SCHEME AND SYLLABUS of PHYSICS

For

BACHELOR OF TECHNOLOGY (1st Year)

(*w.e.f.* the Academic Session 2024 onwards)

DEPARTMENT OF PHYSICS

NATIONAL INSTITUTE OF TECHNOLOGY KURUKSHETRA

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Department of Physics
Syllabus for B. Tech. Courses (I and II Semester)
(Institute Core Courses)

S.N.	Course Code	Course Name	Semester	Credits
1.	PHIC101	Engineering Physics	I	04
2.	PHIC102	Advanced Engineering Physics (CE, ME and PIE)	II	04
3.	PHIC103	Advanced Engineering Physics (ECE)	II	04
4.	PHIC104	Advanced Engineering Physics (EE)	II	04
5.	PHIC105	Advanced Engineering Physics (IIoT)	II	04
6.	PHIC106	Advanced Engineering Physics (Sustainable Energy Technology)	II	04

(Open Elective Courses)
(V, VI, VII, and VIII Semester)

S.N.	Course Code	Course Name	Semester	Credits
1.	PHOE 301	INDUSTRIAL PHYSICS	V	03
2.	PHOE 302	NUCLEAR TECHNOLOGY	V	03
3.	PHOE 303	PHYSICS OF ADVANCED SEMICONDUCTOR DEVICES	VI	03
4.	PHOE 304	OPTICAL FIBER COMMUNICATION SYSTEMS	VI	03
5.	PHOE 401	NANOSCIENCE AND TECHNOLOGY	VII	03
6.	PHOE 402	PHYSICS OF ENERGY HARVESTING TECHNOLOGIES	VII	03
7.	PHOE 403	LASER TECHNOLOGY	VIII	03
8.	PHOE 404	ULTRASONICS AND APPLICATIONS	VIII	03

Department of Physics

(Minor Courses)

Sr. No	Course Code	Name of the Course	Pre-requisite	Credits	Course Coordinator
1.	PHMC301	PHYSICS AT NANO SCALE	PHIC 101	03	Dr. Prakash Chand
2.	PHMC302	MATHEMATICAL PHYSICS FOR ENGINEERS	PHIC 101, MAIC 12	03	Dr. Tanmay Maji
3.	PHMC303	NUCLEAR AND PARTICLE PHYSICS	PHIC 101	03	Dr. Ashavani Kumar
4.	PHMC304	PHOTONICS	PHIC 101	03	Dr. Than Singh Saini
5.	PHMC305	THERMO DYNAMICS AND STATISTICAL PHYSICS	PHIC 101, PHIC 102	03	Dr. Neena Jaggi
6.	PHMC401	CONDENSED MATTER PHYSICS	PHIC 101, PHIC 102	03	Dr. A. K. Tripathi
7.	PHMC402	LASER PHYSICS AND APPLICATIONS	PHIC 101	03	Dr. Y. Dwivedi
8.	PHMC403	MATERIAL SCIENCE FOR ENGINEERS	PHIC 101	03	Dr. R. P. Chauhan
9.	PHMC404	SENSORS-SCIENCE AND TECHNOLOGY	PHIC 101	03	Dr. Kolla Lakshmi Ganapathi
10.	PHMC405	MINOR PROJECT	--	03	Dr. Ashavani Kumar Dr. Than Singh Saini

DEPARTMENT OF PHYSICS

(B. TECH. 1ST Sem. All Branches)
(CORE COURSES)

PHIC101: ENGINEERING PHYSICS

L	T	P	Credits	Total contact hours
2	1	2	4	64

Pre-requisite: …

Brief Description about the course: This course includes the fundamentals of physics essential for various engineering disciplines pertaining to quantum mechanics, electromagnetism, lasers and optical fiber technology. Moreover, theory of relativity and the nuclear technology for sustainable energy applications are included.

Course Content

UNIT-I (7 hrs.)

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 equations, Particle in 1-D potential box, Quantum Tunnelling Phenomenon.

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

UNIT-II (7 hrs.)

Physics of Solids: Crystal Structure, Space Lattice, Translation vectors; Crystal Symmetry, Miller indices, Simple and close-packed crystal structures with examples, Free electron theory: Drude's Theory of Conduction; Quantum theory of free electrons, Fermi-Dirac distribution function, Fermi–level and Fermi Energy; Density of States, equilibrium and extrinsic carrier concentration.

UNIT-III (7 hrs.)

Laser Physics: Basic principle and characteristics of lasers, Einstein's coefficients, Types of the Lasers: He-Ne laser, Semiconductor Laser, Applications of Lasers in research and industry, Safety protocols of lasers.

Fundamentals of Optical Fiber: Acceptance angle, Numerical aperture, Classification of optical fibres, Fiber losses, Fiber manufacturing, Applications of optical fibre in industry and communications.

UNIT-IV (7 Hours)

Special Theory of Relativity: Frame of references: inertial and non-inertial, Galilean transformation, The Michelson-Morley experiment, Postulates of Special Theory of Relativity, Lorentz transformations, Length contraction, Time dilation, Velocity addition, Variation of mass with velocity, Mass-energy equivalence.

Nuclear Technology: Interaction of radiation with matter, Neutron cross-section, Nuclear Reaction, Moderators, Reactor criticality, Nuclear reactors for power generation, Safety protocols.

Text Books/Reference Books

T-1: S.O.Pillai, **"Solid state Physics"**, New age International publishers, 2012.
T-2: A. Beiser, **"Concepts of Modern Physics"**, McGraw-Hill, 2008.
R-1: D.J. Griffiths, **"Introduction to Electrodynamics"**, PHI Learning Publishers, New Delhi, 2012.
R-2: S. M. Sze, K. K. Ng, **"Physics of Semiconductor Devices"**, United Kingdom, Wiley, 2021.
R-3: M. A. Wahab, **"Solid State Physics",** Narosa, 2022.
R-4: John Lilley, **"Nuclear Physics, Principles and applications"**, Wiley, 2016.

Course Outcomes:

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

CO1: Develop the skills to apply various Physics concepts in tackling real life engineering problems.

CO2: Apply the ideas of Quantum Mechanics and Electromagnetic Theory for designing and development of various technological equipments.

CO3: Understand various technological domains of applicability of Crystal Physics, Theory of Relativity, and Nuclear technology.

CO3: Design and develop relevant applications based on fundamentals of Optics, LASERs, and Optical Fibers.

DEPARTMENT OF PHYSICS

(B. TECH. 1ST Sem. All Branches)
(CORE COURSES)

PHIC101: ENGINEERING PHYSICS (Practical)

List of the 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.

DEPARTMENT OF PHYSICS

(B. TECH. 2nd Sem. for CE, ME & PIE Branches)
(CORE COURSES)

PHIC102: ADVANCED ENGINEERING PHYSICS

L	T	P	Credits	Total contact hours
2	1	2	4	64

Pre-requisite: PHIC101

Brief Description about the course: The course consists of mechanical and thermal properties of materials and their applications. The concepts of Magnetic Materials, Superconductors, and Nanotechnology are included for the application in futuristic technologies.

Course Content

UNIT-I (7 Hours)

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 (7 Hours)

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, and Fermi-Dirac statistics.

UNIT-III (7 Hours)

Magnetic Materials and Superconductors: Orbital diamagnetism, Magnetic moments, 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 (7 Hours)

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 Top-down synthesis processes, Basic characterization techniques for nanomaterials, Applications of nanotechnology.

Text Books/Reference Books

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

Course Outcomes:

At the end of the course Students will be able to:
CO1: Develop the skill to apply various physics concepts for advance engineering problems.
CO2: Apply fundamentals of mechanical and thermal properties of materials for technological applications.
CO3: Apply the concepts of Magnetic Materials, Superconductors, and Nanotechnology.
CO4: Design and develop materials for industrial applications.

DEPARTMENT OF PHYSICS

(B. TECH. 2nd Sem. for CE, ME, PIE, ECE, EE, and IIoT Branches)
(CORE COURSES)

ADVANCED ENGINEERING PHYSICS (PRATICAL)

List of the Experiments:

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

DEPARTMENT OF PHYSICS

(B. TECH. 2nd Sem. For ECE Branch)
(CORE COURSES)

PHIC103: ADVANCED ENGINEERING PHYSICS

L	T	P	Credits	Total contact hours
2	1	2	4	64

Pre-requisite: PHIC101

Brief Description about the course: The course is focused on the electronic and semiconducting properties of materials to understand theories relevant to the engineering principles of Semiconductor devices. The content consists of topics related to the technical and strategic problems, electronic device fabrication and operations in the industry.

COURSE CONTENTS

UNIT-I (7 H)

BAND THEORY OF SOLIDS: Periodic structures, Origin of Energy Bands- Bloch Theorem, Kronig-Penney Model (qualitative), E-K diagram, Brillouin Zones-extended, reduced and periodic zone schemes, Electrons and Holes, Concept of effective mass, Material classification, Direct and Indirect Band gap semiconductors.

UNIT-II (7 H)

SEMICONDUCTOR PHYSICS: Crystal properties, Elemental and compound semiconductors, Density of states, Doping- donors and acceptors, Equilibrium and extrinsic carrier concentration, Carrier transport, Drift and Diffusion current, Mobility, Einstein relation, Excess carrier generation and recombination, Luminescence, Four probe and Hall effect measurement.

UNIT-III (7 H)

JUNCTIONS AND DEVICES: Types of junctions: Metal-Metal; Metal-Semiconductor; Semiconductor-Semiconductor- Homo-junction and Hetero-junction, typical Single layer and multilayer devices and their characteristics: PN diode; Light Emitting Diodes; Solar cells; Photodetectors; Tunnel diode, Transistors; Field Effect Transistors.

UNIT-IV (7 H)

FABRICATION TOOLS AND TECHNIQUES: Importance of Vacuum in fabrication- methods of achieving vacuum, Crystal growth techniques, Wafer cleaning techniques, Surface conditioning and modification techniques, Photolithography, Doping techniques, Metallization, semiconductor device sealing and packaging.

Text Books/References

T-1: Charles Kittel, **"Introduction to Solid State Physics"**, John Wiley publication, 2013.

T-2: S. M. Sze, **"Semiconductor Devices: Physics and Technology"**, John Wiley publication, 2013.

R-1: Ben G. Streetman, **"Solid State Electronic Devices"**, Prentice-Hall of India, 2012.

R-2: Jaspreet Singh, **"Semiconductor Devices-Basic Principles"**, John Wiley publication, 2008.

R-3: Donald A. Neamen, **"Semiconductor Physics and Devices: Basic Principles"**, 4th Edition, McGraw-Hill publication, 2012.

R-4: M.S. Tyagi, "**Introduction to Semiconductor Materials and Devices**" Wiley, 1991.

Course Outcomes:

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

CO1: Solve and realize Electronics Engineering problems and challenges.

CO2: Understand fundamentals of semiconducting properties of materials for technological applications.

CO3: Realize the operation mechanism of various electrical and electronic devices.

CO4: Solve technical and strategic problems related to electronic device fabrication and operations in the industry

DEPARTMENT OF PHYSICS

(B. TECH. 2nd Sem. For EE Branch)
(CORE COURSES)

PHIC104: ADVANCED ENGINEERING PHYSICS

L	T	P	Credits	Total contact hours
2	1	2	4	64

Pre-requisite: PHIC101

Brief Description about the course: This course provides the knowledge of the electrical and magnetic fields for simple configurations under static and dynamic electromagnetism relevant to the engineering systems and devices. The propagation of EM waves and Maxwell's equation in different forms and different media are elaborated.

Course Contents

UNIT-I (6 Hours)

Vector Calculus & Electrodynamics: Vectors, Gradient, Divergence, Curl and their physical significance, Divergence theorem, Stoke's thereom.

Electrostatics: Electric field due to distributed charges configurations lines of charges, Uniform plane surface and spherical volume charge distributions: Behavior of conductors and dielectric in electrostatic fields, Boundary conditions.

UNIT-II (8 Hours)

Magnetostatics: Biot - Savart's Law , Ampere's Circuital Law and their Applications, capacitance and inductance calculations for simple configurations; Time varying fields-displacement current, wave equation for Poynting vector, electromagnetic radiation, electromagnetic wave propagation in free space and isotropic dielectric medium, Boundary conditions, Poynting theorem, Maxwell's equations.

UNIT-III (6 Hours)

Magnetic Materials and Superconductors: Magnetization M, relation between B, H & M. Bohr megneton, Hysteresis loss, Antiferromagnetism, Ferromagnetism & Ferrites, 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.

UNIT-IV (8 Hours)

Electromagnetic Theory: Wave equation, Uniform plane waves, Plane wave propagation in dielectric and conducting media, Reflection and refraction of plane wave (Normal incidence) , Wave propagation in bounded media, Ground waves, Sky waves and space waves,

Wave Guides: Parallel plane guide, TE, TM and TEM waves, Rectangular and cylindrical wave guides, resonators and Planes transmission line; Strip lines, Micro strip line.

TextBooks/Reference Books

T-1: M. N. O. Sadiku, Elements of Electromagnetics, Oxford University Publication, 2014.
T-2: W. Hayt, Engineering Electromagnetics, McGraw Hill Education, 2012.
R-1: A. Pramanik, Electromagnetism-Problems with solution, Prentice Hall India, 2012.
R-2: Jaspreet Singh, John Wiley, Semiconductor Devices-Basic Principles, publication 2008.
R-3: Arthur Beiser, Tata McGraw Hill, Concept of Modern Physics, publication, 2003.
R-4: Pramanik, Electromagnetism - Theory and applications, PHI Learning Pvt. Ltd, New Delhi, 2009.
R-5: A. S. Vasudeva, Modern Engineering Physics, S. Chand.

Course Outcomes

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

CO1: understand the physics underlying the electric and magnetic fields.
CO2: understand the operation mechanism of basic laws of electromagnetism relevant to the engineering principles of materials and devices.
CO3: understand the applications of EM waves, Maxwell's equation in different forms and different media.

DEPARTMENT OF PHYSICS

(B. TECH. 2nd Sem. For IIoT Branch)
(CORE COURSES)

PHIC105: ADVANCED ENGINEERING PHYSICS (THEORY)

L	T	P	Credits	Total contact hours
2	1	2	4	64

Pre-requisite: PHIC101

Brief Description about the course: This course is focused on the working principle of different types of sensors and development of sensors utilizing advanced sensing materials. Fabrication techniques and applications in AI and IIoT are elaborated.

Course Contents

UNIT-I (7 L)

Principles of Sensors and Actuators: Fundamentals and Physics of sensors and Actuators (sensing and actuation mechanisms), physical effects, measurement, measurement standards, measurement errors, Static and Dynamic Characteristics, reliability, aging test, failure mechanisms and their evaluation and stability study, Sensor signal amplification and filtering, Analog-to-digital conversion, Noise reduction techniques, Digital signal processing for sensor data.

UNIT-II (7 L)

Materials and Fabrication methods for Sensors: Semiconductors, Metal Oxides, Polymers, Metals, piezoelectric materials, optical glass fibres and Organic Materials; Sensor configurations and geometries, Thin/thick film formation techniques: Physical, chemical and Langmuir-Blodgett film formation techniques, Screen Printing Techniques, Lithography.

UNIT-III (7 L)

Sensors:
Optoelectronic sensors, Mechanical sensors, Thermal sensors, Magnetic sensors, Gas sensors, pressure sensors, chemical and bio sensors, Calibration methods and standards, Error sources and compensation techniques, Sensor fusion and multi-sensor systems.

UNIT-IV (7 L)

Sensor Systems and Applications:
Sensors for AI and IoT: Agriculture, health care, environmental monitoring and control, smart home, transportation, Smart Energy monitoring; robotic, nautical, aeronautical and space measurement systems; Flexible and wearable sensors; Sensors for lab on chip, sensor networks, Nanosensors and MEMS technology.

Text Books/Reference Books:

T-1: Clarence W. de Silva, "Sensors and Actuators- Engineering System and Instrumentation", CRC Press, Taylor &Francis Group, 2016.

T-2: S.C. Mukhopadhyay, "Next Generation Sensors And Systems", Sringer, 2016.

R-1: J. Fraden, "Handbook of Modern Sensors: Physical, Designs, and Applications", AIP Press, Springer, 2010.

R-2: D. Patranabis, "Sensors and Transducers", PHI Publication, New Delhi, 2003.

R-3: Ezzat G. Bakhoum, "Micro- and Nanoscale Sensors and Transducers", CRC press, 2019.

R-4: P.T. Moseley, B.C. Toefield "Solid State Gas Sensors", CRC Press, 1987.

R-5: S. M. Sze, "Semiconductor Sensors", Wiley-Interscience, 1994. ISBN: 978-0471546092.

Course Outcomes

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

CO1: Students will be able to design various sensors.

CO2: Students will learn about various materials and methods of fabrication of sensors.

CO3: Students will be familiarized to the practical approaches for different sensors and their utilization for AI and IIoT Applications.

Institute Core (Semester-2)
B. TECH. (SUSTAINABLE ENERGY TECHNOLOGY)
PHIC106: Advanced Engineering Physics

Pre-requisite: --

L	T	P	Credits	Total contact hours
3	-	2	4	60

Brief description:
Upon successful completion of this course, the student will have an understanding of semiconducting materials for energy applications. Semiconductor junctions with the motivation of charge carrier separation/collection and transport. Role of semiconductors-metal junctions also for charge carrier transport. Semiconductor junctions under voltage- and light-bias conditions.

Course Content:

UNIT - I

Classical and Quantum Statistics (8 hours):

Microstates and Macro states; Classical statistical mechanics: Concepts of Maxwell-Boltzmann distribution law; Motivations for quantum statistics: Identical particle and symmetry requirement; Concepts of Fermi-Dirac and Bose-Einstein statistics.

UNIT - II

Physics of Semiconducting Materials (10 hours):

Formation of Energy Bands and Energy Gap; Fundamentals of Band structure; Charge carriers in semiconductors: Electrons and holes, Effective mass; Fermi-Dirac distribution and Density of States.

Types of Semiconductors: Direct and Indirect bandgap semiconductors; Doping and Intrinsic Carrier concentration; Carrier Concentration at Thermal Equilibrium; Temperature dependent carrier concentration; Carrier Transport Phenomena: Diffusion and Drift; Trap statistics; Current continuity equation.

17/12/2024 17.12.24 17/12/24 17/12/2024 17/12/24

UNIT - III

Junctions and their Characteristics (10 hours):

Metal semiconductor Junctions: Introduction on the work function, Ionization potential, and electron affinity, formation of the energy Barrier, Schottky and Ohmic contacts and Measurement of barrier height.

PN junctions: Introduction, PN junction under equilibrium, PN Junction under bias, I-V characteristics and Junction breakdown.

UNIT-IV

Optoelectronic Devices (8 hours):

Optoelectronic Processes in semiconductors: Optical Absorption and Emission; Radiative and Non-Radiative recombination process.

Generation and Recombination currents in PN junction.

Devices and Characteristics: Photodiodes, Photo detectors, Light-emitting diode and Solar Cells.

References/Textbooks:

1. Dittrich T., Material Concepts for Solar cells, World Scientific Publishing, 2018.
2. Neamen D. K., Semiconductor Physics and Devices Basic Principles, McGraw-Hill Companies, Inc., 4th Edition, 2011.
3. Yu P.Y. and Cardona M., Fundamentals of Semiconductors Physics and Materials Properties, Springer, 4th Edition, 2010.
4. Sze S. M. and Ng K. K., Physics of Semiconductor Devices. Hoboken, NJ, USA: John Wiley & Sons, Inc., 2006.
5. Streetman B. and Sanjay B., Solid State Electronic Devices. Pearson, 2006.
6. Fox M., Optical properties of solids. Oxford University Press, 2001.

Course outcomes:

On successful completion of the course, students will be able to

CO1: Understand the principles of classical and quantum statistics, fundamentals of semiconducting materials, doping and PN-junction formation

CO2: Appraise various optical process in semiconductors and metal-semiconductor contacts.

CO3: Understand about energy bands and charge carriers in semiconductors

CO4: Understand about optoelectronic devices

(Open Elective Courses)

(V, VI, VII, and VIII Semester)

DEPARTMENT OF PHYSICS

(B. TECH: V Sem.)
(OPEN ELECTIVE)

PHOE301: INDUSTRIAL PHYSICS

L	T	P	Credits	Total contact hours
3	0	0	3	36

Pre-requisite: PHIC101

Brief Description about the course: This course includes the energy generation techniques their environmental effects and their industrial impact. The development of basic techniques behind various nano and microscale industrial devices and processes for designing of emerging nano and microscale sensors and transducers.

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, storage, reserves, new environmental effects, electrical energy from nuclear reactors, fusion power, solar power, biomass, Fuel Cells.

UNIT-II

Elemental Analysis instrumentation: Instrumentation of spectroscopic analytical system, UV-VIS absorption spectrophotometers (single and double beam), Flame emission and atomic absorption spectrophotometer, Laminar flow burner, Grating monochromator, Photomultiplier tube, Atomic emission spectrophotometer, X-ray fluorescence, Energy dispersive X-ray spectroscopy, Laser Induced Breakdown Spectroscopy.

UNIT- III

Transducers: Design of transducers, Nano-Mechanical, Chemical and magnetic transducers, Thermoelectric sensors, Piezoelectric sensors, Pyroelectric sensors, Photovoltaic sensors, Optical sensors.

UNIT-IV

Applications: Elemental analysis and application of transducers in sustainable technologies, case studies from the Indian knowledge systems.

Text Books/Reference Books

T-1: Kenneth J. Skipka, Louis Theodore, Energy Resources: Availability, Management, and Environmental Impacts, CRC Press, 2014.

T-2: Sugiyama, Masakazu, Fujii, Katsushi, Nakamura, Shinichiro (Eds.), Solar to Chemical Energy Conversion- Theory and Application, Springer, 2016.

T-3: Sergy Edward Lyshevski, Micro-Electromechanical and Nano-Electromechanical Systems, CRC Press, 2005.

Course Outcomes

CO1: Student will understand various energy generation techniques, environmental effects and its economics.

CO2: Student will be able to solve technical problems on various nano and microscale industrial devices and processes.

CO3: Student will be able to gain knowledge in designing of emerging sensors and transducers.

CO4: Student will be able to gain knowledge of various elemental analysis instrumentations used in various engineering branches.

DEPARTMENT OF PHYSICS

(B. TECH: V Sem.)
(OPEN ELECTIVE)

PHOE302: NUCLEAR TECHNOLOGY

L	T	P	Credits	Total contact hours
3	0	0	3	36

Pre-requisite: PHIC101

Brief Description about the course: This course includes the concept of nuclear physics and instrumentation in various field of science and technology to implement their concept in energy generation. Nuclear radiations and their detection to understand the properties of materials and biological samples.

Course Content

UNIT-I (9 Hours)

General Properties of Atomic Nucleus: Properties of nucleus, binding energy, nuclear stability, radioactivity: Natural and artificial, Alpha, Beta and Gamma radiations and their applications, half-life, mean life, laws of radioactivity, radioactive equilibrium.

UNIT-II (9 Hours)

Interaction and Detection of Nuclear Radiation: Interaction of radiations with matter (Charge particle, Electromagnetic and Neutron), stopping power, cross section, gas filled radiation detectors, scintillation detectors, semiconductor detectors, photomultiplier tube, SSNTDs and their applications.

UNIT-III (9 Hours)

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 (9 Hours)

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 radiations in medical and forensic sciences, radiation therapy, oncology and radionuclide therapy, radiation safety, applications in sustainable technologies.

Course Outcomes

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

CO1: Understand the nuclear processes and reactions in various phenomena.

CO2: Apply nuclear physics in nuclear reactors and devolvement for science and technology.

CO3: Aware of latest developments in accelerators and detectors and their applications in science, technology and research.

Text Books/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

DEPARTMENT OF PHYSICS

(B. TECH: VI Sem.)
(OPEN ELECTIVE)

PHOE303: PHYSICS OF ADVANCED SEMICONDUCTOR DEVICES

L	T	P	Credits	Total contact hours
3	0	0	3	36

Pre-requisite: PHIC101

Brief Description about the course: This course contains physical principles, theories and operational characteristics of advanced semiconductor electronic devices. Also the introduction and fabrication of next generation electronic devices for IIoT and AI applications has been included.

Course Contents

Unit-I: (10 hours)

Physics and Properties of Semiconductors- A Review

Fundamentals of Semiconductors: Intrinsic and Extrinsic Semiconductors, Drift and diffusion of carriers, Generation and recombination of charges, continuity equation, Direct and indirect bandgap semiconductors, Organic semiconductor, Fermi and Quasi Fermi levels.

Junctions and Devices: Background on Solid State electronics, Types of junctions: Metal-Metal; Metal-Semiconductor; Homo-junction; Hetero-junction, Single layer and multilayer Devices and their characteristics.

UNIT-II: (8 hours)

Physics of Metal-Oxide-Semiconductor (MOS) Devices

MOS Capacitors: Ideal and Non- Ideal Capacitance-Voltage (C-V) characteristics; Parameter extraction: Threshold voltage, doping concentration, fixed oxide charges, interface traps/states etc.; Current-Voltage (I-V) characteristics, current conduction mechanisms: Schottky conduction, Poole-Frenkel conduction, Fowler-Nordheim tunnelling etc.

Metal-Oxide-Filed Effect Transistors (MOSFETs): Basic Device Characteristics; Device Scaling and Short-Channel Effects.: Threshold voltage Roll off, Drain Induced Barrier Lowering, Sub-threshold swing, tunneling etc.

UNIT-III: (10 hours)

Physics of Advanced Electronic Devices:

Transistors: Fin Field-Effect Transistors (FinFETs), Tunnel Field Effect Transistors, Single Electron Transistors, Carbon Nanotube transistors, 2D semiconductor based nano transistors and thin film transistors,

Non-volatile memory devices: Resistive Random Access Memory, Ferroelectric Random Access Memory, Phase change memory and Magnetic memory)

UNIT-IV: (8 hours)

Semiconductor Sensors:

Semiconductor based Sensors: Gas sensors, Thermal sensors, Chemical sensors, Pressure sensors, bio-sensors and their applications in sustainable technologies.

Course Outcomes:

At the end of the course students will be able to:
CO1: Implement the internal workings of the current generation semiconductor devices.
CO2: Apply the relevant Physics concepts for realizing and solving Electronics Engineering problems and challenges.
CO3: Apply the background in semiconductor-based electronic devices in nano and quantum electronics.
CO4: Solve technical and strategic problems related to electronic device fabrication and operations in industry.

Text Books/Reference Books:

1. S. M. Sze., K. K. Ng, "Physics of Semiconductor Devices", United Kingdom, Wiley, 2021. ISBN:9780471143239
2. Karl Hess, "Advanced Theory of Semiconductor Devices", John Wiley, 2008: ISBN: 978-0-780-33479-3
3. Bonani, Fabrizio, Ghione, Giovanni, "Noise in Semiconductor Devices", Springer, 2001. ISBN 978-3-662-04530-5
4. Colinge, J.-P., "FinFETs and Other Multi-Gate Transistors", Springer, 2008. ISBN 978-0-387-71752
5. M. S. Tyagi, "Introduction to Semiconductor Materials and Devices", John Wiley, 2008: ISBN: 978-0-471-60560-7
6. S. M. Sze, "Semiconductor Sensors", Wiley-Interscience, 1994. ISBN: 978-0471546092
7. Santosh K. Kurinec, "Nanoscale Semiconductor Memories", CRC Press, 2017. ISBN: 9781351832083.

DEPARTMENT OF PHYSICS

(B. TECH: VI Sem.)
(OPEN ELECTIVE)

PHOE304: OPTICAL FIBER COMMUNICATION SYSTEMS

L	T	P	Credits	Total contact hours
3	0	0	3	36

Pre-requisite: PHIC101

Brief Description about the course: The course provides essential knowledge of fiber optical technology, light guidance inside the optical fibers, and various potential applications in optical communication system and other fields.

Course contents:

Unit-I (10 Hours)

Introduction: Basic elements of the fiber optic communication system; Single and multimode optical fibers; Ray analysis of optical fiber: Propagation mechanism of rays in an optical fiber; Meridional rays, Skew rays, Fiber numerical aperture; Electromagnetic mode theory for optical propagation.

Unit-II (10 Hours)

Propagation Mechanics: Mode theory for circular waveguides: step index optical fibers; Propagation characteristics of step index optical fibers; graded index optical fibers; Fabrication of optical fibers: MOCVD and fiber drawing techniques.

Unit-III (8 Hours)

Fiber Optics Losses and Dispersion: Linear and nonlinear losses, Signal degradation in optical fibers due to dispersion and attenuation; Pulse dispersion in graded index optical fibers, Material dispersion, Waveguide dispersion and design considerations.

Unit-IV (8 Hours)

Fiber Devices and Applications: Optical fiber amplifiers: EDFA, Gain spectrum and gain band width, EDFAs for WDM transmission, Various potential applications of the optical fibers other than the telecommunication industry.

Course Outcomes:

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

CO1: Apply the concept of optical fiber technology and their applications.

CO2: Solve technical and strategic problems related to the fabrication of optical fibers.

CO3: Apply the relevant physics concepts for realizing and solving light guidance in different structures.

CO4: Realize the various potential applications of the optical fibers in telecommunication and other industries.

Text Books/Reference Books:

1. Keiser, "**Fiber optic communication**" McGraw Hill, 2009.
2. F. C. Allard, **"Fiber Optics Handbook for engineers and scientists"**, McGraw Hill, 2009.
3. J. Gowar, "**Optical communication system**", Printice Hall, 1993.
4. T. Tamir, **"Integrated optics"**, Academic Press, 2010.
5. S.E. Miller & A. G. Chynoweth, "**Optical Fibers Telecommunication**", Academic Press, 1979.

DEPARTMENT OF PHYSICS

(B. TECH: VII Sem.)
(OPEN ELECTIVE)

PHOE401: NANOSCEICE AND TECHNOLOGY

L	T	P	Credits	Total contact hours
3	0	0	3	36

Pre-requisite: PHIC101

Brief Description about the course: This course includes the fundamentals of nanoscience and nanotechnology and their various synthesis, characterization techniques and potentials applications in different fields.

Course Content:

UNIT I (9 Hours)

Baiscs 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 (10 Hours)

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).

UNIT-III (10 Hours)

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 (7 Hours)

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.

Course Outcomes:

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

CO1: Engineer the properties of materials at the nanoscale.

CO2: Synthesize and characterize the nanomaterials of different shapes and sizes.

CO3: Design and develop the various devices at the nanoscale.

Text Books/Reference 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. Dupas C., Houdy P., Lahmani M., "Nanoscience: Nanotechnologies and Nanophysics", Springer-Verlag Berlin Heidelberg, 2007.

DEPARTMENT OF PHYSICS

(B. TECH: VII Sem.)
(OPEN ELECTIVE)

PHOE402: PHYSICS OF ENERGY HARVESTING TECHNOLOGIES

L	T	P	Credits	Total contact hours
3	0	0	3	36

Pre-requisite: PHIC101

Brief Description about the course: This course discus about the various energy harvesting approaches, basic physics behind it and their hybrid approaches to design various emerging energy harvesting systems.

Course Content

UNIT-I (9 Hours)

Introduction to energy harvesting, Available energy, Experimental characterization techniques, Wind energy, 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 (8 Hours)

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 (9 Hours)

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 (10 Hours)

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

Other energy harvesting approaches: Bio-inspired energy harvesting approaches, Dielectric elastomer based harvesters, Electrostatic energy harvesters, Electrets based harvesters and applications in sustainable technologies, Waste to energy.

Course Outcomes:

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

CO1: Apply the ideas of physics for various energy harvesting approaches.

CO2: Analyze practical problems on various energy harvesting techniques.

CO3: Design and develop the energy harvesting systems.

Text Books/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

DEPARTMENT OF PHYSICS

(B. TECH: VII Sem.)
(OPEN ELECTIVE)

PHOE403: LASER TECHNOLOGY

L	T	P	Credits	Total contact hours
3	0	0	3	36

Pre-requisite: PHIC101

Brief Description about the course: This course elaborates the interaction of light with matter and physical principles underlying the fabrication of laser systems, necessary conditions laser active materials and their applications in different fields of science and technology.

Course Content

UNIT-I (9 Hours)

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 (9 Hours)

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 (9 Hours)

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 (9 Hours)

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.

Text Books/Reference Books

T-1: W.T. Silfvast, **"Laser Fundamentals"**, Cambridge University Press, 2004

T-1: B.B. Laud, **"Lasers and Non-linear Optics"**, Wiley Eastern Limited, 2nd Edition 1991

R-1: Orazio Svelto, **"Principle of Lasers"**, 5th Edition, Springer New York 2010

R-2: K Thyagarajan and Ajoy Ghatak, **"Lasers: Fundamentals and Applications"**, Springer, USA, 2010.

R-3: Ajoy Ghatak and K. Thyagarajan, **"Fiber Optics and Lasers: The two revolutions"**, Macmillan India, 2006, Reprint 2008-09.

R-4: G. Kaur and Gary R. Pickrell, **"Modern Physics"**, McGraw Hill education, 2014.

Course Outcomes:

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

CO1: Know latest developments in laser technology and their applications in science, technology and research.

CO2: Utilize laser technology in modern devices and technologies based on lasers.

CO3: Apply laser technology in spectroscopic and industrial applications.

DEPARTMENT OF PHYSICS

(B. TECH: VIII Sem.)
(OPEN ELECTIVE)

PHOE404: ULTRASONICS AND APPLICAITONS

L	T	P	Credits	Total contact hours
3	0	0	3	36

Pre-requisite: PHIC101

Brief Description about the course: This course provides knowledge about the physics of ultrasonic waves, ultrasonic instruments their applications in industries.

UNIT- I (9 Hours)

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 (9 Hours)

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

Unit III (9 Hours)

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 (9 Hours)

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.

Text Books/Reference Books

T-1: J. David & N. Checke, **"Fundamental and Applications of Ultrasonics"**, 2nd Edition, CRC Press, 2017.

T-2: Ensminger, **"Ultrasonics Fundamental, Technology & Applications"**, CRC Press, 2011.

R-1: K C Srivastava, **"Ultrasonic Testing"**, 2003.

Course Outcome

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

CO1: Realize the concept of ultrasonics and its industrial applications.

CO2: Design and develop ultrasonic instrumentations for potential applications.

CO3: Solve industrial problems and design instruments on ultrasonics.

Department of Physics

(Minor Courses)

Sr. No	Course Code	Name of the Course	Pre-requisite	Credits
1.	PHMC301	PHYSICS AT NANO SCALE	PHIC 101	03
2.	PHMC302	MATHEMATICAL PHYSICS FOR ENGINEERS	PHIC 101, MAIC 12	03
3.	PHMC303	NUCLEAR AND PARTICLE PHYSICS	PHIC 101	03
4.	PHMC304	PHOTONICS	PHIC 101	03
5.	PHMC305	THERMO DYNAMICS AND STATISTICAL PHYSICS	PHIC 101, PHIC 102	03
6.	PHMC401	CONDENSED MATTER PHYSICS	PHIC 101, PHIC 102	03
7.	PHMC402	LASER PHYSICS AND APPLICATIONS	PHIC 101	03
8.	PHMC403	MATERIAL SCIENCE FOR ENGINEERS	PHIC 101	03
9.	PHMC404	SENSORS-SCIENCE AND TECHNOLOGY	PHIC 101	03
10.	PHMC405	MINOR PROJECT	--	03

DEPARTMENT OF PHYSICS

PHMC301 Physics at Nanoscale

Prerequisites: PHMC101

L	T	P	Credits	Total contact hours
3	0	0	3	36

Brief Description: The course intends the students to learn the fundamental physical principles underlying the nanoscale materials and their properties. The course describes the influence of dimensionality the fundamental principles underlying and connecting the structure, processing, properties, and performance of materials. Size and shape-controlled synthesis of materials at nanoscale and their applications is introduced.

Course Content

UNIT I **10 hrs**

Introduction to Nanoscience: Characteristic length scales of materials and their properties, Basic Concepts of Nanoscience, Nanotechnology, Features of nanosystems, bulk and nanomaterials, Significance of Nanoscale, Classifications and types of nanomaterials as nano particles. Quantum size effect: 1D 2D 3D nanomaterials, Formation of quantum well, Quantum dots and quantum wires, introduction to classical physics and quantum mechanics, importance of nanoscale materials and their devices.

UNIT II **8 hrs**

Synthesis Methods: Top-down and bottom-up approach of synthesis with suitable examples like sol-gel method, hydrothermal, micro emulsion technique, Microwave, Chemical vapor deposition, Physical vapor deposition (PVD), Spray Pyrolysis, mechanical milling.

UNIT III **8 hrs**

Nano-Scale Characterization: Size and shape dependence of optical, electronic, mechanical, magnetic and catalytic properties. XRD, SEM/FESEM, TEM/HRTEM, AFM, UV, SQUID (basic idea only).

UNIT IV **10 hrs**

Applications of Materials at Nano-Scale: Applications of nano-scale materials in the remediation of Pollution in industrial and wastewater treatment- Drinking water and air/gas purifications, solar cells, nanoscale catalysts for energy and automobile industries, rechargeable batteries based on nanomaterials, Nano based coating and paints, Drug deliveries and optoelectronic devices.

Text Books / Reference Books:

T1. Nanoscale Physics for Materials Science by T.Tsurumi, H. Hirayama, M. Vacha, T. Taniyama, CRC Press, 2009.

T2. Nanomaterials – Handbook by Yury Gogotsi, CRC Press, Taylor & Francis group, 2006.

R1. Nanophysics and Nanotechnology- An Introduction to Modern Concepts in Nanoscience by Edward L. Wolf, Second Edition, John Wiley & Sons, 2006.

R2. Nanostructures and Nanomaterials, synthesis, properties and applications by Guozhong Cao Imperial College Press, 2004.

R3. Nanoscale Science and Technology by Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley and Sons Ltd 2004.

Course Outcomes:

On the successful completion of the course, graduates will be able to:

CO1: Realized the physics behind the small systems (at nanoscale).

CO2: Apply the fundamental science and engineering principles relevant to material at nanoscale.

CO3: Utilize various process techniques to synthesize materials at nanoscale.

DEPARTMENT OF PHYSICS

PHMC302: Mathematical Physics for Engineers

Prerequisites: PHMC102

L	T	P	Credits	Total contact hours
3	0	0	3	36

Brief Description: This course is focused on the essential mathematical methods to use in various engineering disciplines. This also includes different infinite series and essential transformations used in mathematical methods and their applicability in tackling real life engineering challenges.

UNIT I **9 hrs**

Co-ordinate systems: Cartesian and curvilinear co-ordinate system, position vector, cylindrical systems, spherical system, the gradient, divergence and curl operations on different co-ordinate systems;

Examples of singular functions and their applications-- Kronecker delta, Levi-civita, Dirac delta functions.

UNIT II **9 hrs**

Vector and scalar Fields: Fundamentals offields, Integral operators—Line, Surface and Volume integrals, and their applications, Differential operators—Gradient, Divergence and Curl operators, Gauss Theorem, Greens theorem and Stokes's theorem, and their applications.

UNIT III **9 hrs**

Fourier Series: The Sine-Cosine series, Fourier series circuit, Evaluation of Fourier coefficients, Fourier series analysis for different types of electrical signals— periodic signals, rectangular signal, saw-tooth wave, triangular wave.

UNIT IV **9 hrs**

Fourier transformation: Fourier Series treatment for non-periodic signals, Fourier transformation circuit, Properties of Fourier transform, Examples of FT—Square pulses, delta functions, Gaussian signal and periodic functions.

Text Books / Reference Books:

T1. M. R. Spiegel, **Introduction to Vector analysis**, 1st edition, 1959B. Kusse, E. Westwig,
T2. **Applied Mathematics for Scientists and Engineers**, John Wiley & Sons Publishers, 2nd edition, 2006.
R1. D. J. Griffiths, **Introduction to Electrodynamics**, 3rd edition, 1999.
R2. Arfken and George, **Mathematical Methods of Physics**, Academic press, San Diego, CA, 1985.

Course Outcomes:

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

CO1: develop the skills to apply Mathematical technique as a tool to Physics concepts in tackling real life engineering problems.

CO2: realize and apply the ideas of tensors and series functions used in various technological equipment.

CO3: Apply the transformation methods in mathematics to a real life signal transportation.

DEPARTMENT OF PHYSICS

PHMC303: Nuclear and Particle Physics

Prerequisites: PHIC101

L	T	P	Credits	Total contact hours
3	0	0	3	36

Brief Description: The principles of fundamental particles of the Universe are covered in this course. The course also covers influence of dimensionality of the object at the nuclear scale and the fundamental principles underlying the structure of the bound states.

UNIT I **10 hrs**

Atomic Nucleus and detectors: Properties of Nucleus, Binding Energy, Nuclear stability, Radioactivity: Natural and artificial, half-life, Mean life, Alpha, Beta and Gamma radiations and their properties, Laws of radioactivity, Interaction of radiation with matter (Charge particle, Electromagnetic and Neutron), Radiation Detectors (working principle), Environmental radioactivity, Biological effects of radiation.

UNIT II **8 hrs**

Nuclear Reactors and Accelerators: Nuclear reaction and their type, Conservation laws, Nuclear fission, Fission reactors, Fast Breeder reactor, Nuclear Fuel, particle accelerators (different types with their principle of working), Safety protocols.

UNIT III **8 hrs**

Elementary Particles: Classification of elementary particles; leptons, mesons, baryons, strange particles, quantum numbers of elementary particles, Gell Mann-Nishijima formula, antiparticles and antimatter.

UNIT IV **10 hrs**

Standard Model of Particle Physics: Unitary symmetry, quarks, the "Eightfold way" and quark model, gluons, standard model of particle physics, symmetries and conservation laws, the C-P-T theorem, fundamental interactions in nature.

Reference Books:

T1. Glenn F Knoll, Jhon Wiley & Sons Inc. Singapore, **Radiation detection and measurement**, 2012

T2. R M Singru, Wiley Eastern Pvt. Ltd, New Delhi, **Experimental Nuclear Physics**, 2011

R1. Roy and Nigam, Himalaya Publishing House, **Nuclear Physics: Theory and Experiment**, 2016

R2. D. J. Griffiths, **Introduction to Particle Physics**, Wiley Publications, 2008

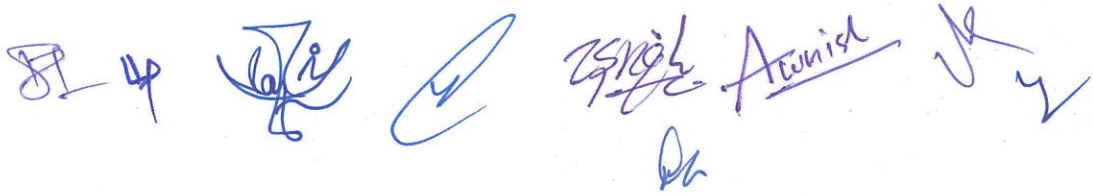
Course Outcomes:

On the successful completion of the course, graduates will be able to:

CO1: Realize the physics behind the fundamental particles by which the Universe is made off.

CO2: Apply the fundamental science and engineering principles of Nuclear Physics and technology.

CO3: Recognize the different phenomenon lead by four fundamental forces of the Universe.



DEPARTMENT OF PHYSICS

PHMC304: Photonics

Prerequisites: PHIC101

L	T	P	Credits	Total contact hours
3	0	0	3	36

Brief Description:

The course intends students to learn the fundamental knowledge about the light matter interaction of novel developments in the area of photonics. The course also includes the understanding of the principles of photon generation, propagation and manipulation.

Course contents:

UNIT I **9 hrs**

Introduction to Photonics: Dual nature of light, Photon energy, Photon position, Photon, momentum, Photon Polarization, Mean photon flux, Photon number statistics, Quantum states of light: Coherent-state light and Squeezed-state light; Propagation of EM waves in anisotropic materials, Uniaxial and biaxial materials.

UNIT II **9 hrs**

Interaction of Light with matter: Electro-optic effects: Kerr and Pockels effects, Amplitude and phase modulations, Magneto-optic effects, Optical diode and isolator. Interaction of light with acoustic waves, Acousto-optic modulators, Beam deflectors and their application to laser, Display technology, Printing Technology, Nonlinear interaction of light with matter. Origin of the optical nonlinearity.

UNIT III **9 hrs**

Second Order Nonlinear Optical Processes: Difference-frequency generation, Sum-frequency generation, Second harmonic generation, Self-phase modulation, Optical parametric oscillation. Parametric down conversion (a source of entangled photons), Frequency converter and their applications.

UNIT IV **9 hrs**

Third Order Nonlinear Optical Processes and Applications: Third harmonic generation, Self-focussing, Degenerate four-wave-mixing, Raman Scattering, Brillouin Scattering, Intensity dependent index of refraction; Role of material symmetry in nonlinear optics, controlling the velocity of light, Applications of photonics.

Text Books / Reference Books:

T1. Fundamental of Photonics by Baha E.A., Saleh and M.C. Teich: John Wiley and Sons 2010.

T2. Photonics by Ralf Menzel: Springer Verilog 2001.

R1. Nonlinear Optics by Boyd: Academic Press 2010.

R2. Nonlinear Fiber Optics by G. P. Aggarwal: Elsevier 2013.

Course Outcomes:

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

CO1: Understand the concept of the photons, their generation and manipulation.
CO2: Apply the relevant concepts of the photonics for the development of novel photonic technologies.
CO3: Solve technical and strategic problems related to the light-matter interaction.

DEPARTMENT OF PHYSICS

PHMC305: Thermodynamics and Statistical Physics

Prerequisites: PHIC101/ PHIC102

L	T	P	Credits	Total contact hours
3	0	0	3	36

Brief Description:

The course contains the various fundamentals and applications of thermodynamics and methods of Statistical Physics. The applications of Classical and quantum statistical methods are discussed in detail.

UNIT I **10 hrs**

Thermodynamics: Laws of thermodynamics and their significance–specific heats–thermodynamic potentials –Maxwell relations significance of entropy.
Models of macroscopic systems, Macro-states and microstates, Phase space, Liouville's theorem, Energy quantization, Fundamental postulate of equilibrium statistical mechanics, Ensembles--Micro-canonical ensemble, Canonical ensemble, Grand canonical ensemble, Gibbs paradox and enumeration of microstates, Partition function, Free energy, calculation of thermodynamic quantities, Entropy, Fluctuations

UNIT II **8 hrs**

Classical ideal gas, Maxwell-Boltzmann distribution, equipartition theorem, virial theorem, specific heat of gases, real gases, para-magnetism, Langevin and Brillouin functions, Curie's law, nuclear spins, ortho and para hydrogen, negative temperature concept.

UNIT I II **8 hrs**

Systems of identical, indistinguishable particles, spin, symmetry of wavefunctions, bosons, fermions, Pauli's exclusion principle, Bose-Einstein distribution,

UNIT I V **10 hrs**

Fermi-Dirac distributions, degeneracy, ideal Fermi gas and ideal Bose gas, applications – free electron gas, liquid helium, specific heat of crystalline materials – Einstein and Debye theories.

Text Books / Reference Books:

T1. R. K. Pathria, Statistical Physics, Butterworth, 1972
T2. C. Kittel, Introduction to solid state Physics, Willey, 2005
R1. S.O. Pillai. Solid State Physics, New Age International.

Course Outcomes:

On the successful completion of the course, graduates will be able to:

CO1: Apply some important results of thermodynamics, thermodynamical potentials and relations

CO2: Realize the fundamentals of classical statistical mechanics. They will learn about phase space, various ensembles and their applications.

CO3: Realize the behavior of quantum mechanical particles Bososns and fermions and implications.

DEPARTMENT OF PHYSICS

PHMC401 Condensed Matter Physics

Prerequisites: PHIC101/ PHIC102

L	T	P	Credits	Total contact hours
3	0	0	3	36

Brief Description: The course covers the fundamentals of Condensed matter Physics and classification of various condensed matter systems including the theory about defects, thermal and electronic properties of solids. The development of energy band theory in solids is also elaborated.

UNIT-I **9 H**

Crystal Physics: Crystalline and non-crystalline solids, Bonding in solids - Ionic, covalent and metallic solids, van der Waals interaction, Hydrogen bonding, Point defects, Surface defects, Volume defects.

UNIT-II **9 H**

Lattice Vibrations and Thermal Properties: Monoatomic and diatomic lattices, normal modes of lattice vibration, phonons and density of states, specific heat- classical, Einstein and Debye models, Electronic contribution to specific heat.

UNIT-III **9 H**

Electronic Properties: Classical Free Electron (Drude–Lorentz) theory, Sommerfeld's Free Electron theory, Concept of Fermi level, Fermi-Dirac distribution function,Charge carrier densities, Failures of free electron theory.

UNIT-IV **9 H**

Energy Band Theory: Kronig-Penny Model, Bloch theorem, Crystal momentum, E-K diagram, Brillouin Zones, effective mass, Concept of hole, Classification into metals, semiconductors and insulators.

Text Books / Reference Books:

T1. Kittel, C.: Introduction to Solid State Physics, Wiley (2007).
T2. Ashcroft and Mermin: Solid state Physics, Thomson (2007).
R1. Ali Omar: Elementary SolidState Physics, Addison-Wesley (2005).
R2. M A Wahab: Solid State Physics-Structure and Properties of Materials, Narosa (2005).

Course Outcome

CO1: Students will be able to understand the basics of bonding in solids, crystal defects and their role in various applications.

CO2: Students will be able to predict electronic and thermal properties of materials and explain their origin.

CO3: Students will be able to explain the concept of energy bands and effect of the same on electronic properties and classification of various condensed matter systems.

DEPARTMENT OF PHYSICS

PHMC402 LASER Physics and Applications

Prerequisites: PHIC102

L	T	P	Credits	Total contact hours
3	0	0	3	36

Brief Description: The topics include the laser fundamentals and their spectroscopic applications in different fields of science and technology. The physical principles underlying the fabrication of laser systems are also included.

UNIT-I **9 H**

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 **9 H**

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 **9 H**

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 **9 H**

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.

Text Books / Reference Books:

T1. W.T. Silfvast: **Laser Fundamentals**, Cambridge University Press, 2004

T2. B.B. Laud: **Lasers and Non-linear Optics**, Wiley Eastern Limited, 2nd Edition 1991

R1. Laser in Bioscience, Industry, and Defence by Mansharamani Narain, Defence Research & Development Organisation (India) 2012

R2. Principle of Lasers, 5th Edition, Orazio Svelto, Springer New York 2010
R3. Lasers: Fundamentals and Applications, K Thyagarajan and Ajoy Ghatak, Springer, USA, 2010
R4. Fiber Optics and Lasers: The two revolutions, Ajay Ghatak and K. Thyagarajan, Macmillan India, 2006, Reprint 2008-09

Course Outcomes

CO1: Students will become aware of latest developments in laser technology and their applications in science, technology and research.

CO2: Students will be able to understand the utilization of laser technology modern devices and technologies based on lasers.

CO3: Students will be able to use laser technology in spectroscopic and industrial applications.

DEPARTMENT OF PHYSICS

PHMC403: Material Science for Engineers

Prerequisites: PHIC101

L	T	P	Credits	Total contact hours
3	0	0	3	36

Brief Description: The course contains about functional materials their applications in engineering along with the future challenges related to advanced materials for developing futuristic devices.

UNIT I **10 H**

Introduction to Material Science: Historical perspective of Materials Science, Impact of structure and bonding over materials properties, Classification of materials, Structure in materials: Amorphous, crystalline and polycrystalline materials, Crystalline defects and their significance. Crystallinity and its effect on physical properties, Structure property relationship in material Classes of engineering materials (metals, polymers, ceramics, composites).

Solid Solutions- Substitutional and interstitial, how to draw phase diagrams of solid solutions, intermediate phases and intermetallic compounds, lever rule, isomorphous, monotectic, eutectic, peritectic, eutectoid, peritectoid reaction.

UNIT II **8 H**

Mechanical properties of materials: Uniaxial stress, strain, engineering and true stress and strain, Stress-strain curves, elastic modulus, plastic deformation, slip, dislocation motion, critical resolved shear stress, strengthening mechanisms. Introduction to fatigue and creep properties of material: Fatigue, low cycle and high cycle fatigue, S-N curves, creep-fatigue interaction.

UNIT III **8 Hours**

Structural application of engineering materials: Static Structural Applications: Application of metals, ceramics, polymers and composites in static structures like buildings, bridges, furnace structure, bulb filaments, etc, strength requirement in transmission lines.
Dynamic structural applications: Application of materials in automobiles, hydroelectric and thermal power plants.

UNIT IV **10 Hours**

Dielectric material and their applications: Dielectric Materials and Insulation: Matter polarization and relative permittivity, Polarization mechanisms, Frequency dependence of dielectric constant and dielectric loss, Dielectric strength, Piezo, Ferro and Pyro-electricity-elemental ideas. Choice of materials for various specific applications: Capacitors, Sensors, Actuators and Transducers in the context of applications.

Text Books / Reference Books:

T1. Material Science and Engineering, 6th edition, V. Raghavan, 2014.

T2. Materials Science and Engineering, William D. Callister, Jr. D. G. Rethwisch, 2014.

R1. Engineering Materials: Properties and Selection by Kenneth G. Budinski, Prentice Hall, [New Edition] USA.

R3. Principles of Electronic Materials and devices by S. O. Kasap, 2009, Third Edition, Tata-McGraw Hill Education Pvt. Ltd., New Delhi Solid State Electronic Devices by Ben G. Streetman and Sanjay Bannerjee, 2000, Fifth edition, Pearson-Prentice Hall, USA

R4. Diffusion in Solids, P. Shewmon, 2016.

Course Outcomes:

CO1: Student should be able to understand the classes of materials available for various applications and selection strategies.

CO2: Student should be able to understand: the properties that influence the behavior of the materials and how to measure them.

CO3: Students will be able to understand the structures in materials that control functional properties. Students may be able to develop futuristic devices.

DEPARTMENT OF PHYSICS

PHMC404: Sensors-Science and Technology

Prerequisites: PHIC101

L	T	P	Credits	Total contact hours
3	0	0	3	36

Brief Description:

The working principle and modeling of different types of sensors and technology at nano-scale are covered in this course.

UNIT-I **9 H**

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

UNIT-II **9 H**

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

UNIT-III **9H**

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 **9 H**

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.

Text Books / Reference Books:

T1. J. Fraden, Handbook of Modern Sensors: Physical, Designs, and Applications, AIP Press, Springer, 2010.
T2. D. Patranabis, Sensors and Transducers, PHI Publication, New Delhi, 2003.
R1. Ganesh S. Hegde, Mechatronics, University Science Press, 2008.
R2. P.T. Moseley, B.C. Toefield, Solid State Gas Sensors', CRC Press, 1987.
R3. M. Meyyappan, Carbon Nanotubes Science and Applications, CRC Press, 2014.

Course Outcomes

CO1: Students will be able to model and design various sensors.

CO2: Students will be familiarized to the practical approaches for different sensors.

CO3: Students will learn about various materials and methods of fabrication of sensors.

DEPARTMENT OF PHYSICS

PHMC405: Minor Projects

Prerequisites: PHIC101

L	T	P	Credits	Total contact hours
0	0	6	3	36

Brief Description:

The course is intended to inculcate the hand on experience on calibration and analysis of materials for their applications in sustainable technology.

Minor Project Related to

1. Nonlinear Fiber Optics
2. Specialty Optical Fibers and Waveguides
3. Mid-IR Photonics & Integrated Photonics
4. Quantum Technologies in Optical Fibers
5. Material Science
6. Energy Storage Devices
7. Nano Composites
8. Advanced Sensor Materials
9. Semiconductor Devices