity, Reynold's number, equation of continuity, coefficient of viscosity by Poisulle's method, Stoke's method. Problems.

(4 hours)

Self Study: Life at lower Reynolds number, E.M.Purcell, American Journal of Physics 45, 3 (1977); https://doi.org/10.1119/1.10903. **(1hour)**

Suggested Activities

Activity:

Arrange a steel spring with its top fixed with a rigid support on a wall and a meter scale along side. Add 100 g load at a time on the bottom of the hanger in steps. This means that while putting each 100g load, we are increasing the stretching force by 1N. Measure the extension for loads up to 500g. Plot a graph of extension versus load. Shape of the graph should be a straight line indicating that the ratio of load to extension is constant. Go for higher loads and find out elastic limit of the material.

Activity:

Repeat the above experiment with rubber and other materials and find out what happens after exceeding elastic limit. Plot and interpret.

2. Collect a set of different liquids and measure their viscosity.
   i) Find out whether sticky or non-sticky liquids are most viscous. Think of reasons.
   ii) Mix non sticky liquid to the sticky liquid in defined quantities and measure viscosity. Find out viscosity is increasing or decreasing with increase of non-sticky liquid concentration.
   iii) Do the above experiment by mixing sticky liquid to the non-sticky liquid. Find out change in viscosity with increase of concentration of sticky liquid.

Think why anyone should know viscosity of the liquid.

Unit - 4

Central force and gravitation: Conservative force – central force, angular momentum in central force field, motion under central force, law of equal areas, nature of motion under central force. Kepler's laws (statements)

Newton's law of Gravitation, Gravitational potential energy, Gravitational field and potential, Calculations of gravitational potential and field – spherical shell & solid sphere.

Satellite in a circular orbit - Launching of artificial satellites, escape velocity, time period of a satellite, Geostationary, Geosynchronous satellites.

(8hours)

Self Study: Basic idea of Global positioning system (GPS). India's satellite programmes. **(1hour)**

Surface tension:

Molecular forces in liquids & liquid surfaces – Adhesive & cohesive forces, Mention of sphere of influence, Molecular interpretation of surface tension. Surface energy – definition and derivation, angle of contact. Capillarity and expression for capillary rise. Pressure difference across a curved surface (derivation), Excess of pressure inside a liquid drop and a bubble. Interfacial tension – drop weight method - balancing condition.

(5 hours)

Self Study: Factors affecting surface tension. **(1hour)**

Suggested Activities

Activity:

1. Measure surface tension of water and other common liquids and compare and learn
   i) Why water has high ST? think of reasons.
   Check whether ST is a function of temperature? You can do it by heating the water to different temperatures and measure ST.
   ii) Plot ST versus T and learn how it behaves.

Mix some quantity of kerosene or any oil to water and measure ST. Check whether ST for the mixture is more or less than pure water. Think of reasons.

Activity:

1. Make a chart of your weight in all planets
2. Calculate the escape velocity of different planets
3. Collect the information about fuel used in rockets currently launched by ISRO
4. Watch interstellar movie and comment on scientific aspects of it.
5. Write a note on the present scenario of Space Tourism

Text Books

Sl No	Title of the Book	Authors Name	Publisher	Year of Publication
1	Mechanics by, New Eition	D. S. Mathur	S.Chand & Co	2000
2	Mechancis and Relativity by 3rd Edition,	Vidwan Singh Soni,	PHI Learning Pvt. Ltd.	
3	Mechanics Berkeley Physics Course, Vol.1:	Charles Kittel, *et.al*.	Tata McGraw-Hill	2007
4	Properties of Matter	Brijlal & Subramanyam.		
5	Physics for Degree Students B.Sc. First year	C.L.Arora Dr. P.S.Hemne	S.Chand	2010

References Books

Sl No	Title of the Book	Authors Name	Publisher	Year of Publication
1	Physics. 9th Edn,	Resnick, Halliday & Walter,	Wiley	2010
2	Physics	Halliday and Resnick,		

List of Experiments to be performed in the Laboratory

Paper Code- PH1P1

1.	Determination of g using bar pendulum (L versus T and L versus LT^2 graphs)
2.	Determination of moment of inertia of a Fly Wheel.
3.	Determination of rigidity modulus using torsional pendulum
4.	Verification of parallel and perpendicular axis theorems.
5.	Determine the Young's Modulus by bar bending method (single cantilever)
6.	Determination of elastic constants of a wire by Searle's method
7.	Young's modulus by Koenig's method
8.	Modulus of rigidity (twisting)
9.	Viscosity by Stoke's method
10.	Radius of capillary tube by mercury pellet method
11.	Hook's law verification
12.	Surface tension by drop weight method
13.	Critical pressure for stream line flow
14.	Moment of inertia of irregular body
15	Moment of inertia of a flywheel
16	Bulk modulus of rubber
17	Viscosity by Poiseuille's method
18	Studying motion of a spring under gravity using tracker software
19	Spring-mass oscillator
20	Interfacial surface Tension
21	Young's modulus by uniform bending
Note: Or any other relevant experiment the department decides to include.	

Reference Book for Laboratory Experiments

Sl No	Title of the Book	Authors Name	Publisher	Year of Publication
1	Physics through experiments	B.Saraf	Vikas Publications	2013
2	A lab manual of Physics for undergraduate classes, 1st Edition,		Vikas Publications	
3	BSc Practical Physics Revised Edition	CL Arora	S.Chand & Co.	2007
4	An advanced course in practical physics.	D. Chatopadhyay, PC Rakshit, B.Saha	New Central Book Agency Pvt Ltd.	**2002**

Continuous Assessment	
Assessment	**Marks**
Activity-1	10
Activity- 2	10
Mid semester Exam	20
Total	40

Course Content

Semester – II

Paper code – PH221

Course Title: **Electricity and Magnetism**	Course Credits: 4
Total Contact Hours: 52+ 8 (Self Study)	Duration of ESA: 2 hours
Formative Assessment Marks:40	Summative Assessment Marks:60

Course Outcomes (COs):

1. Demonstrate Gauss law, Coulomb's law for the electric field, and apply it to systems of point charges as well as line, surface, and volume distributions of charges.
2. Explain and differentiate the vector (electric fields, Coulomb's law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
3. Apply Gauss's law of electrostatics to solve a variety of problems.
4. Describe the magnetic field produced by magnetic dipoles and electric currents.
5. Explain Faraday-Lenz and Maxwell laws to articulate the relationship between electric and magnetic fields.
6. Describe how magnetism is produced and list examples where its effects are observed.
7. Apply Kirchhoff's rules to analyze AC circuits consisting of parallel and/or series combinations of voltage sources and resistors and to describe the graphical relationship of resistance, capacitor and inductor.
8. Apply various network theorems such as Superposition, Thevenin, Norton, Reciprocity, Maximum Power Transfer, etc. and their applications in electronics, electrical circuit analysis, and electrical machines.

Unit - 1

1.Scalar and Vector fields:

The Del operator, Gradient of a scalar field, divergence and curl of a vector - geometrical and physical interpretation, product rule of Del operator and second derivatives. Line integral - conservative nature of electrostatic field, surface and volume integrals - physical interpretation, flux over a vector field, Gauss divergence theorem and Stokes curl theorem (statement). **(4 hours)**

2.Electric charge and field

Coulomb's law, electric field strength, electric field lines, electric field potential due to a point charge,

Relation between field and potential ($\mathbf{E} = -\nabla V$), Electric dipole - electric potential and field at any point due to a dipole.

Potential due to electric quadrupole (qualitative), Constant potential surfaces.

(4 hours)

3. Gauss' law:

Gauss' law in integral and differential form, Poisson's equation and Laplace's equation, Applications of Gauss law (electric fields of a (i) spherical charge distribution, (ii) line charge and (iii)an infinite flat sheet of charge). Force on the surface of a charged conductor, electric pressure, and energy density. **(5 hours)**

Self Study: Potential due to distribution of charges (Examples: potential associated with a spherical charge distribution, infinite line charge distribution, infinite plane sheet of charges). **(2 hours)**

Suggested Activities

Activity:

1. Learn the difference between and DC and AC electricity and their characteristics. Voltage and line frequency standards in different countries.

A small project report on production of electricity as a source of energy: Different methods

Activity:

1. Learn to use a multimeter (analog and digital) to measure voltage, current and resistance Continuity testing of a wire.

2. Learn about household electrical connection terminals: Live, neutral and ground and voltage between the terminals. Role of earthing and safety measures

Unit - 2

4. Conductors and insulators in electrostatic field

Conductors and insulators, conductors in electric field. Capacitance and capacitors, calculating capacitance in a parallel plate capacitor, parallel plate capacitor with dielectric (completely and partially filled), Energy stored in a capacitor, Energy loss due to sharing of charges in capacitors.

Dielectrics: an atomic view- polarizability. Dielectric and Guass's law – electric displacement vector. **(7 hours)**

5. Steady and variable currents:

Physics of electrical conduction in metals. Electric currents and current density, conductivity, drift velocity and Ohm's law.

Transient (variable) currents: Growth and decay of charges in RC circuit, Growth and decay of currents in LR circuit and charging and discharging in series LCR circuit (qualitative discussion of different conditions). **(6 hours)**

Self Study: Currents and voltage in combination of R, L and C circuits **(2 hours)**

Suggested Activities

Activity:

1. Learn about electrical appliances which work with AC and DC electricity

Learn about types of resistors and their colour codes and types of capacitors (electrolytic and non- electrolytic)

Activity:

1. Learn about power transmission: 3-phase electricity, voltage and phase
2. Visit a nearby electrical power station. Interact with line men, Electrical engineers and managers. Discuss about power loss in transmission. How to reduce it?

Prepare a small project report on street lighting and types of electrical bulbs.

Unit - 3

6. Magnetism

Force on a moving charge in a uniform magnetic field. Definition of magnetic field. Lorentz force. Biot-Savart's law, force on a current carrying conductor in a magnetic field, Torque on a current loop, equivalence of a current loop and a magnetic dipole. Magnetic field due to solenoid. Ampere's circuital law-statement and its application to infinite straight conductor, principle and theory of moving coil BG. Hall effect in metals.

Faraday's laws and Lenz's law, conducting rod moving in a magnetic field $e = (-d\Phi/dt)$, energy stored in an inductor, self-induction - self-inductance of a long solenoid, energy density in magnetic field, mutual induction - expression for mutual inductance between two coils, Eddy current. **(8 hours)**

7. AC Circuits: LCR series and parallel circuits (L & R in series and C in parallel) by vector method, applications in tuning circuits, resonance, sharpness of resonance, Q-factor, band width, expression for the power in an AC circuit, power factor, wattless current.

(5 hours)

Self Study: Magnetic field due to circular coil(at the center and along the axis), principle of Helmholtz Tangent Galvanometer.

Phase relation between voltage and current in R, L and C

(2 hours)

Suggested Activities

Activity:

1. Prepare a small project report on street lighting and types of electrical bulbs.

Learn the measurement of electric current using tangent galvanometer.

Activity: Build a small coil with insulated copper wire. Connect an ammeter micro/milli ammeter. Verify magnetic induction using a powerful bar magnet.

Unit4

8.Electromagnetic waves

Concept of displacement current, equation of continuity, setting up of Maxwell's equations & their physical significance, derivation of e.m. wave equation, velocity of e.m. waves in free space and in isotropic dielectric medium. Electromagnetic waves in different frames of reference. Relation between electric and magnetic vectors – transverse nature, phase relation between electric and magnetic vectors, Poynting vector and energy density of e.m. waves. Skin effect. **(9 hours)**

9.Magnetic Properties of Materials

Electric current in atoms, electron spin and magnetic moment, magnetization and magnetic susceptibility.

Types of magnetic materials: diamagnetic, paramagnetic and ferromagnetic materials. Curie - Wiess law. B-H hysteresis curves. **(5 hours)**

Self Study: B-H curves and its characteristics Ferrites **(1 hour)**

Suggested Activities

Activity:

1. Prepare a small project report on production of magnetic field: Permanent magnets, electromagnets and superconducting magnets.

Learn the principle of working of a Gauss meter to measure magnetic field

Activity:

1. Model the earth's magnetic field with a diagram. Explain the effect of tilt of the earth's axis and reasons for the change in the tilt of the earth's axis over thousands of years.

Text Books

1, Electricity and Magnetism, R. Murugesan, S. Chand and Co, 2000.
2. Fundamentals of Electricity and Magnetism, B.D. Duggal and Chopra, 4 th Edition, S. Chand and Co, 1086.
3. Electricity and Magnetism, Sehgal, Chopra and Sehgal, S. Chand and Co., 2020.

References Books

Sl No	Title of the Book	Authors Name	Publisher	Year of Publication
1	Physics-Part-II,	David Halliday and Robert Resnick	Wiley Eastern Limited	2001
2	Berkeley Physics Course, Vol-2, Electricity and Magnetism, Special Edition	Edward M Purcell	Tata Mc Graw- Hill Publishing Company Ltd, New Delhi	2008
3	Introduction to Electrodynamics	David J. Griffiths,	Pearson Education, India.	2015.
4	Electricity and Magnetism.	K.K. Tiwari, S	Chand & Co	1995.
5	Vector analysis, Scheme Series, 2 nd Edition,	Murray R. Spiegel, et al,	McGraw-Hil l Education	2000

List of Experiments to be performed in the Laboratory

Paper Code- PH2P1

Physics Practical

1.	Experiments on tracing of electric and magnetic flux lines for standard configuration
2.	Variation of electrical conductivity with temperature in Metals
3.	Variation of electrical conductivity with temperature in Semiconductors
4.	Experiments using Ballistic galvanometer – Determination of components of earth's magnetic field
5.	Experiments using Ballistic galvanometer – Determination of capacitance of a condenser
6.	Experiments using Ballistic galvanometer – Determination of high resistance by leakage
7.	Charging and discharging of a capacitor (energy dissipated during charging and time constant measurements
8.	Experiments on AC circuits Series and parallel resonance circuits (LCR circuits)
9.	Experiments on AC circuits Determination of self-inductance of a coil
10.	Experiments on AC circuits Impedance of series RC circuits- determination of frequency of AC
11.	Black box -Identification of circuit elements and measurement of their values.
12.	de-Sauty's bridge- verification of laws of combination of capacitors
13.	Sonometer- Frequency of AC
14.	Helmholtz Tangent Galvanometer- determination of K and B_H

Continuous Assessment	
Assessment	**Marks**
Activity-1	10
Activity-2	10
Mid-Semester Exam	20
Total	40

Course Content

Semester – III

Paper code – PH322

Course Title: **Oscillations, Waves and Optics**	Course Credits:4
Total Contact Hours: 52+ 8 (Self Study)	Duration of ESA: 2 hours
Formative Assessment Marks: 40	Summative Assessment Marks: 60

Course Learning Outcomes	
At the end of the course students will be able to:	
i.	Identify different types of waves by looking into their characteristics.
ii.	Formulate a wave equation and obtain the expression for different parameters associated with waves.
iii.	Explain and give a mathematical treatment of the superposition of waves under different conditions, such as, when they overlap linearly and perpendicularly with equal or different frequencies and equal or different phases.
iv.	Describe the formation of standing waves and how the energy is transferred along the standing wave in different applications, and mathematically model in the case of stretched string and vibration of a rod.
v.	Give an analytical treatment of resonance in the case of open and closed pipes in general and Helmholtz resonators in particular.
vi.	Describe the different parameters that affect the acoustics in a building, measure it and control it.
vii.	Give the different models of light propagation and phenomenon associated and measure the parameters like the wavelength of light using experiments like Michelson interferometer, interference and thin films.
viii.	Explain diffraction due to different objects like singles slit, two slits, diffraction of grating, oblique incidence, circular aperture and give the theory and experimental setup for the same.
ix.	Explain the polarization of light and obtain how the polarization occurs due to quarter wave plates, half wave plates, and through the optical activity of a medium.

Unit – 1 - Waves and Simple Harmonic Motion

Simple Harmonic Motion: Plane Definition of Simple harmonic motion, Differential equation of simple harmonic motion, Solution of differential equation. Simple harmonic motion as a projection of circular motion, velocity and acceleration of a particle having simple harmonic oscillation, Energy conservation in SHM, Angular SHM. Composition of two SHM's - Lissajou's figures. Equation of motion of Damped harmonic oscillation – critical damping, under damping and over damping (qualitative). Concept of coupled oscillator. **(10 Hours)**

Self-Study: Forced oscillation – concept of resonance. *Watch in internet:* Collapse of Tacoma-narrow bridge **(1 hour)**

Wave Motion: Characteristics of wave motion, progressive wave equation- different forms of wave equations, differential equation of wave motion. - phase of the wave- relation between phase difference and path difference. Dispersive and non-dispersive medium. Energy transmitted by a wave, Intensity and Power transmitted by a sine wave, **(3 Hours)**

Text book: Undergraduate Physics Volume II- A.B. Bhattacharya

Suggested Activities (2 Hours)

We know that sound is produced because of vibration. Look into at least 10 musical instruments and identify the regions of vibrations that produces the sound and those parts which enhances the sound because of reverberation.

1. Identify one common element in all of these.
2. Identify equipment which creates beats and try to explain the underlying basic principles. Demonstrate the examples of beats using two tuning forks.
3. Identify what will happen when you drop a stone in a standing water, and when your drop two stones side by side.
4. Make your observations sketch them and comment on it in a report.

Draw two sine waves (Amplitude vs time) one shifted with other in phase. Identity where the resonance occurs for each phase shift. Plot phase vs time taken for resonance

Take smooth sand, place a pointed edged pen vertically on the sand. To the mid of the pen, connect two perpendicular threads. Pull these perpendicular threads by varying the forces and timings. Note down the different shapes produced on the sand. Try to interpret the shapes. Make a report of it

Hang a pot with sand, which has a hole in the bottom. Gently pull the pot on one side and observe the pattern formed by the sand on the floor. Report the observations.

Design a coupled pendulum. Study the impact of the motion of one pendulum over the other pendulum by varying the length, direction of the motion of one pendulum and mass of pendulum and observe the resultant changes. Trace the path of the bobs and make a report.

Activity: Take a stretched spring. Stretch it across two edges. Put a weight on the string, pluck it and measure the amplitude of the vibration. All group will measure the total damping time of oscillating spring. (Using mobile or scale) And plot a graph of the-

1. Varying load on the spring and amplitude at the centre.
2. Take another weight and put that in another place and measure the amplitude of vibration at

	the centre. Vary the load in the centre of the spring and measure the amplitude at the centre.

Unit – 2 - Superposition of Waves and Interference

Superposition of waves-concept of phase velocity, group velocity, and the relation between them, Derivation of Vg=dw/dk. Fourier theorem, Fourier series, Evaluation of the Fourier coefficients, Fourier analysis of a square wave. (If square wave is above or below the X-axis should be mentioned clearly) **(5 Hours)**

Self-study: Superposition of waves- beats. **(1hour)**

Interference: Various theories of light, Huygens' principle and construction of wave front. Theory of interference- conditions for sustained interference. Fresnel's Biprism- distance between two virtual sources by shift method, effect of thin film in one of the interfering beams. Interference at thin films (reflected system), theory of interference at a wedge and theory of Newton's rings. **(7 Hours)**

Self-Study: Young's double slit experiment. **(1 Hour)**

Activity:In the table given below explore which phenomenon can be explained by what and make a report.

Sl No	Phenomenon	Particle of Light	Wave Nature	Dual Nature
	Pinhole camera			
1	Formation of images on lenses			
2	Formation of images on mirror			
3	Interference			
4	Polarization			
5	Diffraction due to single slit			
6	Black body radiation			
7	Photoelectric effect			
8	De-Broglie hypothesis			
9	Devison & Germer Experiment			

Why colour strips are seen in paddles on roads in rainy seasons try to simulate the same. Give the reasons Make a report.

Unit – 3 – Diffraction and Polarisation

Diffraction: Fresnel and Fraunhofer diffraction, Fresnel half period zones-rectilinear propagation of light, Zone plate – construction and theory, comparison of a zone plate with a convex lens. Cylindrical wave front-half period strips, theory of diffraction at a straight edge, Fraunhofer diffraction -theory of single slit diffraction, theory of grating - oblique incidence, normal incidence. **(9 Hours)**

Self-study: Discussion of dispersive power - Grating, Rayleigh's criterion for resolution, resolving power of a grating (no derivation), Original paper of Sir. C.V. Raman on oblique incidence (Reading) (1 **hour)**

Polarisation: Review of Polarization of light and methods of polarization, plane of polarization, Polarization by reflection-Brewster's law, Malus' law with proof. Huygens' theory of double refraction in uniaxial crystal, (mention as- Normal incidence, optic axis being perpendicular to the paper) birefringence, theory of retarding plates, quarter & half wave plates. production and detection of plane, circularly and elliptically polarized light, Optical activity, specific rotation, Fresnel's theory of optical rotation. **(7 Hours)**

Self-study: Applications of polarized light, Polaroid, optical isolator. **(1 hour)**

Suggested Activities (2 Hours)

Explain polarization of light through a chart. List out the surfaces that reflect polarized light.

Learn how polarization of light can be done by both transmission and reflection. Perform an experiment and make a report.

USING CDs AND DVDs AS DIFFRACTION Gratings

Ref:https://www.nnin.org/sites/default/files/files/Karen_Rama_USING_CDs_AND_DVDs_AS_DIFFRACTION_GRATINGS_0.pdf

Obtain the diffraction spectra using a CD and design an experiment to find the distance between the tracks on it)(Ref: https://www.brighthubeducation.com/science-lessons-grades-9-12/39347-diffraction-experiment-measuring-groove-spacing-on-cds/, https://silo.tips/download/diffraction-from-a- compact-disk)

What is the physics behind making 3D movies? Group Discussion (https://www.slideserve.com/rae/physics-behind-3d-movies-powerpoint-ppt- presentation) Make a report.

List out different types of zone plates and look for their applications in day to day life. Make a report.

Collect information and study how optically polarizing lenses are made. Visit a nearby lens making facility. Learn the principle behind sunglasses. Make a report.

Unit – 4 – Lasers and Fibre Optics

Lasers: General principles - Spontaneous and stimulated emission, Einstein's A and B coefficients, monochromaticity, coherence and directionality, spatial and temporal coherence, spectral energy density, Condition for laser action - population inversion, metastable states, optical pumping, lasing and active systems. Construction and working- Ruby laser and He- Ne laser with energy level diagrams. **(6 Hours)**

Self-study: Applications of lasers, organic dye lasers (**1 hour**)

Fibre Optics: Description of optical fibre – principle and construction, Types of optical fibre (w.r.t refractive index) -single mode and multi-mode - step index mode and graded index mode Expressions for acceptance angle and numerical aperture (NA), Fractional index change (Δ) and relation between NA and Δ, Modes of propagation, (Qualitative) V-number, Mechanisms of energy loss in optical fibre, attenuation. **(5 Hours)**

Self-study: Applications of optical fibre - communication and medical field. **(1 hour)**

Suggested Activities (2 Hours)

Determine the wavelength of a laser by using a diffraction grating, a broken CD, and a metal scale

How a laser can be used for welding and cutting purposes

Students can be given laser-cutting projects on paper, wood, cork, etc

Students can be asked to discuss laser treatment in the medical field

Students can be motivated for future self-employment

To find out the acceptance angle and numerical aperture

Students can be given different diameters of optical fibre and made to learn how the bending of the fibre results in a loss of energy.

Students can be given projects to discuss how optical fibre is used for communication purposes

Identify any 3 sharp edges of varying thickness and assign them to 3 groups.
Shine a laser light pointing towards the edge of the needle. Observe the patterns formed on the wall or screen and measure the distance between the bands. Correlate the distance between the bands formed with the the edge and the distance from the edge to the screen. By this, calculate the laser light used.

Textbooks				
Sl No	**Title of the Book**	**Authors Name**	**Publisher**	**Year of Publication**
1.	The Physics of Waves and Oscillations,	N K Bajaj	Tata McGraw-Hill Publishing Company Ltd., Second Edition,	1984
2.	Waves and Oscillations	N Subramanyam and Brij Lal	Vikas Publishing House Pvt. Ltd., Second Revised Edition	2010
3.	A Text Book of Sound	D R Khanna and R S Bedi	Atma Ram & Sons, Third Edition	1952
4.	Oscillations and Waves	Satya Prakash	Pragathi Prakashan, Meerut, Second Edition	2003
5.	Optics	Ajoy Ghatak	McGraw Hill Education (India) Pvt Ltd	2017
6.	A text Book of Optics	Brij Lal, M N Avadhanulu & N Subrahmanyam	S. Chand Publishing	2012

References Books				
Sl No	**Title of the Book**	**Authors Name**	**Publisher**	**Year of Publication**
1.	Berkeley Physics Course – Waves,	Frank S Crawford Jr.	Tata Mc Graw-Hill Publishing Company Ltd., Special Indian Edition,.	2011
2.	Optics	Eugene *Hecht*	Pearson Paperback	2019
3.	Introduction To Optics	Pedrotti and Frank L ,	Pearson India	3rd Edition
4.	Fundamentals of Optics	Francis Jenkins Harvey White	McGraw Hill Education	2017

Continuous Assessment	
Assessment	**Marks**
Activity -1	10
Activity - 2	10
Mid semester Exam	20
Total	40

List of Experiments to be performed in the Laboratory	
1.	Velocity of sound through a wire using Sonometer.
2.	Frequency of AC using Sonometer.
3.	Study of Lissajous' Figures
4.	To verify the laws of transverse vibration using Melde's apparatus
5.	Helmholtz resonator using tuning fork.
6.	Helmholtz resonator using electrical signal generator.
7.	To determine refractive index of the Material of a prism using sodium source.
8.	To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
9.	To determine the wavelength of sodium source using Michelson's interferometer.
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 thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
13.	To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
14	To determine dispersive power and resolving power of a plane diffraction grating.
15	To determine wavelength of laser using (1) diffraction grating and (2) using meter scale
16	To determine the numerical aperture of the optical fibre
17	To determine the attenuation coefficient of the optical fibre using fibre optic bench

Reference Book for Laboratory Experiments				
Sl No	**Title of the Book**	**Authors Name**	**Publisher**	**Year of Publication**
1.	Advanced Practical Physics for students	B.L. Flint and H.T. Worsnop	Asia Publishing House.	1971
2.	A Text Book of Practical Physics	I. Prakash & Ramakrishna	Kitab Mahal, 11th Edition	2011
3.	Advanced level Physics Practicals	Michael Nelson and Jon M. Ogborn	Heinemann Educational Publishers, 4th Edition	1985
4.	A Laboratory Manual of Physics for undergraduate classes	D.P.Khandelwal	Vani Publications.	1985

Course Content

Semester – IV

Paper code – PH422

Course Title: **Thermal Physics and Electronics**	Course Credits:4
Total Contact Hours: 52+ 8 (Self Study)	Duration of ESA: 2 hours
Continuous Assessment Marks: 40	End Semester Exam Marks: 60

Course Learning Outcomes

At the end of the course students will be able to:

i.	Apply the laws of thermodynamics and analyze the thermal system.
ii.	Apply the laws of kinetic theory to the ideal and practical thermodynamics systems through derived thermodynamic relations.
iii.	Use the concepts of semiconductors to describe different Semiconductor devices such as diode transistors, BJT, FET etc and explain their functioning.
iv.	Explain the functioning of OP-AMPS and use them as the building blocks of logic gates.

Course Articulation Matrix

Mapping of Course Outcomes (CO) Program Outcomes

Course Outcomes / Program Outcomes		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
i.	Apply the laws of thermodynamics and analyze the thermal system.	X	X	X	X	X	X					X	X
ii.	Apply the laws of kinetic theory and radiation laws to the ideal and practical thermodynamics systems through derived thermodynamic relations.	X	X	X	X	X	X					X	X
iii.	Use the concepts of semiconductors describe different Semiconductor devices like diode transistors, BJT, explain functioning.	X	X	X	X	X	X					X	X
iv.	Explain the functioning of OP-AMPS and them as the building blocks of logic gates.	X	X	X	X	X	X					X	X

Unit – 1

1. Kinetic theory of gases:

Kinetic theory of gases: Assumptions of kinetic theory of gasses, Deduction of the pressure of an ideal gas, Deduction of Boyle's law, Charles's law & Avogadro's law from kinetic theory, Maxwell's velocity distribution (Graph & interpretation without derivation), Definition & expressions for rms, mean & most-probable velocity. Degrees of freedom, Principle of equipartition of energy, ratio of specific heat capacity for mono-atomic, di-atomic & tri-atomic gas. Mean free path (Derivation). Transport phenomenon – derivation of coefficient of viscosity.

(9 hours)

2. Real gases & Liquefaction of gases:

Real gases & Liquefaction of gases: Andrew's isothermal curves for real gases, Vander Waals' equation critical constants (Definition & derivation). Joule Thomson expansion- porous plug experiment with theory. **(4 hours)**

Self Study: Coefficient of thermal conductivity **(1Hour)**

Difference between Joule Thomson expansion & adiabatic expansion, adiabatic de-magnetization **(1Hour)**

Suggested Activities (2 Hours)

(i) Take two balloons, submerge one balloon into the cold water and the other balloon into the hot water. Wait several minutes and then compare the sizes of the balloons. Return each balloon to its original bucket, wait several more minutes and compare their sizes again. Draw what has taken place and compare the results with their original predictions. How did temperature impact the molecules? Why did changes in temperature affect the size of the balloons?

(ii) Using sticky tape, stick small pieces of cotton wool to the inside end of two rubber bungs. Add a few drops of concentrated hydrochloric acid to the cotton wool on one of the bungs and concentrated ammonia to the cotton wool on the other. Quickly push the bungs into opposite ends of the tube ensuring that they are placed in position at the same time. Observe for 10–15 minutes. Explain the position of the smoke ring? Discuss how diffusion depends on molar mass.

http://www.physics.umd.edu/perg/abp/think/thermo/kt.htm

Unit – 2

3.Thermodynamics:
Zeroth law, First law of thermodynamics, Concept of internal energy, Different types of thermodynamic processes – isothermal, adiabatic, isobaric & isochoric. Derivation of $PV^{\gamma} =$ constant. Work done during isothermal & adiabatic changes. Carnot cycle, Carnot engine – efficiency, Carnot's theorem (No proof only statement & explanation). Concept of absolute zero, Entropy & second law of thermodynamics. Expressions for change of entropy- for phase transition and change in temperature. Statement of Clausius inequality, T-S diagram & its use to find the efficiency of Carnot cycle. Third law of thermodynamics. **(8 Hours)**

4. Thermodynamic potentials: Internal energy, enthalpy, Helmholtz free energy, Gibbs free energy & their significance, Maxwell's thermodynamic relations from thermodynamic potentials & their significance. Application of Maxwell's thermodynamic relation – nature of variation of internal energy with volume, Clausius – Clayperon's equation.

(5 Hours)

Self Study: Reversibility of Carnot engine – refrigerator, coefficient of performance

(1 Hours)

Application of Maxwell's thermodynamic relation - difference between the specific heat capacities for ideal gases & real gases. **(1 Hours)**

Suggested Activities (2 Hours)

I feel cold because coldness enter my body. Discuss the statement in day-to- day life. Approximately give examples of

(i) open system
(ii) closed system and
(iii)isolated system

Discuss when the temperature of the body is locked until what time you hold the thermometer in contact with a body. Discuss it in contact with laws of thermodynamics.

Discuss why when a person works or does exercise, he sweats. Reason it with the laws of thermodynamics.

Activity: Take four different sizes of same metal, preferable of same shape and give one piece to each group. Heat it uniformly on a hot plate. Keep a beaker of water with a thermometer immersed in it. Drop one hot metal into the water and record the temperature with time. Repeat the experiment for the other heated metal pieces of different sizes.

(i) Plot a graph for the volume of the metal piece used v/s respective temperature change observed
(ii) Determine the heat capacity and specific heat of the metal used.

Activity: Take ice cubes of different size and immerse in water and measure the temperature change with time and repeat the experiment. Graph the observations.

Unit – 3

5. Semiconductor diodes

p-n junction, forward and reverse bias. Rectifiers – half wave and full wave with input and output waveforms, expression for ripple factor and efficiency, capacitor filter. Zener diode-characteristics and application as a voltage regulator-load and line regulation.

(6 Hours)

6. Bipolar Junction Transistor (BJT)

Construction and basic action, Configurations (CB, CE and CC). Definition of α, β and their relations. Input, output and transfer characteristics of CE. Comparison between CB, CE, and CC mode. CE mode - leakage current and thermal runaway. Biasing methods – base biasing and voltage divider biasing. DC load line, operating point (Q point). Transistor as an amplifier: CE – working, gain and frequency response, CC amplifier - applications. **(7 Hours)**

Self-study: Bridge rectifier- ripple factor, efficiency **(1 hour)**

Transistor as a switch. **(1 hour)**

Suggested Activities (2 Hours)

Wire a regulated DC power supply on a bread board or groove board to give a regulated output voltage of + 5 V; +15 V; Dual power output : ± 5 V; Dual power output : ± 15 V. Use: 3-pin voltage regulators.

Components required:

1. Step down transformer- 1 No. (5 V tapping, 100 – 500 mA current rating), BY 127 semiconductor diodes – 4 Nos, Inductor -1, Capacitor - 1, 3 pin 5V regulator-1

Search for circuit diagram in books/net.

Activity: Form 3 groups and tell them to make a DC supply of low current of different voltages like 5V, 10V, and 15V on a breadboard

(i) Learn to identify the terminals of different types (packages) of BJTs

(ii) In the case of power transistors, learn how to fix a heat sink for the transistor

(iii) Learn the difference between BJT and FET in its operational characteristics.

Activity: Take any 3 diode and assign one to each group. Measure its resistance when dipped in ice and heating the ice till it boils. Using this data, plot calibration curve of temperature v/s resistance and also the cooling curve of temperature V/s time for the diode by each group

Unit – 4

7. Field Effect Transistor(FET)

FET- Construction and working, Static Characteristics, Shockley's equation. Drain characteristic and transfer characteristic. FET parameters. FET amplifiers. **(5 hours)**

8. Operational Amplifier - Characteristics of an ideal op-amp. CMRR, slew rate. Concept of virtual ground. Inverting and non-inverting operational amplifiers - expression for gain. Operational amplifier as adder, subtractor, integrator and differentiator.

Oscillators - Concept of positive and negative feedback. Barkhausen criterion for an oscillator. RC and LC oscillations. RC oscillator - Wien bridge oscillator, Phase shift oscillator. LC oscillator – Hartley Oscillator and Colpitt oscillators – Construction, working, expression for frequency (no derivation), applications. **(8 hours)**

Self study: MOSFET **(1 hour)**

Operational amplifier as comparator. **(1 hour)**

Suggested Activities (2 Hours)

Operational Amplifiers

(i) Understand the concept of virtual ground of an OP-AMP.
(ii) Learn the different types of op-amps used for different applications.
(iii) What is a buffer? Prepare a report on buffers and its application in instrumentation electronics.

Textbooks	
Sl No	**Title of the Book**
1.	Electronic Devices and Circuits, David A. Bell, 2004, PHI, New Delhi
2.	Integrated Electronics, Jacob Millman and CC Halkias
3.	Physics for Degree students (BSc First year)- C. L Arora, Dr. P. S. Hemne S. Chand & Company 2nd revised edition -2013

References Books	
1.	Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2.	Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
3.	A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
4.	Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
5.	Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
6.	An Introduction to Thermal Physics, Daniel V Schroeder, 2020, Oxford University Press
7	Heat and Thermodynamics – D. S. Mathur – S Chand & Co, New Delhi 5th Edition (2004).
8.	Heat Thermodynamics and Statistical Physics – Brijlal Subramanyam & P.. Hemne, S Chand & Co.
9.	Heat and Thermodynamics – J.B Rajam 2008
10.	Thermodynamics -Enrico Fermi
11.	Why are Things They are? (Vignettes of Physics) - G. Venkataraman
12.	Electronic devices and circuit theory – Robert Boylsted
13.	Electronic principles – A.P Malvino 10.Principles of electronics- A.P.Malvino (Mc Graw-Hill Pub.)
14.	OP AMP and linear integrated circuits-Gayakwad (Pearson Education)
15.	Basic electronics – B.L.Theraja (S. Chand& Company Ltd)

Continuous Assessment	
Assessment	**Marks**
Activity-1	10
Activity-2	10
Mid-Semester Exam	20
Total	40

PH4P1: PHYSICS PRACTICAL

List of Experiments to be performed in the Laboratory	
1.	Transistor Characteristics-CE Mode
2.	Transistor Amplifier – CE mode and CC Mode
3.	FET Characteristics
4.	FET amplifier
5.	OP AMP- Inverting & Non-inverting amplifiers
6.	Determination of Thermal conductivity of a bad conductor
7.	Wien bridge oscillator
8.	Half-wave and Full-wave rectifiers – determination of ripple factor and percentage of regulation with and without filter.
9.	Zener diode characteristics – study of characteristics and voltage regulation.
10.	Determination of specific heat of water by Joule's calorimeter.
11.	Determination of Thermal conductivity of rubber.

Reference Book for Laboratory Experiments	
Sl No	**Title of the Book**
1.	Basic Electronics Lab (P242) Manual 2015-16, National Institute of Science Education and Research, Bhubaneswar, 2015
2.	**Suggested Readings:** 1. B.L. Worsnop, H.T. Flint, "Advanced Practical Physics for Students", Methuen & Co., Ltd., London, 1962, 9e. 2. S. Panigrahi, B. Mallick, "Engineering Practical Physics", Cengage Learning India Pvt. Ltd., 2015, 1e.

Semester-V

(NEP Syllabus)

PH5123: Introduction to Classical Mechanics and Quantum Mechanics

TOTAL HOURS 45

UNIT I: Lagrangian Formulation:

Constraints: - Holonomic and Non-holonomic constraints, Scleronomous and Rheonomous constraints, Degrees of freedom, generalized coordinates, Configuration space, Principle of virtual work, D' Alembert's principle, Lagrange's equations, Kinetic energy in generalized coordinates, Generalized momentum, First integrals of motion and cyclic coordinates.

Conservation Laws and symmetry properties: - Homogeneity of space and conservation of linear momentum. Isotropy of space and conservation of angular momentum, Homogeneity of time and conservation of energy. **(10 hours)**

Self-study:- Noether's theorem (qualitative) **(1 hour)**

Hamilton's principle:

Deduction of Hamilton's principle from D'Alembert's principle, Lagrange's equation from Hamilton's principle. **(4 hours)**

UNIT II: Matter waves:

Failure of classical mechanics and introduction to quantum mechanics (qualitative), de Broglie hypothesis, de-Broglie equation, different forms- both non-relativistic and relativistic cases. Davisson and Germer experiment, G.P Thomson experiment, properties of de-Broglie waves, phase velocity, concept of wave packet- group velocity, relation between phase velocity and group velocity for non-relativistic particles. Heisenberg's uncertainty principle - different forms. **(9 hours)**

Concept of wave function, conditions for an acceptable wave function of a de- Broglie wave, probability density, Born's interpretation of wave function, normalization condition, operators – eigenvalue equation, eigenfunction, eigenvalue, expectation values and commutation relations (between **x, p, L, H**, **V** & **E** operators). **(4 hours)**

Self-study: - Application of uncertainty principle-Wave concept applied to Bohr orbit, Non-existence of electron inside the nucleus, size of the Bohr atom. **(2 hours)**

UNIT III: Schrodinger's equation and its applications:

Setting up of Schrodinger's wave equation- both time-dependent and time-independent cases. Particle in an infinite potential well in one dimension-expression for energy and eigenfunction, Extension to three dimensions (no derivation) – degeneracy. Equation of continuity, probability-current density. Step potential in one dimension- Setting up of the wave equation and its solutions for both $E>V_o$ and $E<V_o$ cases, reflection and transmission coefficients for $E>V_o$ case (no derivations), barrier penetration, and its transmission coefficient (qualitative). **(9 hours)**

Harmonic oscillator - expression for energy, zero-point energy and mention of waveforms. Hydrogen atom- setting up of azimuthal, polar and radial equations and their significance (qualitative) - quantum numbers, n, l, m_l and m_s. **(4 hours)**

Self-study:- Tunneling effects- alpha decay and tunnel diode (qualitative), Quantum dots **(2 hours)**

Text Books:

1. Classical Mechanics - Aruldhas, G., (3rd Edition) 2012, PHI Learning Pvt. Ltd
2. Modern Physics-Tipler, P.A., Llewellyn, R.A., (5th Edition), 2007, Freeman and Company

Reference Books:

1. Classical Mechanics- Goldstein, H, Safko, Poole, (3rd Edition), 2011, Pearson New International Edition
2. Classical Mechanics- Rana. N, Jog, P, (2nd Edition), 2017, McGraw Hill Education
3. Fundamentals of Classical Mechanics- Gupta, A.B., 2022, A.B. Book House
4. An Introduction to Mechanics- Kleppner. D, Kolenkov, R, (2nd Edition), 2014, Cambridge University Press
5. Classical Mechanics – Kibble, T, Berkshire F.H, (5th Edition), 2004, Imperial College Press
6. Mechanics: Course of Theoretical Physics-Vol 1- Landau, L.D, Lifshitz, E.M., (3rd Edition), 2010, Elsevier Publishing

7. Classical Mechanics- Upadhyaya, J.C., (3rd Edition), 2019, Himalaya Publishing House
8. Feynman Lectures-Vol.3-Feynman, R. P, Leighton, R. B. Sands, M, (New Millennium Edition) 2013, Pearson Education
9. Introduction to Quantum Mechanics- Griffiths, D.J., (2nd Edition), 2013, Pearson
10. Quantum Mechanics Theory and Applications- Ghatak, A. Lokanathan, S. (6th Edition), 2012, Trinity Press
11. Concepts of Modern Physics- Arthur Beiser, Mahajan, S., Rai Choudhury, S. (7th Edition), 2017, McGraw Hill Education
12. Quantum Mechanics-Vol.1-Cohen-Tannoudji, C. Diu, B. Laloe, F.1977, John Wiley & Sons
13. Quantum Mechanics- Merzbacher. E, (2nd Edition), 1970, John Wiley & Sons.
14. Modern Physics, J. B. Rajam, S. Chand & Co. (2014)
15. Modern Physics, H.S. Mani and Metha.(problems), Affiliated East-West Press, (2014)

PH 5P1 General Physics Laboratory

List of Experiments:

1. Wavelength of Laser by diffraction using a steel ruler
2. Application of CRO to study Lissajous figures
3. Emissivity of an object that is close to a black body
4. Michelson Interferometer
5. Young's double slit experiment
6. Estimating Stefan's constant
7. Dielectric constant of a nonpolar liquid
8. Hysteresis curve of a ferro-magnetic material
9. Particle size measurement-lycopodium
10. Gouys method for magnetic susceptibility
11. Tunnel diode characteristics

*Any other relevant experiment that the Department of Physics deems fit to be included.

Semester-V

(NEP Syllabus)

PH5223: ELEMENTS OF ATOMIC AND MOLECULAR PHYSICS

UNIT I:

Atomic Spectra: Review of atom models, (Thomson's model, Rutherford's model, Bohr's model, Sommerfeld's relativistic atom model and Vector model). Space quantisation, spin electron hypothesis. Spectrum of H. Various quantum numbers n, l, s, j, m_l, m_s, m_j. Pauli's exclusion Principle. Spectroscopic notation of state of atoms, Coupling schemes, L-S coupling, and j-j coupling schemes. **(8 hours)**

Magnetic moment due to orbital motion. Magnetic moment due to spin. Stern -Gerlach experiment -Experimental procedure and interpretation of result. Spin-orbit coupling. Expression for the spin orbit interaction energy (Qualitative). General selection rules. Fine structure - separation of sodium lines. **(5 hours)**

Self-Study: fine structure of Hydrogen atom. **(2 Hours)**

UNIT II:

Zeeman effect - Larmour precession, Normal Zeeman effect, expression for Zeeman shift (on the basis of vector atom model), Anomalous Zeeman effect **(4 hours)**

Molecular spectra: Different regions of molecular spectra-Energy level diagram of a molecule, pure rotational motion – diatomic molecule as a rigid rotator, expression for the rotational energy, rotational spectrum- selection rule. Intensity of spectral line. Pure vibrational spectrum - mention of vibrational energy levels – selection rule. Rotational – vibrational spectrum, selection rules. Electronic Spectra of Diatomic molecules: The Born-Oppenheimer approximation, Intensity of vibrational-electronic spectra, Franck-Condon Principle (Qualitative) **(9 hours)**

Self-study: Stark Effect and Paschen-Back Effect **(2 Hours)**

UNIT III:

Scattering and Raman effect: Coherent and Incoherent scattering, Rayleigh scattering. Raman Scattering. Quantum Theory of Raman effect, Pure Rotational

Raman spectra: Linear molecules, symmetric top molecules, asymmetric top molecules, Raman activity of vibrations. Intensity, depolarisation ratio of Raman lines. Compton effect-expression for Compton shift. Rayleigh scattering and Mie scattering(qualitative). **(10 hours)**

Black body spectra: Wien's displacement law, Rayleigh-Jean's law, Planck's law of radiation: quantum hypothesis, deductions from Planck's law. CMB Radiations as an example. **(3 hours)**

Self-study: Applications of Raman Effect, Vibrational Raman spectra. **(2 hours)**

Text Book:

1. Atomic Physics (Modern Physics) by Dr. S.N. Goshal, S. Chand Publications, Year

Reference Books: year

1. Concepts of Modern Physics by Arthur Beiser ,6th edition, Tata Mc Graw Hill (2002).
2. Atomic spectra & atomic structure, Gerhard Hertzberg: Dover publication, New York (1944).
3. Molecular structure & spectroscopy, G. Aruldhas; Prentice – Hall of India, New Delhi (2001).
4. Fundamentals of molecular spectroscopy, Colin N. Banwell & Elaine M. McCash, Tata McGraw –Hill publishing company limited (2004).
5. Introduction to Atomic spectra by H.E. White, McGraw Hill (1934).
6. Spectra of diatomic molecules by Gerhard Herzberg, Krieger Publishing Co. (1989).
7. Quantum Mechanics by Jyotrimoy Guha, Books and Allied (P) Ltd. (Chap. 7) (2019).
8. Modern Physics– Murugeshan, Kiruthiga Sivaprasath, S. Chand and Co. Ltd(2018).
9. Modern Physics – Richtmyer, Kennard and Cooper, Tata McGraw Hill (2000)

PH 5P2 Atomic and Molecular Physics Laboratory

List of Experiments:

1. e/m by Thomson’s method using bar magnets.
2. e/m by Thomson’s method using Helmholtz coils.
3. Ionization potential of Xenon.
4. Zeeman Effect- Zeeman shift and hence e/m.
5. Absorption spectra of KMnO4.
6. Analysis of rotational spectrum of Nitrogen.
7. Analysis of rotational- vibrational spectra of HBr.
8. Planck’s constant using photo cell.
9. Rydberg constant using Hydrogen spectrum.
10. Fine structure constant using Sodium lamp.

*Or any other experiments the department deems fit to be incorporated.

Semester-VI

(NEP Syllabus)

PH6123: Elements of Nuclear Physics and Nuclear Instruments

TOTAL HOURS 45

UNIT I:

NUCLEAR STRUCTURE

Nuclear charge, size, radius measurement- mirror nuclei method, electron scattering, mass, spin and binding energy – determination of magnetic dipole moment, electric quadruple moment, parity of nuclei, isospin, theories of nuclear composition, proton – neutron hypothesis, properties of nuclear forces. **(5 hours)**

RADIOACTIVE DECAY

Radioactive disintegration – law of successive disintegration – transient and secular equilibrium –alpha particle disintegration energy – alpha particle spectra. Alpha decay: Gamow's theory, Geiger – Nuttal law. Beta Decay: Beta ray spectra – types of beta decay, Pauli's neutrino hypothesis. Gamma rays –excited states **(5 hours)**

NUCLEAR MODELS

Introduction to different nuclear models- Shell model – evidences – theory – energy level diagram –spin-orbit interaction – magic numbers –spin and Parity- nuclear stability**.** **(3 hours)**

Self-study: proton and electron hypothesis, Radioactive series, Fission and Fusion, Nuclear stability **(2 hours)**

UNIT - II

NUCLEAR REACTIONS

Types of nuclear reactions, Conservation laws, Expression for Q-value equation and threshold energy. Scattering cross-section, Reaction cross section, Coulomb scattering, nuclear scattering, compound and direct nuclear reaction (Qualitative) **(5 hours)**

PARTICLE PHYSICS

Classification of elementary particles - Types of interaction- standard model- hadrons –leptons – baryons – mesons – strangeness – hyperons – antiparticles –antimatter – basic ideas about quarks – types of quarks – quark dynamics– symmetry and

conservation laws -Feynman diagrams– Gell-Mann Nishijima relations, strange particle, CPT Theorem. **(8 hours)**

Self-study: introduction to QCD, CP violation in k decay **(2 Hour)**

UNIT - III

NUCLEAR INSTRUMENTATION

ACCELERATORS Cyclotron – synchrocyclotron – Betatron (**2 hours)**

RADIATION DETECTORS: Techniques for radiation detection – detectors for alpha, beta, gamma rays. Detectors classifications: Gas filled detectors, characteristic curves. Photo multiplier tubes: dark current-pulse resolving power, efficiency of detection, Solid state detectors- CCDs **(7 hours)**

COUNTERS: Proportional counter – GM counter- Scintillation counter. **(2 hours)**

RADIATION PHYSICS

Radiation hazards – biological effects of radiation - radiation sickness – radiation units and operational limits radiation survey meters – pocket dosimeter –control of radiation hazards – radiation therapy – radioisotopes used for therapy – nuclear medicine – industrial applications – food preservativation. **(2 hours)**

Self-study: Electron synchrotron – proton synchrotron (Bevatron), Ionization Chamber. **(2 Hour)**

Text Books:

1. Modern Physics by R. Murugeshan and S. Kiruthiga, S. Chand Publication, Twelfth edition,2005.
2. Modern Atomic and Nuclear Physics by A. B. Gupta, 4th Ed., Books &Allied.

Reference Books:

1. The Atomic nucleus, R.D. Evans, McGraw-Hill, Boston(1969).
2. Radiation detection and measurements Glenn Knoll, 3rd Ed., John Wiley & Sons, Inc.(1999).
3. Physics of nuclear and particles: Vol II, P. Marmier and E. Sheldon, Academic Press, (2013).
4. K. S. Krane, Introductory Nuclear Physics, John Wiley (1988).

5. A. Das and T. Ferbel, Introduction to nuclear and particle physics, John Wiley (1994).
6. I. S. Hughes, Elementary Particles, Cambridge (1991).
7. F. Halzen and A. D. Martin, Quarks and Leptons, John Wiley
8. R. R. Roy and B. P. Nigam, Nuclear Physics: Theory and Experiment, New Age (1967).

PH 6P2 Nuclear Physics Laboratory

List of Experiments:

1. GM Counter Characteristics – to study the operating voltage
2. Verification of inverse square law using G-M Counter
3. Absorption coefficient of Aluminium / Copper using G-M counter
4. Poisson distribution using radioactive source
5. Gamma ray analyser
6. Finding Compton edge using Gamma ray analyser
7. Analog to Digital converter
8. Integrator and Differentiator circuits
9. Clippers and Clampers circuit

*Or any experiments department deems fit to be incorporated.

Semester-VI

(NEP Syllabus)

PH 6223: Elements of Condensed Matter Physics and Devices

Total number of hours: 45

UNIT I:

Crystal structure-Unit cell and its characteristics, seven crystal systems, and Bravais- lattices. Symmetry elements in crystals - cubic crystal. Miller indices, Inter planar spacing, Lattice directions, planes. Wigner - Seitz cell, Concept of reciprocal lattice point, calculation of reciprocal lattice point of SC, BCC and FCC lattices. Lattice directions and planes using miller indices. Structure of first Brillouin zone. Geometric structure factor. Atomic form factor

(10 hours)

X-rays: X-ray production and spectra. X-ray diffraction. Formulation of Bragg and Von Laue condition. (**3 hours**)

Self-study: Liquid crystals- classification properties and applications. (**2 hours**)

UNIT II:

Properties of solids

Classical free electron theory of metals- Drude -Lorentz Expression for electrical conductivity of metals, Ohm's law, Thermal conductivity of metals - Wiedmann-Franz law. **(3 hours)**

Band theory of solids

Free electron gas in three dimension. Fermi-Dirac distribution function. Fermi energy-Density of states for free electrons; Expression for Fermi energy and kinetic energy at T=0K and T>0K (qualitative).

Bloch Theorem -The Bloch function; One dimensional Kronig-Penney Model. Velocity of electron in periodic potential. Energy Vs Wave vector relationship (E Vs k), distinction between conductors, semi-conductors, and insulators.

Intrinsic semiconductors-concept of hole- concept of effective mass and energy gap. Expressions for carrier concentration in an intrinsic semiconductor.

(10 hours)

Self-study: Formation of energy bands in solids. **(2 hours)**

UNIT III:

Superconductivity

Introduction, experimental facts-zero resistivity, critical field, Meissner effect, persistent currents, superconducting magnets, magnetic levitation, isotopic effect. Cooper pairs, BCS theory (qualitative) -Type-I-and Type-II superconductors, high temperature superconductors-applications **(3 hours)**

Self-study: DC and AC Josephson Effect (qualitative) **(1 hour)**

Dielectric Materials:

Electric susceptibility-Dielectric Constant-Electronic, ionic, orientational and Space-charge polarizations-Frequency and temperature dependance of polarization-Internal field-Clausius -Mosotti relation. **(5 hours)**

Self-study: Uses of dielectric materials. **(1 Hour)**

Specific heat of metals-Introduction-classical theory, Dulong and Petit's law - Einstein theory - Debye's theory. (**3 hours**)

Solid state Devices -Solar cells, photoconductivity, light dependent-resistors. Light emitting diodes. **(2 hours)**

Text book:

1. Solid State Physics- S.O. Pillai, New Age International, Eighth edition (2018).

References:

1. Kittel's Introduction to Solid State Physics, Wiley India Edition (2019).
2. Solid state physics- M.A. Wahab, Narosa Publications, II edition, (2005).
3. Fundamentals of Solid-State Physics –A.J. Dekker, Laxmi Publications (2008).
4. Thermodynamics and Statistical Physics- Singhal, Agarwal, Pragati Prakashan (2017).
5. Fundamentals of Statistical and Thermal Physics, Sarat Book House (2010)
6. Statistical Mechanics, B.K. Agarwal, M. Eisner, New Age International (2012)

PH6P2 Condensed Matter Physics Laboratory

List of Experiments:

1. Fermi energy of copper.
2. LDR – Characteristics.
3. Planck’s constant using LED.
4. Analysis of X-ray Photograph-powder method.
5. Diode as a temperature sensor.
6. Solar cell – Fill factor, inverse square law.
7. Determination of dielectric constant.
8. Determination of resistivity by Four probe method.
9. Characteristics of solid-state devices.
10. Hall effect.

- Or any experiments department deems fit to be incorporated.