ST JOSEPH'S UNIVERSITY

BENGALURU – 560027

SYLLABUS

followed during

2024-2027

School of Physical Sciences

DEPARTMENT OF PHYSICS

ST JOSEPH'S UNIVERSITY

BENGALURU-27

School of Physical Sciences

DEPARTMENT OF PHYSICS

Curriculum for B.Sc.

as per

NEP- 2020

UNDERGRADUATE PROGRAMME SYLLABUS FOR

I to VI semester

2021-2022 Onwards

Curriculum Structure

Semester	Title	
	Major: Discipline Core	**OE/DSE**
I Semester	DSC 1: Mechanics & Properties of Matter	OE1.1 Astronomy- the evolving universe OE1.2 Medical Physics
II Semester	DSC 2: Electricity and Magnetism	OE2.1 Wonders of Physics OE2.2 Nanostructures – beauty at the nanoscale
III Semester	DSC 3: Wave Motion and Optics	OE3.3 Energy Resources OE3.4 Introductory Nanotechnology
IV Semester	DSC 4: Thermal Physics & Electronics	OE3.5 Introductory Nanotechnology OE3. 6 Physics of Sports
V Semester	DSC 5: Classical Mechanics and Quantum Mechanics-I DSC 6: Elements of Atomic, Molecular Physics	
VI Semester	DSC 7: Elements of Nuclear Physics and Nuclear Instruments DSC 8: Element of Condensed Matter Physics & Devices	
VII Semester	DSC 9: Mathematical Methods of Physics- I DSC 10: Classical Electrodynamics DSC 11: Experimental Methods of Physics DSC : Research Methodology	
VIII Semester	DSC 12: Classical Mechanics and Quantum Mechanics-II DSC 13: Statistical Mechanics DSC 14: Astrophysics & Astronomy DSC : Research Project	

DSC: Discipline Core (Major)

OE: Open Elective (Open for all the streams)

DSE: Discipline Elective (Optional for I and II Semester)

Course Outcomes and Course Content

Semester	I
Paper Code	**PH 121**
Paper Title	**Mechanics and Properties of Matter**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To make the students understand and learn the basic concepts of Mechanics and Properties of Matter in detail which makes a firm basis for the advanced topics taught in higher semesters. The paper gives a detailed overview of units and measurements, co-ordinate systems, relativity, basic mechanics of system of particles and gravitation which are the basic building blocks for understanding classical mechanics.

Semester- I

PH121: MECHANICS AND PROPERTIES OF MATTER

Unit 1 **15 Hours**

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 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 Cartesian coordinate system.

Self-study: Fictitious forces. Coriolis force.

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.

Self-study: Collision- elastic and inelastic. Perfectly inelastic collision in one dimension - decrease in energy (qualitative).

Unit 2 **15 Hours**

1. 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.

Self-study: Paradoxes in length contraction and time dilation.

2. 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.

Self-study: examples of conservation of angular momentum. Ref: Rotation, Scientific America, compilation of scientific paper.

Unit 3 **15 Hours**

1. 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.

Self-study: I-section girders and its applications.

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

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

Unit 4 15 Hours

1. 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, law of time periods($T^2 \propto A^3$), Geostationary, Geosynchronous satellites.

Self-study: Basic idea of Global positioning system (GPS). India's satellite programmes.

2. 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.

Self-study: Factors affecting surface tension.

Course Outcomes

At the end of this course, students will be able to

- will learn fixing units, tabulation of observations, analysis of data (graphical/analytical)
- will learn about accuracy of measurement and sources of errors, importance of significant figures.
- will know how g can be determined experimentally and derive satisfaction.

- will see the difference between simple and torsional pendulum and their use in the determination of various physical parameters.
- will come to know how various elastic moduli can be determined.
- will measure surface tension and viscosity and appreciate the methods adopted.
- will get hands on experience of different equipment.

Recommended Text Books

1. Mechanics, D.S. Mathur, S. Chand and Company Ltd. 2000.
2. Mechanics and Relativity, Vidwan Singh Soni, 3th edition., PHI leaning Pvt. Ltd, 2014.
3. Mechanics Berkeley Physics Course, Vol.1, Charles Kittel, 7th edition, Tata McGraw-Hill, 2007.
4. Properties of Matter, Brijlal & Subramanyam, S. Chand and Company Ltd. 2002.
5. Physics for Degree Students, B.Sc First Year, C.L. Arora and P.S. Hemne, S. Chand and Company Ltd. 2010.

Reference Books:

1. Fundamentals of Physics, Resnick, Halliday & Walter, Wiley, 2002.
2. Newtonian Mechanics, A.P. French, WW Norton & Co.
3. Solid State Physics, Charles Kittle, Wiley India Pvt, Ltd. 2018.

Practical I

PH 1P1: Practical **(11 sessions 4 hours/week)**

List of experiments

1. Determination of g using bar pendulum (L versus T, L vs Log 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. Study of Hook's law
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 (Study of damping)
19. Spring-mass oscillator
20. Interfacial surface Tension
21. Young's modulus by uniform bending

PH-OE1- ASTRONOMY – THE EVOLVING UNIVERSE

Prerequisite: PUC Pass. **Total hours: 45**

Course Title: **Astronomy -the evolving universe**	Course Credits: 3
Total Contact Hours: 39	Self-study Hours: 6
Formative Assessment Marks: 40	Summative Assessment Marks: 60
Duration of ESA: 1 Hr 30 min	

The objective of the course:

1. To communicate the excitement about astronomy and to awaken students to themarvelous universe.
2. To understand and appreciate the evolving universe which eventually helps us to think about who you are and where you and the human race are going.

SYLLABUS

1. The Foundations of astronomy: **6 Hours**

Celestial sphere, constellations in the sky, celestial co-ordinates. The changing perceptions of the universe, our place in space, earth's orbital motion, rotational motion, seasonal changes and eclipses.

2. The tools of astronomy: **9 Hours**

Electromagnetic spectrum, The seven astronomies, the visible astronomy, optical telescopes, functions of the telescopes - reflecting and refracting telescopes, invisible astronomy, radio telescopes, radio interferometers, advantages and disadvantages, space-based astronomy. Discovery of gravitational waves.

3. Solar System: **4 Hours**

Origin of solar system, terrestrial planets, Jovian planets, moons and other celestial objects. Sun: Overall structure of sun, the solar atmosphere, sun spots, solar flares.

4. Evolution of stars: **9 Hours**

stellar classification, H-R-diagram, main sequence stars, evolution of sun like stars, planetary nebula, white dwarf- physical properties, Chandrasekhar limit, evolution of massive stars, supernova, neutron stars- physical properties, pulsars, Blackholes, event horizon.

5. The Milky Way Galaxy: **3 Hours**

Overall structure, galactic disc, galactic halo and bulge. The galactic Centre. The central supermassive balck hole.

6. Universe beyond the Milky Way: **3 Hours**

Hubble's galaxy classification, clusters of galaxes, Hubbles's law, the expanding universe, the rae of expansion of the universe-Hubble's constant. Determination of an obect's distance along the object.

7. The Big Bang and the fate of Universe: 5 Hours The Big Bang theory, red shift, distance and look-back time. Calculation of the age of the universe. Cosmic Microwave Background Radiations (CMBR), dark matter and dark energy.

Reference

1. Universe: Roger A. Freedman and William J. Kaufmann III, W. H. Freeman and company, New York.
2. Introductory Astronomy and Astrophysics 4th edn.1998 by Michael Zelik & Stephan A Gregory.

PH-OE2 MEDICAL PHYSICS

Prerequisite: PUC Pass. **Total hours: 45**

Course Title: **Medical Physics**	Course Credits: 3
Total Contact Hours: 39	Self-study Hours: 6
Formative Assessment Marks: 40	Summative Assessment Marks: 60
Duration of ESA: 1 Hr 30 min	

The objective of the course:

1. To promote the application of Physics
2. Understand the anatomy of the nervous system and its signal measurements (EMG, CAT).
3. Analyze and understand the applications of the imaging techniques transmission (x- ray and ultrasound)
4. Updating the knowledge in recent trends in medical field.

1. Mechanics of Human Body: 7 Hours

Static, Dynamic and Frictional forces in the Body – Composition, properties and functions of Bone– Heat and Temperature – Temperature scales – Clinical thermometer – thermograph – Heat therapy – Cryogenics in medicine – Heat losses from body – Pressure in the Body – Pressure in skull, Eye and Urinary Bladder.

2. Physics of Respiratory and Cardiovascular System 8 Hours

Body as a machine – Airways – Blood and Lungs interactions – Measurement of Lung volume Structure and Physics of Alveoli – Breathing mechanism – blood Pressure – direct and indirect method of measuring.

3. Electricity in the Body 8 Hours

Nervous system and Neuron – Electrical potentials of Nerves – Electric signals from Muscles, Eye and Heart – Block diagram and working to record EMG – Normal ECG waveform – Amplifier and Recording device – Block diagram and working to record ECG – Patient monitoring – Pace maker.

4. Sound and Light in Medicine 8 Hours

General properties of sound – Stethoscope – Generation, detection and characteristics of Ultrasound– Ultrasound imaging technique – A scan and B scan methods of ultrasound imaging – properties of light – Applications of visible UV, IR light, and Lasers in medicine – Microscope – Eye as an optical system- Elements of the Eye

5. Diagnostic X- Rays and Nuclear Medicine 8 Hours

Production and properties of X- rays – Basic Diagnostic X-ray Machine – X-ray image - Live X-ray image

– Radioactivity sources for nuclear medicine – Basic instrumentation and clinical applications Principles of Radiation Therapy- Nuclear medicine imaging devices – Radiation sources.

REFERENCES:

1. John R. Cameron and James G. Skofronick, John Wiley &Sons –Medical Physics, Wiley – Inter science Publications ,1978.
2. R.S. Khandpur – Handbook of Biomedical Instrumentation, Tata McGraw Hill Publication Co.,Delhi,1987.
3. Biological Physics, Bogdanov.

Prerequisites: *The course is open for students of all the streams. No special prerequisite is required for this course other than interest in learning Astronomy and Medical Physics.*

Course Outcomes and Course Content

Semester	II
Paper Code	**PH-2**
Paper Title	**Electricity and Magnetism**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

The basic working knowledge on the scalar and vector fields and operators. Exposure to electrostatic fields and interaction with systems. Method of applying Gauss law in various systems. Exposure to Conductors and insulators in electrostatic fields. To familiarize the magnetostatic field and interactions, magnetic properties of the system. Develop ability in students to apply knowledge and skills they acquire to find the solution of specific problems in static and dynamic electromagnetic fields.

Semester- II

PH221: ELECTRICITY AND MAGNETISM

UNIT 1: **15 Hours**

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).

2. Electric field and Potential: Coulomb's law, electric field strength, electric field lines, electric field and electric potential due to a point charge, Relation between field and potential ($\mathbf{E} = -\nabla \mathbf{V}$), Electric dipole - electric potential and field at any point due to a dipole. Potential due to electric quadrupole (qualitative), Constant potential surfaces.

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.

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).

UNIT 2: **15 Hours**

1. 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

2. Steady and Variable Currents:

Steady currents: Physics of electrical conduction in metals. Electric currents and current density, Electrical 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).

Self-study: Currents and voltage in combination of R, L and C circuits.

Unit 3: **15 Hours**

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

Electromagnetic Induction: 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.

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

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.

UNIT 4: **15 Hours**

1. 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. Electric and Magnetic fields 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.

2. 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.

Self-study: B-H curves and its characteristics, Ferrites

Course Outcomes

At the end of this course, students will be able to

- 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.
- Explain and differentiate the vector (electric fields, Coulomb's law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
- Apply Gauss's law of electrostatics to solve a variety of problems.
- Describe the magnetic field produced by magnetic dipoles and electric currents.
- Explain Faraday-Lenz and Maxwell laws to articulate the relationship between electric and magnetic fields.

- Describe how magnetism is produced and list examples where its effects are observed.
- 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.
- 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.

Recommended 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.

Reference Books

1. Physics, Part II, David Halliday and Robert Resnick, Wiley Eastern Lt. 2001.
2. Berkeley Physics Course, Vol.2, Electricity and Magnetism, Special Edition, Tata McGraw-Hill Publication, Ltd, 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, Murray R. Spiegel, et al, McGraw-Hill Education, 2^{nd} Edition, 2000.
6. Electromagnetism, B.B. Laud, New age international Publishers, 2005.
7. Feynman Lecture Series, Vol. II,

Practical II

PH2P1: PRACTICALS **(11 sessions 4 hours/week)**

List of experiments

1. Experiments configuration on tracing of electric and magnetic flux lines for standard
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 Eearth'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 BH

PH-OE3 WONDERS OF PHYSICS

Prerequisite: PUC Pass. **Total hours: 45**

Course Title: **Wonders of Physics**	Course Credits: 3
Total Contact Hours: 39	Self-study Hours: 6
Formative Assessment Marks: 40	Summative Assessment Marks: 60
Duration of ESA: 1 Hr 30 min	

Objective of the course:

- To induce a sense of wonder and awe among the students when they look at the world around them.
- To rationalize the thoughts and build a bridge between the science that they study in the course and its application in their daily life.

1. Science: A wonder of reality: **2 hours**

Introduction, six different ways of arriving at knowledge, Aristotelian science, the three fundamental entities of reality – Space, time and matter.

2. Space: **20 hours**

a) Universe by design: Powers of ten, nucleus to deep space, from backyard to the big bang – A brief history of cosmology, cosmic distances and constants, relative size of celestial objects. twentieth century cosmology, composition of stars, the nature of light, introduction to telescopes, more recent developments in cosmology, tools for explaining the universe, the big bang model, fine-tuned universe, the law of cause and effect, A pale blue dot but a privileged planet, the paradox of Newtonian physics and the physics of Einstein - the beauty of relativity, Time machine and time travel, Science and science fiction of interstellar movie, inverse gamblers fallacy and multiverse, uniformity in nature, Hawkings radiation and Hawkings reason, patterns in the universe-math & astronomy. **(15 hours)**

b) Frontiers of Astronomy: From dawn to dusk, exploring the night sky, understanding the eye, recent discoveries in the solar system, other worlds, life and death of stars –white dwarf, supernova, neutron stars and black holes. **(5 hours)**

3. Time **6 hours**

a) A Physical quantity: The International System (SI) of measurement for physical quantities, the unit of time, Measuring time with atomic clocks, Time in astronomy, Time in biological systems, other aspects of physical time. (**2** hours)

b) **An anthropological quantity:** Introduction, Attributes of time, application of information science in interpreting time, the five levels of time, time and eternity. (**4**hours)

4. Matter **6 hours**

Properties of matter, Matter and energy, the amazing quantum world, wave particle duality, logic and physics, materialism, the equation of life and death, Erwin Schrödinger and the birth of information science.

5. Classroom physics: **5 hours**

Demonstration experiments in the class by the resource person and students on pressure, magnetism, electricity, optics, mechanics.

PH-OE4 NANOSTRUCTURES: BEAUTY AT THE ATOMIC SCALE

Prerequisite: PUC Pass. **Total hours: 45**

Course Title: **Nanostructures: Beauty at the atomic scale**	Course Credits: 3
Total Contact Hours: 39	Self-study Hours: 6
Formative Assessment Marks: 40	Summative Assessment
Duration of ESA: 1 Hr 30 min	

Objective of the course:

- To recall the Quantum concepts and density of states
- To compare the different thin film coating techniques
- To understand the theoretical concepts of nanomaterials

Course Outcome: Students will be able to

- apply the knowledge to prepare Nano materials
- interpret different nano structures
- examine the characteristics of nanomaterials
- design nano devices for sensing
- measure the properties of nanomaterials through different techniques
- appraise the MEMS and NEMS technology

I. Introduction to Nanotechnology: **8 Hours**

History of nanotechnology, nano and nature, what is a nanomaterial, properties of nano structured materials, introducing nano to the world: Richard Feynman's role, nanotechnology as process. **(2 hours)**

Survey of different synthesis methods: Sol-gel process, CVD, hydrothermal method, spray pyrolysis, vacuum deposition techniques (with videos) **-(3 hours)**

Investigating materials at the nanoscale: electron microscopies, scanning probe microscopies and optical microscopies, the role of scanning tunneling microscope **-(3 hours)**

II. Graphene and the world of 2D materials: 8 Hours

Carbon-based materials, buckyballs, carbon nanotubes, graphene, diamonded, chemistry of carbon materials (basic)-**(2 hours)**

Graphene, properties of graphene, band structure (quantitative) of graphene, various graphene synthesis methods, properties of graphene-**(3 hours)**

2D materials other than graphene: TMDs, hBN, BP, MOFs, heterostructures, interesting quantum phenomena-magic angle, Moiré patterns, superconductivity in layered materials-**(3 hours)**

III. Nanotechnology in various applications: 8 Hours

Medical nanobiology, biomolecules, organic molecules, nano biosensors, nanolithography, current status of nanobiotechnology **(2 hours).**

Nanosensors, 2D semiconductors, transistors, integrated circuits, memory devices, self-cleaning materials, spintronics, valleytronics (qualitative) **(3 hours).**

Computer simulation of experiments, making models using open-source software (vesta), basics of image analysis using online resources **-(3 hours)**

IV. Nanotechnology, society and ethics: 8 Hours

Nanotechnology applications in water purification, solid waste management, air pollution control designs, harnessing nanotechnology for economic and social development, nano technology in business-**(2 hours)**

Ethical issues: GM food and nanotechnology, nanotechnologically enhanced combat systems, environmental impacts of nano research, public policies **(3 hours)**

Current research trends in nanotechnology, well-known nano websites, research institutes in India and abroad, requirements of research, interaction with nano researchers **(3 hours)**

Reference books:

1. Nano: The essentials-understanding nanoscience and nanotechnology, T. Pradeep, Tata McGraw-Hill Publication Company Limited.

2. Nanotechnology: Environmental implications and solutions, Louis Theodore and Robert G. Kunz, Wiley and Sons.

Course Outcomes and Course Content

Semester	III
Paper Code	**PH321**
Paper Title	**Oscillations, Waves and Optics**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To make the students understand and learn the basic concepts of Physics in detail which makes a firm basis for the advanced topics taught in higher semesters. The paper gives a detailed overview of Waves and Oscillations, Simple Harmonic Motion of Waves. It also provides an overview on light wave phenomena such as Interference, Diffraction and Polarisation which are the basic building blocks for understanding and designing Fiber Optic devices and Lasers.

Semester- III

PH321: OSCILLATIONS, WAVES AND OPTICS

Unit I **(10 Hours)**

Simple Harmonic Motion: 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.
Self-Study. Forced oscillation – concept of resonance. **(1 hour)**

Unit II **(08 Hours)**

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

Text Book: Undergraduate Physics Volume II – A. B. Bhattacharya

UNIT III **(07 Hours)**

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 theinterfering beams. Interference at thin films (reflected system), theory of interference at a wedge and theory of Newton's rings. **Self-study:** Young's double slit experiment. **(1 Hour)**

Unit IV **(09 Hours)**

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

Unit V **(07 Hours)**

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

Unit VI **(06 Hours)**

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

Unit VII **(05 Hours)**

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

Course Outcomes

At the end of this course, students will be able to

- Study and analyze basic properties of waves and oscillations.
- Recognize the general wave motion and its properties
- Identify the importance of Fourier theorem and series and its applications
- Understand the wave nature phenomena of light.
- Describe the behavior of basic fiber optic devices
- Understand the properties of Lasers
- Study to construct the laser and fiber optic devices.
- Explain the characteristics and applications of Optical fibers and Lasers..

Reference Books:

1. Oscillations & waves – D.P.K. Hadelwal, Himalaya Publishing house.
2. Oscillations & Waves – Brijlal & Subramanyam, S Chand & co.
3. Concepts of Physics Vol.I – H.C. Verma , Bharathibavan Publications- Delhi.
4. Mechanics by Berkley Physics Course Vol I, Mittal, Knight & Rudermann, TMH- Delhi, 1981.
5. University Physics – F. W. Sears and Zemansky & H.D. Young – Narosa Publications – New

Delhi.
6. Fundamentals of Physics, 6th Edition – Resnick, Halliday & Walker – Asian Books Pvt Ltd-New Delhi, 5th Edition.
7. Optics & Spectroscopy by Murugeshan S. Chand and Co. Ltd 2008.
8. Optics by D. N. Vasudeva, S. Chand and Co.Ltd
9. Optics by Ajoy Ghatak and Thyagarajan, Tata-McGraw-Hill Education Pvt Ltd, 4th Edition, 2006.
10. Optics by Khanna and Gulati, S. Chand and Co. Ltd. 1985.
11. Optics by Brijlal and Subramanyam S. Chand and Co. Ltd. 2012.
12. Lasers and Fiber Optics by B.B. Laud.
13. Engineering Physics by R.K. Gaur and S.L. Gupta, Dhanpat Rai Publicaitons.
14. Undergraduate Physics by A.B. Bhattacharya and R. Bhattacharya.
15. Engineering Physics by S. B. Bhasavaraju.
16. Waves and oscillation by A.P.French

PH3P1: PHYSICS PRACTICAL

PH 3P1: Practical **(11 sessions 4 hours/week)**

List of experiments

1. Air Wedge – determination of thickness of a wire.
2. Newton's rings – determination of radius of curvature of a plano-convex lens
3. Diffraction grating- determination of wavelengths of spectral lines in normal incidence position.
4. Diffraction grating- determination of wavelengths of spectral lines in minimum deviation position.
5. Focal length of combination of lenses
6. Polarimeter-determination of specific rotation of sugar
7. Measurement of numerical aperture and attenuation coefficient of an optical fiber.
8. Wavelength of laser using grating.
9. Determination of acceleration due to gravity using spring mass oscillator.
10. Coupled Oscillators – determination of period for normal modes and frequency of energy transfer.
11. Melde's experiment -Determination of frequency in transverse and longitudinal mode.
12. Fourier analysis

PHOE5- OPEN ELECTIVE-V

ENERGY RESOURCES/ NON-CONVENTIONAL ENERGY RESOURCES

Prerequisite: I B.Sc. **Total hours: 45**

Course Title: **Energy Resources**	Course Credits: 3
Total Contact Hours: 39	Self-study Hours: 6
Formative Assessment Marks: 40	Summative Assessment Marks: 60
Duration of ESA: 1 Hr 30 min	

The objective of the course: Students be able to

1. Get an introduction to the renewable energy resources – Sun, Wind, Biomass and Geothermal heat.

2. introduce the fundamental physical processes governing various non-conventional energy technology and applications.

3. stresses scientific understanding, analysis and applications of non-conventional energy technology.

4. understand that these sources can play a very important supportive role in addition to conventional energy resources.

5. understand the energy planning, policy making and consumption.

SYLLABUS

1. **INTRODUCTION TO ENERGY SCIENCE AND TECHNOLOGY**

   Classification of Energy resources –common forms of energy-its merits and demerits-importance of non-conventional energy sources – and its salient features –Global Energy Scenario: availability of energy: conventional and non-conventional resources – Energy scenario in India – availability of energy: conventional and non-conventional resources**. (Hours 5)**

   Applied thermodynamics: important terms and definitions-Laws of thermodynamics and its limit – power cycles: Carnot, Brayton and Stirling cycles- its comparison. **(Hours 2)**

2. **SOLAR ENERGY**

Sun and Earth- its radiation spectrum- Extra-terrestrial and terrestrial radiations- spectrum power distribution of solar radiation – Depletion of solar radiation – measurement of solar radiation: pyranometer- pyrheliometer & Sunshine recorder –solar radiation data- solar time(LAT) – Solar radiation geometry- solar day length – Extraterrestrial radiation on inclined surface -Solar radiation on inclined plane surface. **(Hours 7)**

3. **WIND ENERGY**

Origin of winds-nature of winds-estimation of wind energy at a site-applications of wind power. Wind turbine aerodynamics – Wind turbine types and its constructions-conversion system and energy storage- wind energy program in India.

Basic Fluid Mechanics: Elementary fluid flow – stream line and turbulence. **(Hours 6)**

4. **BIO-MASS ENERGY**

Photosynthesis – Biomass forms, composition and fuel properties – Biomass resource-conversion methods- Urban waste to energy conversion-Biomass gasification – Biomass liquification – Biogas production from waste biomass- Various biogas models .**(Hours7)**

5. **GEOTHERMAL ENERGY**

Introduction of geothermal energy and its applications – types of geothermal resources – mathematical analysis of geothermal resources – Exploration and its development – Geothermal energy in India. **(Hours 6)**

6. **OCEAN ENERGY**

Tidal Energy: Origin- Limitations and technology – tidal range power-ocean tidal energy conversion scheme-Environmental impact.

Wave Energy: Power in waves – its technology- Environmental impact.

Ocen thermal Energy: Origin and characteristics- conversion technology-Environmental impact. **(Hours 6)**

7. **ENERGY TECHNOLOGIES AND ITS STORAGE**

Energy Technology: Introduction -Fuel Cell – Hydrogen as Energy Carrier - Thermoelectric power conversion- Magneto Hydrodynamic power conversion – Thermionic power conversion.

Energy storage: Its necessity- specifications – energy storage devices. Storage methods: mechanical, Electrochemical (secondary battery storage), Chemical (hydrogen and reversible chemical storage), Electromagnetic (Superconducting Magnetic Energy storage), Electrostatic (supercapacitors), thermal (sensible and latent heat storage) and biological energy storage methods. **(Hours 7)**

TEXT BOOK:

1. Non-conventional Energy Resources by B.H.Khan.

REFERENCE BOOK:

1. Non-conventional Energy Resources by G.D. Rai.
2. Renewable Energy Resources by John Twidell and Tony Weir.
3. Non-conventional Energy Resources by G.S. Sawhney.
4. Non-conventional Energy Resources by Shobh Nath Singh.
5. Energy and Society: an introduction by Schobert and Harold H.

PHOE6 & PHOE 7- OPEN ELECTIVE-

VI INTRODUCTORY

NANOTECHNOLOGY

Note: This OE paper is approved by the BOS members, however it needs some revision as suggested by members.

Prerequisite: I B.Sc. **Total hours: 45**

Course Title: Introductory Nanotechnology	Course Credits: 3
Total Contact Hours: 39	Self-study Hours: 6
Formative Assessment Marks: 40	Summative Assessment Marks: 60
Duration of ESA: 1 Hr 30 min (or) 2 Hr	

The objective of the course: Students be able to

1. understand the basics of Nanoscience and Nanotechnology.

2. identify 0D, 1D, 2D and 3D nanomaterials.

3. know various synthesis techniques available for nanostructured materials.

3. recognize the role of nanotechnology in electronics and medicine.

1. **INTRODUCTION TO NANOMATERIALS**
   Basic concepts of nano materials – Density of states of 1,2 and 3D - quantum well, wire, dot-Schrodinger wave equation for quantum wire, Quantum well, Quantum Dot- Formulation of super lattice- Quantum confinement- Quantum cryptography. **(Hours 9)**

2. **FABRICATION OF NANOSCALE MATERIALS**

   Top-down versus Bottom-up –Thin film deposition -Epitaxial growth -CVD, MBE, plasma - Lithographic, photo, e-beam - Etching -Synthesis -Colloidal dispersions -

Atomic and molecular -manipulations –Self-assembly -Growth modes, Stransky-Krastinov etc –Ostwald ripening. **(Hours 9)**

3. ELECTRICAL AND MAGNETIC PROPERTIES

Electronic and electrical properties-One dimensional systems-Metallic nanowires and quantum conductance -Carbon nanotubes and dependence on chirality -Quantum dots – Two dimensional systems -Quantum wells and modulation doping -Resonant tunnelling – Magnetic properties Transport in a magnetic field - Quantum Hall effect. -Spin valves - Spin-tunnelling junctions -Domain pinning at constricted geometries -Magnetic vortices. **(Hours 10)**

4. MECHANICAL AND OPTICAL PROPERTIES

Mechanical properties hardness – Nano indentation - Individual nanostructures -Bulk nanostructured materials-Ways of measuring- Optical Properties-Two dimensional systems (quantum wells)-Absorption spectra -Excitons - Coupled wells and superlattices -Quantum confined Stark effect. **(Hours 8)**

5. NANODEVICES

Background -Quantization of resistance -Single-electron transistors - Esaki and resonant tunneling diodes -Magnetic Nanodevices -Magnetoresistance –Spintronics- MEMS and NEMS. **(Hours 9)**

REFERENCE BOOK:

1. Introduction to Nanotechnology, Charles P. Poole, Jr. and Franck J. Owens, Wiley 2004.
2. Silicon VLSI Technologies, J.D. Plummer, M.D. Deal and P.B. Griffin, Prentice Hall, 2000.
3. Introduction to Solid State Physics, C. Kittle, a Chapter about Nanotechnology, Wiley, 2004.
4. Quantum Well, Wire and Dot: Theory and Applications, Paul Harrison, John Wiley & Sons, (2005).

Course Outcomes and Course Content

Semester	IV
Paper Code	**PH421**
Paper Title	**Thermodynamics and Electronics**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To make the students understand and learn the basic concepts of Thermodynamics and Electronics in detail which makes a firm basis for the advanced topics taught in higher semesters. The paper gives a detailed overview of Thermodynamics and Electronics with real time applications. It also provides an overview on semiconductor devices such as semiconductor diodes, BJT, FET, OPAMs and Oscillators which are the basic building blocks for understanding and designing integral parts on devices.

PH421: THERMAL PHYSICS AND ELECTRONICS

Unit I **09 Hours**

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.
Self-study: Coefficient of thermal conductivity **(1Hour).**

Unit II **07 Hours**

Thermodynamics: Zeroth law, First law of thermodynamics, Concept of internal energy, Different types of thermodynamic processes – isothermal, adiabatic, isobaric & isochoric. Derivation of PV^{γ} = 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.
Self-study: Reversibility of Carnot engine – refrigerator, coefficient of performance. **(1 Hour)**

Unit III **06 Hours**

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

Unit IV **04 Hours**

Real gases & Liquefaction of gases: Andrew's isothermal curves for real gases, Vander Waals' equation critical constants (Definition & derivation). Joule Thomson expansion- porus plug experiment with theory.
Self-study: Difference between Joule Thomson expansion & adiabatic expansion, adiabatic de-magnetization. **(1 Hour)**

Unit V **06 Hours**

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

Unit VI **12 Hours**

Bipolar Junction Transistor (BJT) and Field Effect Transistor (FET)
BJT- Construction and basic action, Configurations (CB, CE and CC). Definition of α, β and their relations. Input, output and transfer characteristics of CE mode. 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 amplifier– working, gain and frequency response, CC amplifier - applications.
FET- Construction and working, Static Characteristics, Shockley's equation. Drain characteristic and transfer characteristic. FET parameters. FET amplifiers.
Self-study- Comparison between BJT and FET. Transistor as a switch MOSFET **(2 Hours)**

Unit VII **08 Hours**

Operational Amplifiers, Oscillators 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.
Self-Study- Operational amplifier as comparator. **(1 hours)**

Reference books:
1. Physics for Degree students (BSc First year)- C. L Arora, Dr. P. S. Hemne S. Chand & Company 2nd revised edition -2013
2.Heat and Thermodynamics – D. S. Mathur – S Chand & Co, New Delhi 5th Edition (2004).
3. Heat Thermodynamics and Statistical Physics – Brijlal Subramanyam & P.. Hemne, S Chand & Co.
4. Heat and Thermodynamics – J.B Rajam
5. Heat and Thermodynamics - M.W. Zemansky, Richard H. Dittman
6. Thermodynamics -Enrico Fermi
7. Why are Things They are? (Vignettes of Physics) - G. Venkataraman
8. Electronic devices and circuit theory – Robert Boylsted
9. Electronic principles – A.P Malvino
10.Principles of electronics- A.P.Malvino (Mc Graw-Hill Pub.)
11. Electronic devices and circuits- Millman and Halkias (Mc Graw-Hill Pub.)
12. OP AMP and linear integrated circuits-Gayakwad (Pearson Education)
13. Basic electronics – B.L.Theraja (S. Chand& Company Ltd)
14.Basic Electronics - B.L.Theraja, S.Chand and Co. Ltd. 2008.
14.

PH4P1 PHYSICS PRACTICAL

PH 4P1: Practical **(11 sessions 4 hours/week)**

List of experiments

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. Wien bridge oscillator
7. Half-wave and Full-wave rectifiers – determination of ripple factor and percentage of regulation with and without filter.
8. Zener diode characteristics – study of characteristics and voltage regulation.
9. Determination of specific heat of water by Joule's calorimeter.
10. Determination of Thermal conductivity of rubber.
11. Determination of Thermal conductivity of a bad conductor.

PHOE8- OPEN ELECTIVE-VIII

PHYSICS OF SPORTS

Prerequisite: I B.Sc. **Total hours: 45**

Course Title: Physics of Sports	Course Credits: 3
Total Contact Hours: 39	Self-study Hours: 6
Formative Assessment Marks: 40	Summative Assessment Marks: 60
Duration of ESA: 1 Hr 30 min (or) 2 Hr	

The objective of the course: Students be able to

1. Understand the fundamental scientific concepts of body mechanics.
2. Discover several physics aspects in running and jumping body dynamics
3. Understand numerous physics principles and how to use them effectively in tournaments
3. Recognize the importance of physics in gymnastics and adventure sports.

SYLLABUS

Unit – I : **Introduction:**

Distribution of mass in Human body – forces in muscles and bones – elastic properties – work, energy and power of the body – sizes – strength and food requirements – calculation of calorific content needed for each sports person. **(8 Hours)**

Unit – II : Running and Jumping :

Basic ideas about distance – velocity and speed –acceleration, acceleration due to gravity – angular distance, speed and angular acceleration. Analysis Of Track Techniques: Starting, running, hurdling, stride length, frequency, sprint length, frequency and sprint start. Analysis Of Field Techniques: Standing broad jump, running broad jump, pole vault-techniques involved-guiding principles–(video demonstration of track and field events and the techniques). **(8 Hours)**

Unit – III : **Bats and Balls Linear Kinetic :**

Inertia-mass –force-momentum – Newton's laws of motion – friction – impulse – impact – oblique impact – elasticity – impact on fixed surface, moving bodies. Analysis Of Cricket / Base Ball: Impact – moment of inertia – spin – size of the ball-size of the bat – batting – stride

– swing – bunting. Analysis Of Tennis Techniques: Grip- striking – serve – direction of flight of ball – guiding principles (video demonstrations of the above events). **(9 Hours)**

Unit – IV: Different Projectiles in Sports:

Projectiles – horizontal and vertical motion- range of projectile – trajectory – Analysis of throwing events: techniques involved in speed of release, angle of release and reverse in shot-put, discus, javelin and hammer throw-analysis of broad jump-basketball shooting and football kicking (video demonstration of projectiles in sports) – guiding principles – analysis of basketball techniques: Dribbling and passing. **(10 Hours)**

Unit – V: **The Gymnastics and Adventure Sports:**

Eccentric force-moment – equilibrium – centre of gravity – weight – rotator and circular motion – Analysis of Gymnastics activities: Techniques of lift-rotation-take off – landing for long horse vault, parallel bar etc., - Analysis of rope climb, tight rope walking, skipping – car race, boat race, cycle race – guiding principles (video demonstration). Swimming And Diving: Basic ideas of flotation – buoyant force – centre of buoyancy – specific gravity - relative motion – fluid resistance – conservation of momentum – Analysis of swimming techniques – starting – racing – turn different strokes – diving techniques (video demonstration) Other Factors Influencing Performance: Air resistance – spin or gyration – available force – human characteristics – effects of gyroscopic action – guiding principles. **(10 Hours)**

REFERENCE BOOK:

1. The Biomechanics of Sports Technique, Third Ed. Hay. G. James – Relevant portion of Chapter 3 to 10 & 12, 13 to 17.
2. Scientific Principles of Coaching, Second Ed. – Relevant portion of chapters, 5,7 to 14, 16 to 18.
3. General Physics with Bioscience Essays, Marion and Noryak, Second Ed, - Chapter 1.2, 2.5, 2., 3.4, 4.2, 5.3, 7.3.

Question Paper Pattern

Exam duration: 3hrs
Total marks 100

Part A	MCQ (Answer all the following)	1*20 = 20
Part B	Descriptive (Answer any 5 out of 7)	12*5 = 60
Part C	Numerical (Answer any 5 out of 7)	4*5 = 20
	Total	100

*Note: 100 will be converted to 60

Discipline Core Question Paper Pattern

Exam duration : 3hrs
Total marks 100

Part A	MCQ (Answer all the following)	20×1 = 20
Part B	Descriptive (Answer any 4 out of 6)	4×10 = 40
Part C	Problem Solving (Answer any 6 out of 8)	6×5 = 30
Part D	Though Provoking Questions (Answer any 5 out of 7)	5×2 = 10
Total		100

Note: 100 will be converted to 60

Course Outcomes and Course Content

Semester	V
Paper Code	**PH5123**
Paper Title	**Introduction to Classical Mechanics and Quantum Mechanics**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To make the students understand and learn the basic concepts of classical and quantum mechanics in detail, which provides a firm basis for the advanced topics taught in higher semesters. The paper gives a detailed overview of classical and quantum computing combined with real-time applications. It also provides an introduction to how realistic situations can be addressed and solved by basic mathematical equations, solutions, and interpretations of the results.

Semester-V

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:- Noiether'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, Nonexistence 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>Vo and E<Vo cases, reflection and transmission coefficients for E>Vo 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, mland ms. **(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, (3^{rd} Edition), 2011, Pearson New International Edition
2. Classical Mechanics- Rana. N, Jog, P, (2^{nd} 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, (2^{nd} Edition), 2014, Cambridge University Press
5. Classical Mechanics – Kibble, T, Berkshire F.H, (5^{th} Edition), 2004, Imperial College Press
6. Mechanics: Course of Theoretical Physics-Vol 1- Landau, L.D, Lifshitz, E.M., (3^{rd} 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.

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.

Course Outcomes and Course Content

Semester	V
Paper Code	**PH5223**
Paper Title	**Elements of Atomic and Molecular Physics**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To make the students understand and learn the basic concepts of atomic and molecular physics in detail, which provides a firm basis for the advanced topics taught in higher semesters. The paper gives a detailed overview of atomic and molecular spectroscopy combined with real-time applications. It also provides an introduction to understanding the elementary atomic and molecular energy spectra.

Semester-V

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 quantization, spin electron hypothesis. Spectrum of H and He-atom. 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: Energy levels of single and two-electron system. **(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 – 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, depolarization ratio of Raman lines. Compton effect-expression for Compton shift. **(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. **(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

Reference Books:

1. Concepts of Modern Physics by Arthur Beiser ,6th edition, Tata Mc Graw Hill
2. Atomic spectra & atomic structure, Gerhard Hertzberg: Dover publication, New York.
3. Molecular structure & spectroscopy, G. Aruldhas; Prentice – Hall of India, New Delhi.
4. Fundamentals of molecular spectroscopy, Colin N. Banwell & Elaine M. McCash, Tata McGraw –Hill publishing company limited.
5. Introduction to Atomic spectra by H.E. White
6. Spectra of diatomic molecules by Gerhard Herzberg
7. Quantum Mechanics by Jyotrimoy Guha, Books and Allied (P) Ltd. (Chap. 7).
8. Modern Physics– Murugeshan, Kiruthiga Sivaprasath, S. Chand and Co. Ltd
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 $KMnO_4$.
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 spectra
10. Fine structure constant using Sodium lamp.

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

Course Outcomes and Course Content

Semester	VI
Paper Code	**PH6123**
Paper Title	**Elements of Nuclear Physics and Nuclear Instruments**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To make the students understand and learn the basic concepts of nuclear physics in detail, which is the application of all the other courses studied in the previous semester. The paper gives a detailed overview of the static and dynamic properties of nuclei, nuclear models, nuclear reactors, and their real-time applications.

Semester-VI

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, introduction to QCD, CP violation in k decay

(2 hours)

UNIT - II

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: Radioactive series, Fission and Fusion, Nuclear stability **(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 **(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 preservatives. **(2 hours)**

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

Course Outcomes:

By the end of this course, students will be able to:

1. Recall and apply fundamental principles of nuclear structure and radioactive decay.
2. Understand nuclear models, particle physics, and their significance.
3. Apply conservation laws and experimental methods to analyze nuclear reactions.
4. Analyze radiation detectors and evaluate their efficiency.
5. Evaluate biological effects of radiation and propose control measures.
6. Design experiments and propose solutions in nuclear and radiation physics contexts.

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, 4^{th} Ed., Books &Allied

Reference Books:

1. K. S. Krane, Introductory Nuclear Physics, John Wiley (1988).
2. A. Das and T. Ferbel, Introduction to nuclear and particle physics, John Wiley (1994).
3. I. S. Hughes, Elementary Particles, Cambridge (1991).
4. F. Halzen and A. D. Martin, Quarks and Leptons, John Wiley
5. R. R. Roy and B. P. Nigam, Nuclear Physics: Theory and Experiment, New Age (1967).

PH 6P1 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 Aluminum / Copper using G-M counter
4. Poisson distribution using radioactive source
5. Gamma ray analyzer
6. Finding Compton edge using Gamma ray analyzer
7. Analog to Digital converter
8. Integrator and Differentiator circuits
9. Clippers and Clampers circuit

*Or any experiments department deems fit to be incorporated.

Course Outcomes and Course Content

Semester	VI
Paper Code	**PH6223**
Paper Title	**Elements of Condensed Matter Physics and Devices**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To make the students understand and learn the basic concepts of condensed matter physics in detail, which is the immediate application of materials, The paper gives a detailed overview of the basic properties of materials, such as the mechanical, electrical, magnetic, and optical properties of solid-state materials. It also provides basic knowledge about the performance of solid-state devices and their real-time applications.

Semester-VI

PH 6223: ELEMENT 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. Wigner - Seitz cell, Concept of reciprocal lattice point, calculation of reciprocal lattice points of SC, BCC and FCC lattices. Structure of first Brillouin zone. Lattice directions, planes. Miller indices. 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- Drude -Lorentz Expression for electrical conductivity of metals, Ohm's law, Thermal conductivity of metals - W i e d m a n n -Franz law **(3 hours)**

Band theory of solids-

Free electron gas in three dimensions. 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.

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 holes- 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' 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**)

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

Course Outcomes:

By the end of this course, students will be able to:

1. Understand crystal structures and X-ray diffraction for material characterization.
2. Apply classical and Band theories to interpret solid-state properties and behaviors.
3. Analyze superconductivity phenomena and dielectric material properties.
4. Evaluate specific heat of metals and their implications.
5. Examine the operation and applications of solid-state devices.
6. Synthesize knowledge for material analysis and device design in practical contexts.

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.
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.

PHOE 4 Medical Physics: The Art and Science of Healing

UNIT 1: Physics of human body

Mechanics of human body: static, dynamic and frictional forces in the body, composition, properties and functions of bones, Heat and temperature, temperature scales, clinical thermometer, thermography, heat therapy, heat loss from body. Pressure in the body, skull, eye andurinary bladder. **(8 Hours)**

Physics of Respiratory and cardiovascular system: airways, blood and lung interactions, measurement of lung volume, alveoli and breathing mechanism, blood pressure and measurement. **(7 Hours)**

UNIT 2: Imaging and Therapy

Electricity in the body: Nervous system and neuron, electrical signals from muscle, eye and heart. **(7 Hours)**

Medical Imaging Basics: Introduction to medical imaging, overview of medical imaging techniques (X-rays, CT scans, ECG, MRI) and limitations. **(8 Hours)**

UNIT 3: Nuclear Medicine and Radiation Therapy

Principles of radiation therapy, Radiation detectors and imaging systems, Radionuclide, Imaging and therapy techniques in nuclear medicine, Radiation exposure and its effects on human health, Regulatory frameworks for radiation safety, Radiation protection practices and equipment **(8 Hours)**

UNIT 4: Emerging Technologies in Medical Physics

Artificial intelligence and machine learning in medical physics, Big data analytics in medical physics, Advanced imaging techniques in medical physics **(7 Hours)**

Textbooks:

1. Biology in Physics: Is Life Matter? K.A. Bogdanov and Konstantin Bogdanov, Academic press, 1999.
2. John R. Cameron and James G. Skofronick, John Wiley &Sons –Medical Physics, Wiley – InterscíencePublications ,1978.
3. 2. R.S.Khandpur – Handbook of Biomedical Instrumentation, Tata McGraw Hill Publication Co.,Delhi,1987.
4. Medical Imaging: Principles and Practices by David Dowsett and Patrick Kench
5. Radiation Oncology: Rationale, Technique, Results by James D. Cox, et al.