ST. JOSEPH'S COLLEGE (AUTONOMOUS)

BENGALURU-27

Re-accredited with **'A++' GRADE with 3.79/4 CGPA** by
NAAC Recognized by UGC as College of Excellence

DEPARTMENT OF PHYSICS

Curriculum for B.Sc.

as per

NEP- 2020

UNDERGRADUATE PROGRAMME SYLLABUS FOR

I and II 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	
IV Semester	DSC 4: Thermal Physics & Electronics	
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 1**
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

PH-DSC 1: 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^2graphs)
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 the marvelous 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 Bod: 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

PH-2: 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 (**$\mathbf{E = -\nabla V}$**), 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, 4th 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, 2nd 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 Nanoscale**	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 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.

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