Course Code	**:**	**PHIR11**
Course Title	**:**	Physics –I (Theory)
Credits	**:**	**3 (2L +1T)**
Prerequisites	:	**-**
Course Type	**:**	**EPR**

Course Learning Objectives:

- To develop the understanding of fundamentals of Physics essential for engineering and technology.
- To introduce engineering relevance of Quantum mechanics, Electromagnetic theory, Crystal Physics, Optics, Theory of relativity, Lasers and Nuclear technology.

Course Content

UNIT-I

QUANTUM MECHANICS: Basics of quantum mechanics, De-Broglie's hypothesis, Uncertainty principle, Probability and Wave function, Postulates of quantum mechanics, Time-dependent and Time-independent Schrodinger wave equation, Particle in a box.

ELECTRO MAGNETIC THEORY: Maxwell's equations in vacuum and medium, Electromagnetic Waves, Propagation Energy and Poynting Vector.

UNIT-II

SOLID STATE PHYSICS: Space Lattice, unit cell and translation vectors; Miller indices, Simple and close-packed crystal structures with examples, Origin of energy bands, Kronig Penney Model (qualitative), E-K diagram, Brillouin Zones, Concept of effective mass and holes, Classification into metals, Semiconductors and insulators, Liquid crystals, Hall effect.

UNIT-III

SPECIAL THEORY OF RELATIVITY: The Michelson-Morley experiment, relativistic transformations, length contraction, time dilation, variation of mass with velocity, mass-energy equivalence.

NUCLEAR TECHNOLOGY: Interaction of radiation with matter, Nuclear reactors, Moderators, Reactor criticality & Neutron cross-section

UNIT-IV

ENGINEERING OPTICS: Basics of Interference, Diffraction and Polarization. Lasers and characteristics, Einstein's coefficients, He-Ne laser, semiconductor lasers, Applications of Lasers, Optical fibres; Numerical aperture, Classification of optical fibres, fibre Losses, fibre manufacturing, Applications of optical fibre in industry and communication.

Reference Books

1. D.J. Griffiths, Introduction to Electrodynamics, PHI Learning Publishers, New Delhi, 2012
2. H.D Young and R.A Freedman, University Physics with Modern Pearsons publications, 2012.
3. S.O.Pillai, Solid state Physics, New age International publishers, 2012
4. A. Beiser, Concepts of Modern Physics, McGraw-Hill, 2008.
5. John Lilley, Nuclear Physics, Principles and applications, Wiley, 2016

Course Outcomes:

- Students will be able to understand the basics of quantum mechanics and electromagnetic theory for technological applications.
- Students will be able to solve engineering problems on solid state materials and nuclear reactors
- Students will get knowledge of latest developments in Lasers and fibre optics and their applications in technology.

B. TECH. 1ST SEMESTER PHYSICS PRACTICALS

Course Code	**:**	**PHIR11 L**
Course Title	**:**	Physics –I (Practical)
Credits	**:**	**1**
Prerequisites	:	**-**
Course Type	**:**	**EPR**

LIST OF EXPERIMENTS

1. To find the wavelength of Sodium light by using diffraction grating.
2. To find the wavelength of different colours of white light by using diffraction grating.
3. To study Polarization of light and verification of Malus's law.
4. To find the wavelength of light by using Newton's rings.
5. To find the specific rotation of a solution by using a polarimeter.
6. To find the temperature coefficient of resistance of platinum by using platinum resistance thermometer.
7. To study the variation of magnetic field along the axis of a circular coil carrying current and to estimate the radius of the coil.
8. To find the frequency of AC mains using sonometer.
9. To plot a graph between the difference of temperature of two junctions and thermo e.m.f. for a thermocouple using a potentiometer.
10. To study I-V characteristics and rectification properties of a semiconductor diode.
11. To find high resistance by leakage method.
12. To find a) the wavelength of sodium light b) the thickness of a thin transparent sheet by Michelson's interferometer.
13. Wavelength, angle of divergence and Particle size determination using Diode Laser.
14. To determine the acceptance angle and numerical aperture of an optical fibre.
15. To study the characteristics of a GM Tube and determination of its operating voltage and Plateau length.

Course Code	**:**	**PHIR12A**
Course Title	**:**	**B. Tech. Physics-II (CE, ME &PR)**
Credits	**:**	**3(2L +1T)**
Prerequisites	:	**-**
Course Type	**:**	**EPR**

Course Learning Objectives

- To understand mechanical properties of materials, Physics of Magnetic Materials and Superconductors, Thermal Physics and Physics of Nanotechnology.
- To develop the approach to handle engineering problems on various materials.
- To prepare the students to take up the future engineering challenges related to materials.

Course Content

UNIT-I

MECHANICAL PROPERTIES OF MATERIALS: Phase diagram, Gibbs phase rule, Binary phase diagram its types, solid solution: Hume Rothery Rules, Concepts of stress and strain, Stress-Strain diagrams; Tensile test; Elastic deformation, Plastic deformation. Impact Testing & toughness behavior. Hardness of materials, Imperfections and dislocations

UNIT-II

THERMAL PHYSICS: Seebeck effect, Peltier effect, Thomson effect, Kelvin relationships, Wiedemann-Franz law, Thermal equilibrium, Entropy, The laws of thermodynamics, Thermal conductivity of bulk materials, Phonons: lattice vibration heat transfer, specific heat of solids, classical, Einstein and Debye Model, Ideal quantum gases: Maxwell-Boltazmann, Bose–Einstein, Fermi-Dirac statistics, Carnot efficiency.

UNIT-III

MAGNETIC MATERIALS AND SUPERCONDUCTORS: Orbital diamagnetism, Magnetic moments, orbital diamagnetism, Classical theory of Paramagnetism, Ferromagnetism, molecular field theory and domains, applications of magnetic materials, Type I and II Superconductors, London equation, Applications of superconductivity.

UNIT-IV

NANOTECHNOLOGY: Classifications of nanomaterials (3D, 2D, 1D and 0D) and their density of states, nanocomposites, carbon nanotubes (CNTs), graphene, nanoclusters, structural, thermal and mechanical properties of nanomaterials, bottom up and bottom down synthesis processes, basic characterization techniques for nanomaterials, Applications of nanotechnology.

Reference Books

1. Schroeder, Daniel V. "An introduction to thermal physics, 1999
2. Garg, Bansal. Thermal physics, Tata McGraw-Hill Education, 2013
3. Wole Soboyejo, Mechanical Properties of Engineered Materials, Marcel Dekker, 2003
4. D. K. Bhattacharya, Engineering Physics, Oxford University Press, 2015
5. Charles P. Poole, Jr and Frank J. Owens, Introduction to Nanotechnology, John Wiley & Sons,2006

Course Outcomes

- Students will be able to solve the practical problems related to the technological applications of materials.
- Students will be able to design and develop materials for industrial applications

Course Code	**:**	**PHIR12B**
Course Title	**:**	**PHYSICS – II (EE & ECE)**
Credits	**:**	**3 (2L+1T)**
Prerequisites	:	**-**
Course Type	**:**	**EPR**

Course Learning Objectives

- To gain knowledge of the electronic, dielectric and magnetic properties of materials.
- To understand theories relevant to the engineering principles of materials and devices.
- To solve problems related to semiconductor device operation in technology.

Course Content

UNIT-I

ELECTRONIC PROPERTIES OF MATERIALS: Drude and Sommerfeld's Free Electron theory of Metals, Concept of Fermi level, Fermi-Dirac distribution function, Charge carrier densities.

NANOTECHNOLOGY: Classifications of nanomaterials (3D, 2D, 1D and 0D) and their density of states, Quantum confinement, Manifestation of quantum confinement on optical, electrical and mechanical properties, basic characterization techniques for nanomaterials, Applications of nanotechnology.

UNIT-II

DIELECTRIC PROPERTIES OF MATERIALS: Polarization, Bound Charges, Electric displacement, susceptibility, dielectric coefficient, permittivity & various relations between these, Dielectrics in ac fields, Dielectric loss factor, effect of temperature and frequency on dielectric constant and dielectrics loss factor (qualitative description), Applications of dielectrics.

UNIT-III

SEMICONDUCTING PROPERTIES OF MATERIALS: Direct and indirect Band gap semiconductors, Elemental and compound semiconductors, Equilibrium and extrinsic carrier

concentration, carrier transport, Drift and Diffusion current, mobility, Excess carrier generation and recombination, tunnel diode, solar cell, LEDs

UNIT-IV

MAGNETIC MATERIALS AND SUPERCONDUCTORS: Orbital diamagnetism, Atomic magnetic moments, orbital diamagnetism, Classical theory of Paramagnetism, Ferromagnetism, molecular field theory and domains, applications of magnetic materials, Type I and II Superconductors, London equation, Applications of superconductivity.

Reference Books

1. Arthur Beiser, Tata McGraw Hill, Concept of Modern Physics, publication, 2003
2. Charles Kittel, John Wiley, Introduction to Solid State Physics, publication, 2013
3. Ben G. Streetman, Prentice-Hall of India, Solid State Electronic Devices, 2012
4. Jaspreet Singh, John Wiley, Semiconductor Devices-Basic Principles, publication 2008
5. D. K. Bhattacharya, Oxford University Press, Engineering Physics, 2015

Course Outcomes

- Students will understand the physics underlying the electronic and magnetic behavior of materials.
- Students will be able to estimate materials properties and engineer these.
- Students will understand the operation mechanism of basic components of various electrical and electronic devices.

Course Code	**:**	**PHIR12C**
Course Title	**:**	**Physics –II (CS & IT)**
Credits	**:**	**3(2L +1T)**
Prerequisites	:	**-**
Course Type	**:**	**IR**

Course Learning Objectives

- To understand the basics of quantum computing
- To understand the fundamental concepts of optoelectronic devices for information technology
- To understand the behavior of emerging magnetic materials for data storage devices and nanomaterials

Course Content

UNIT-I

PHYSICS OF QUANTUM COMPUTING: Quantum theory- simple concepts, Wave function and its physical significance, applications of Schrödinger wave equations, concept of spin, qubits and quantum computing

UNIT –II

OPTOELECTRONIC DEVICES: Optoelectronic processes and systems, Photoconductive devices, Photoemissive devices, Photovoltaic devices, Photodetectors, Light Emitting Diode, Liquid Crystal Display, Plasma display panel.

UNIT- III

MAGNETIC MATERIALS AND DEVICES: Molecular field theory and domains, basic ideas of Magnetoresistance, types and applications of Magnetoresistance, spintronics, fundamental concepts of magnetic data storage: writing and read head sensors.

UNIT-IV

NANOTECHNOLOGY: Classification of nanomaterials (3D, 2D, 1D and 0D) and their density of states, nanocomposites, carbon nanotubes (CNTs), graphene, nanoclusters, structural, thermal and mechanical properties of nanomaterials, bottom up and bottom down synthesis processes, basic characterization techniques for nanomaterials, Applications of nanotechnology.

Reference Books

1. Alastair I. M. Rae, Quantum Mechanics, Taylor and Francis, 2011
2. S. O. Kasap, Principles of Electronic Materials and Devices, McGraw Hill, 2006.
3. John Wilson and John Hawkes, Optoelectronics: an introduction, Prentice Hall, 1997.
4. S. L. Gupta, V. Kumar, A Hand Book of Electronics, Pragati Prakashan, 2012.
5. Katsuaki Sato and Eiji Saitoh (Editors), Fundamentals of Magnetoresistance Effects, John Wiley publication, 2016
6. Charles P. Poole, Jr, Frank J. Owens, Introduction to Nanotechnology, Wiley, 2016

Course Outcomes

- Students will understand quantum computing for information technology.
- Students will be able to use the Physics of optoelectronic devices, fiber optics in engineering applications
- Students will be able to develop new magnetic materials and devices used for data storage

B. TECH. 2nd SEMESTER PHYSICS PRACTICALS

Course Code	**:**	**PHIR12 L**
Course Title	**:**	Physics –II (Practical)
Credits	**:**	**1**
Prerequisites	:	**-**
Course Type	**:**	**EPR**

LIST OF EXPERIMENTS

1. To find the value of Planck's constant by photo electric cell.
2. To calibrate an electromagnet using Guoy's balance.
3. To measure Hall's co-efficient of Germanium and calculation of charge carrier concentration.
4. To measure the velocity of ultrasonic waves in organic liquids.
5. To study the decay of charge on a capacitor and to find its capacitance.
6. To determine the resistivity of a semiconductor by four probe method.
7. To determine the band gap of germanium from the variation of its resistivity with temperature.
8. To study the intensity response of a cadmium sulphide cell.
9. To calibrate a voltmeter by using potentiometer.
10. To study the shunting effect of a voltmeter on voltage measurement
11. To measure i) Saturation magnetization ii) coercivity and iii) retentivity in a given ferromagnetic material.
12. To study the dielectric properties of a dielectric at different frequencies by resonance method.
13. To draw the I-V characteristics of a solar cell under constant illumination.
14. To verify Stefan's radiation law by using incandescent filament.
15. To verify the inverse square law of gamma ray using GM counter

Course Code	**:**	**PHOE10**
Course Title	**:**	**LASER TECHNOLOGY**
Credits	**:**	**3**
Prerequisites	:	**-**
Course Type	**:**	**OE**

Course Learning Objectives

- To familiarize the students in the field of laser physics and their spectroscopic applications in different fields of science and technology.
- To understand the interaction of light and matter and physical principles underlying the fabrication of laser systems.

Course Content

UNIT-I

Laser Fundamentals: Concept of Laser emission, Characteristics of Lasers, Main components of Laser system, Necessary and sufficient conditions for Laser action, Einstein coefficients, population inversion, laser pumping, two, three and four level laser systems.

UNIT-II

Laser Beam Propagation and Transformation: Optical cavities, Types of optical resonator, Stability criterion (stable and unstable resonator), Threshold gain coefficient, Resonator modes (longitudinal and transverse modes), Threshold condition of laser oscillation, Q-switching and mode locking.

UNIT-III

Types of Laser: Solid State laser (Ruby laser, Nd: YAG, Nd: Glass etc**),** Gas laser (CO_2 and Argon ion laser) and Dye laser, Excimer laser, Free electron laser, Chemical laser and Semiconductor laser, Homojunction Laser (Laser Diode) and Heterojunction Laser.

UNIT-IV

Laser Applications: Laser in materials processing and industry, Lasers in Micro- and Nano-fabrication and metrology, Lasers in spectroscopy, Lasers in communication and Holography, Lasers induced fusion, Laser systems for biomedical and remote sensing applications.

Reference Books

1. W.T. Silfvast: Laser Fundamentals, Cambridge University Press, 2004
2. B.B. Laud: Lasers and Non-linear Optics, Wiley Eastern Limited, 2nd Edition 1991
3. Laser in Bioscience, Industry, and Defence by Mansharamani Narain, Defence Research & Development Organisation (India) 2012
4. Principle of Lasers, 5th Edition, Orazio Svelto, Springer New York 2010
5. Lasers: Fundamentals and Applications, K Thyagarajan and Ajoy Ghatak, Springer, USA, 2010
6. Fiber Optics and Lasers: The two revolutions, Ajay Ghatak and K. Thyagarajan, Macmillan India, 2006, Reprint 2008-09
7. Modern Physics, G.Kaur and Gary R. Pickrell, McGraw Hill education, 2014

Course Outcomes

- Students will become aware of latest developments in laser technology and their applications in science, technology and research.
- Students will be able to understand the utilization of laser technology modern devices and technologies based on lasers.
- Students will be able to use laser technology in spectroscopic and industrial applications.

Course Code	**:**	**PHOE11**
Course Title	**:**	**NUCLEAR TECHNOLOGY**
Credits	**:**	**3**
Prerequisites	:	**-**
Course Type	**:**	**OE**

Course Learning Objectives

- To gain knowledge of nuclear physics and implement it in Science and Technology.
- To learn about nuclear radiations and their detection and understand the biological effect of radiation.
- To learn about nuclear physics and instrumentation in different fields of science, technology and research.

Course Content

UNIT-I

General Properties of Atomic Nucleus: Alpha, Beta and Gamma radiation and their properties. Properties of Nucleus, Binding Energy, Nuclear stability, Radioactivity: Natural and artificial, half life, Mean life, Laws of radioactivity, Radioactive equilibrium.

UNIT-II

Interaction and Detection of Nuclear Radiation: Interaction of radiation with matter (Charge particle, Electromagnetic and Neutron) Stopping Power, cross section, Gas filled radiation detectors, Scintillation detectors, Semiconductor detectors, SSNTD and their applications.

UNIT-III

Nuclear Reactors: Nuclear reaction and their type, Conservation laws, Direct and compound nucleus reaction, Nuclear fission, fission products, Mass and energy distribution of fission products, nuclear fission reactors, Fast Breeder reactor, Nuclear Fuel, Control rods, nuclear fusion–controlled thermonuclear reactions.

UNIT-IV

Accelerators and their applications: Accelerators: Cyclotron, Tandem, LINAC and Pelletron, Ion source, Role of accelerators in research and Technology.

Radiation dosimetry: Radiation monitoring and dosimeters, Physical and biological effects. Applications of radiation in medical and forensic sciences, Radiation Therapy.

Reference Books

1. Glenn F Knoll, Jhon Wiley & Sons Inc. Singapore, Radiation detection and measurement, 2012
2. R M Singru, Wiley Eastern Pvt. Ltd ,New Delhi, Experimental Nuclear Physics, 2011
3. Roy and Nigam, Himalaya Publishing House, Nuclear Physics: Theory and Experiment, 2016
4. D C Tayal, John Wiley & Sons Ltd; Nuclear Physics, 2015

Course Outcomes

- Students will be able to understand the nuclear processes and reactions in various phenomena.
- Students will learn to apply nuclear physics in research and devolvement for science and technology.
- Students will become aware of latest developments in nuclear reactors and detectors and their applications in science, technology and research.

Course code		**PHOE 12**
Course Title		**Industrial Physics**
Credits		**3**
Prerequisite		**-**
Course Type		**OE**

Course Learning Objectives

- To gain current knowledge of energy generation techniques, environmental effects and its industrial impact
- To understand basic Physics and chemistry behind various industrial devices/ processes.
- To gain knowledge in designing of emerging devices/ processes

Course Content

UNIT-I

Energy- environment and its industrial impact: Energy and power- principles, demands outlook, transformation of energy and its cost, thermal pollution, electrical energy from fossil fuels, hydroelectric generation- principles and problems, costs, capacity, storage, reserves, efficiency, new environmental effects, electrical energy from nuclear reactors, fusion power, solar power, biomass, etc.

UNIT-II

Chemical energy scavenging: Absolute activities of joint dilute solution in common solvent, Volta potential, equilibrium, non-cosmic membrane and contact examples of electrochemical, general treatment of electromotive force-electrochemical transport, fuel cells.

UNIT- III

Lithography and nano-devices: Nano-manipulation, E beam lithography Ion beam lithography, Deep UV lithography, X-ray based lithography, Dip pen lithography, diffraction effects in nanolithography, MEM/ NEMS- basics and fabrication, NEMS/MEMS based oscillators, sensors and detector

UNIT-IV

Industrial application of vacuum: Fundamentals of vacuum science, Vacuum measurements, Vacuum coating, vacuum impregnation, freeze drying, space simulation, ion implantation, vacuum distillation,

Sensors: Fabrication of sensors, gas sensors, magnetic sensors, piezoelectric sensors, optical sensors, etc., sensing mechanisms in different sensors

Reference Books

1. Kenneth J. Skipka, Louis Theodore, Energy Resources: Availability, Management, and Environmental Impacts, CRC Press, 2014
2. Sugiyama, Masakazu, Fujii, Katsushi, Nakamura, Shinichiro (Eds.), Solar to Chemical Energy Conversion- Theory and Application, Springer, 2016
3. Sergy Edward Lyshevski, Micro-Electro Mechanical and Nano-Electro Mechanical Systems, CRC Press, 2005
4. Mick Wilson et al, Nanotechnology-Basic Science and Emerging Technologies, Overseas Press, 2002
5. A. Roth, Vacuum Technology, A. Roth, Elsevier, 1990

Course Outcomes

- Student will understand various energy generation techniques, environmental effects and its economics
- Student will be able to solve technical problems on various industrial devices/ processes.
- Student will be able to design emerging devices of current industrial importance.

Course code		**PHOE13**
Course Title		**Physics of Energy Harvesting Technologies**
Credits		**3**
Prerequisite		**-**
Course Type		**OE**

Course Learning Objectives

- To gain current knowledge of various energy harvesting approaches.
- To understand basic physics behind various energy harvesting systems.
- To understand hybrid approaches and design emerging energy harvesting systems

Course Content

UNIT-I

Introduction to energy harvesting, Available energy, Experimental characterization techniques, Applications

Photovoltaic energy harvesting: Background physics, Solar cell design and strategies for optimizing figure of merit, Various types of solar cells, Future directions

UNIT-II

Thermoelectric energy harvesting: Background physics, Semiconductors and thermoelectrics, Bulk thermoelectric materials performance, Strategies for optimizing figure of merit (ZT), Thermoelectric modules, Future directions

UNIT-III

Piezoelectric energy harvesting: Background physics, Piezoelectric harvester design, Modeling of piezoelectric harvesters, Strategies for optimizing figure of merit, Future directions

Magnetostrictive energy harvesting: Background physics, Magnetostrictive harvester design, Modeling of magnetostrictive harvesters, Strategies for optimizing figure of merit, Future directions

UNIT-IV

Hybrid and emerging energy harvesting approaches: Solar-thermal energy harvesting, energy for garbage, emerging nanotechnology based approaches of energy harvesting

Introduction to other energy harvesting approaches: Bio-inspired energy harvesting approaches, Dielectric elastomer based harvesters, Electrostatic energy harvesters, Electrets based harvesters

Reference Books

1. D . M . Rowe (Ed.), Thermoelectrics Handbook- Macro to Nano, CRC Press, 2005
2. Antonio Luque and Steven Hegedus Handbook of Photovoltaic science and engineering, Wiley, 2010
3. T. J. Kazmierski and S. Beeby, Energy Harvesting Systems: Principles, Modeling and Applications, Springer-Verlag, 2011
4. S. Priya, D. J. Inman (Eds.), Energy Harvesting Technologies, Springer, 2009

Course Outcomes

- Students will have knowledge of the physics of various energy harvesting approaches.
- Students will be able to analyze practical problems on various energy harvesting techniques.
- Students will be able to design energy harvesting systems

Course code		**PHOE14**
Course Title		**Ultrasonics and Applications**
Credits		**3**
Prerequisite		**-**
Course Type		**OE**

Course Learning Objectives

- To gain knowledge about the Physics of ultrasonics
- To gain skills of ultrasonics instrumentation
- To have insight of applications of ultrasonics in industry

UNIT- I

Concept of Ultrasonics: Physics of ultrasonics-wave motion, velocity of propagation, characteristic impedance, reflection, attenuation and transmission through layers, Acousto-optic effect, Acoustic Grating, Ultrasonic velocity and thickness measurement

Unit II

Production of Ultrasonics: Ultrasonic transducers: piezoelectric and magnetostrictive transducers, Equivalent circuits, Impedance matching, High and low power devices.

Unit III

Ultrasonic Instrumentation: Detection of Ultrasonic, Instrumentation and applications: Ultrasonic sensing using plus echo and Doppler techniques, SONAR, Industrial processing units, Ultrasonic measurement and control; Limitation of Ultrasonics.

Unit IV

Ultrasonic Industry Application: Industrial Ultrasonic: Drilling, welding and soldering, Ultrasonic testing, Cavitation, Ultrasonic cleaning, Flaw detection diagnostic: Pulse–echo and Transmission technique, Echocardiogram, Laser Ultrasonics, Ultrasonic Microscopy, Ultrasonic imaging and therapy.

Reference Books

1. J. David & N. Checke, Fundamental and Applications of Ultrasonics, 2nd Edition, CRC Press, 2017.

2. Ensminger, Ultrasonics Fundamental, Technology & Applications, CRC Press, 2011

3. K C Shrivastava, Ultrasonic Testing, 2003

Course Outcome

- Students will able to understand the concept of ultrasonics and its industrial applications
- Students will gain knowledge of ultrasonic instrumentation
- Students will be able to solve industrial problems and design instruments on ultrasonics

Course Code	**:**	**PHOE15**
Course Title	**:**	**Nanoscience and Technology**
Credits	**:**	**3**
Prerequisites	:	**-**
Course Type	**:**	**OE**

Course Learning Objectives:

- To understand the fundamentals of Nanoscience and Technology.
- To impart knowledge about various synthesis and characterization techniques involved in Nanoscience and Technology.
- To familiarize the students with nanotechnology potentials and its applications in different fields.

Course Content:

UNIT I

BASICS OF NANO SCIENCE AND TECHNOLOGY: Basic concepts of Nanoscience: Quantum dot, Potential barrier, Background of Nanotechnology, types of Nanotechnology and nano-machines, top down and bottom up techniques, atomic manipulation, self-assembly monolayers, Time and length scale in structures, Dimensionality and size dependent phenomena, Surface to volume ratio, Fraction of surface atoms, Properties at nanoscale (electronic, magnetic, optical and mechanical).

UNIT II

SYNTHESIS METHODS OF NANOMATERIALS: Introduction to Nanomaterials, Synthesis of nanomaterials: Sol-gels techniques, Co-precipitation and Hydrothermal method, Lithography: Photolithography, Electron beam lithography, Focused Ion Beam Lithography (FIB); Dip-Pen Nanolithography, Template Synthesis; Self Assembly and Bio/Chemical Methods, Chemical Vapor Deposition(CVD); Electron beam evaporation, Pulse laser deposition (PLD), DC/RF Magnetron Sputtering, Molecular Beam Epitaxy (MBE).

UNIT-III

CHARACTERIZATION TECHNIQUES FOR NANOMATERIALS: Structural Characterization: X-Ray Diffraction (XRD), Surface Characterization: Scanning Electron

Microscopy (SEM), High Resolution Transmission Electron Microscope (HRTEM), Scanning Probe Microscope (STM, AFM, MFM), Raman Spectrometry.

UNIT-IV

POTENTIAL APPLICATIONS: Applications of Nanomaterials: Data storage, Water purification, Photocatalytic degradation, Targeted drug delivery, Hyperthermia, Solar energy conversion and catalysis, Molecular electronics and nanoelectronics, Nanomedicine and Nanobiotechnology: Nanotoxicology challenges, Cosmetics, Building construction, Heat transfer etc.

Suggested Books:

1. Pradeep T., "A Textbook of Nanoscience and Nanotechnology", Tata McGraw Hill Education Pvt. Ltd., 2012.
2. Hari Singh Nalwa, "Nanostructured Materials and Nanotechnology", Academic Press, 2002.
3. Nabok A., "Organic and Inorganic Nanostructures", Artech House, 2005.
4. 4. Dupas C., Houdy P., Lahmani M., "Nanoscience: Nanotechnologies and Nanophysics", Springer-Verlag Berlin Heidelberg, 2007.

Course Outcomes:

1. Students will be able to understand engineering of the properties at nanoscale materials.
2. Students will be able to synthesize and characterize the nanomaterials of different shapes and sizes.
3. Students will be able to design and develop the nanotechnology based devices based on the learned fundamentals.

Course Code	**:**	**PHOE16**
Course Title	**:**	**SENSORS-SCIENCE AND TECHNOLOGY**
Credits	**:**	**3**
Prerequisites	:	**-**
Course Type	**:**	**OE**

Course Learning Objectives

- To gain knowledge about the working principle of different types of sensors used in various applications.
- To gain skills about the modelling and calibration of different types of sensors.
- To gain knowledge of the sensor materials and technology at nano-scale.

Course Content

UNIT-I

Principles of Physical and Chemical Sensors: Sensors Fundamentals and Characteristics, Sensing mechanism of Mechanical, Electrical, Thermal, Magnetic, Optical, Chemical and Biological Sensors.

UNIT-II

Sensor Characteristics and Calibration: Static and Dynamic Characteristics, Sensor reliability, aging test, failure mechanisms and their evaluation and stability study.

UNIT-III

Fabrication methods: Sensor configurations and geometries, Use of nano-materials in sensors, Thin/thick film formation techniques (physical, chemical and Langmuir-Blodgett film formation techniques),

UNIT-IV

Sensor Modeling: Numerical modeling techniques, Modeling effects on different parameters of sensing mechanisms (Mechanical, Electrical, Thermal, Magnetic, Optical, Chemical and Biological) and examples of modeling. Sensors applications.

Reference Books

1. J. Fraden, Handbook of Modern Sensors: Physical, Designs, and Applications, AIP Press, Springer, 2010.
2. D. Patranabis, Sensors and Transducers, PHI Publication, New Delhi, 2003.
3. Ganesh S. Hegde, Mechatronics, University Science Press, 2008.
4. P.T. Moseley, B.C. Toefield, Solid State Gas Sensors', CRC Press, 1987.
5. M. Meyyappan, Carbon Nanotubes Science and Applications, CRC Press, 2014.

Course Outcome

- Students will be able to model and design various sensors.
- Students will be familiarized to the practical approaches for different sensors.
- Students will learn about various materials and methods of fabrication of sensors.