NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

DEPARTMENT OF PHYSICS

SYLLABI FOR THE CURRICULAM OF UG COURSE

(updated on 2nd December, 2021)

(BACHELOR OF TECHNOLOGY)

Curriculum & Syllabi for B. Tech/Integrated M.Sc. (Chem.) Courses

List of Courses to be offered by the Dept of Physics

Sl. No	Sub. Code	Subject	L-T-P	Credits	Hours
1	PHC01	Engineering Physics	2-1-0	3	3
2	PHS51	Physics Laboratory	0-0-2	1	2
3	PHC331	Physics of Semiconductor Devices	3-0-0	3	3
4	PHS381	Semiconductor Devices Laboratory	0-0-3	1.5	3
5	PHC332	Electromagnetic Field Theory	3-0-0	3	3
6	PHS382	Advanced Physics Laboratory	0-0-3	1.5	3
7	PHC333	Physics of Engineering Materials	3-0-0	3	3
8	PHS383	Physics of Engineering Materials Laboratory	0-0-3	1.5	3
9	PHC334	Physics II	3-0-0	3	3
10	PHS384	Physics II Laboratory	0-0-3	1.5	3
Open Elective Basket					
11	PHO441	Quantitative Biology	3-0-0	3	3
12	PHO541	Thin Film Technology	3-0-0	3	3
13	PHO741	Nuclear Reactor Technology	3-0-0	3	3
14	PHO841	Quantum Physics	3-0-0	3	3
15	PHO851	Fiber-Optics Communication	3-0-0	3	3
16	PHO852	Optical Instrumentation	3-0-0	3	3

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PHC01</td><td>Engineering Physics</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites:</td><td colspan="6">Course Assessment methods: (Continuous (CT), MID term and End Term Assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
</table>

<table>
<tr><td>Course Outcomes</td><td>CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems.
CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field.
CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization.
CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.</td></tr>
<tr><td>Topics Covered</td><td>Harmonic Oscillations - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, etc. [8]

Wave Motion - Wave equation, Longitudinal waves, Transverse waves, Electro-magnetic waves. [3]
Introductory Quantum Mechanics - Inadequacy of classical mechanics, Blackbody radiation, Planck’s quantum hypothesis, de Broglie’s hypothesis, Heisenberg’s uncertainty principle and applications, Schrodinger’s wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8]

Interference & Diffraction - Huygens’ principle, Young’s experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13]
Polarisation - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster’s law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5]
Laser and Optical Fiber - Spontaneous and stimulated emission of radiation, Population inversion, Einstein’s A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]</td></tr>
<tr><td>Text Books, and/or reference material</td><td>TEXT BOOKS:
1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons
2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications
3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill.

REFERENCE BOOKS:
1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press
2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons
3. Fundamental of Optics, Jankins and White, McGraw-Hill
4. Optics, A. K. Ghatak, Tata McGraw-Hill
5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill
6. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PHS51</td><td>Physics Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To realize and apply different techniques for measuring refractive indices of different materials.
CO2: To realize different types of waveforms in electrical signals using CRO.
CO3: To understand charging and discharging mechanism of a capacitor.
CO4: To understand interference, diffraction and polarization related optical phenomena.
CO5: To acquire basic knowledge of light propagation through fibers.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Find the refractive index of a liquid by a travelling microscope.
2. Determine the refractive index of the material of prism using spectrometer.
3. Determination of amplitude and frequency of electrical signals by oscilloscope.
4. To study the characteristics of RC circuits.
5. To study Brewster’s law/Malus’ law using laser light.
6. To study the diffraction of light by a grating.
7. To study the interference of light by Newton’s ring apparatus.
8. To determine numerical aperture of optical fiber.
9. Determination of Planck constant.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">SUGGESTED BOOKS:
1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh
2) Practical Physics – Worsnop and Flint</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PCR)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PHC331</td><td>Physics of Semiconductor Devices</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods: (Continuous (CT) and Midterm (MT) end assessment (EA)):</td></tr>
<tr><td colspan="2">PHC 01 in 1st year.</td><td colspan="6">CT, MT, EA Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of the course, a student will be able to:
CO1. Describe the different electronic properties of semiconductor materials.
CO2. Understand the working principal of electronic devises (PN Diode, Photodetector, Solar cell, Light-Emitting Diodes, Laser Diodes, JFET, MOSFET, Tunnel Diode, Gunn Diode, IMPATT Diode, TRAPATT Diode and semiconductor memory).
CO3. Apply the knowledge of memory expansion to design required expanded memory for specific application.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Fundamentals of Semiconductor & Semiconductor Devices Fabrication: Introduction to crystal growth, Intrinsic and extrinsic semiconductors, Fermi level, Conductivity, Mobility and its temperature dependence, Energy bands of semiconductors, Direct and indirect semiconductor, Variation of energy band with alloy composition, III-V and II-VI alloy semiconductor, Homo and hetero-structure semiconductor, Effective masses of carriers in semiconductor, Fermi-Dirac distribution function, Density of states, Carrier concentrations at equilibrium, Calculation of number density of carriers and their temperature dependence, Effects of temperature on carrier concentrations, High field effects, Hall effect, Lithography, Optical lithography and Electron beam lithography. [14]

Junction-Diode & Optoelectronic Devices: P-N junction, Contact potential, Band diagram, Degenerate semiconductors, Photodetector, Solar cell, Light-Emitting Diodes, Internal and external quantum efficiency etc., Semiconductor Lasers, Population inversion at a junction, Emission spectra for P-N junction Lasers. [3]

Negative Conductance Microwave Devices: Materials for negative conductance devices, The Gunn effect and related devices, The transferred electron mechanism, Transit time devices, The IMPATT Diode, the TRAPATT Diode,Tunnel Diode. [10]

JFET and MOSFET: Junction Field Effect Transistors (JFET), Operation, I-V Characteristics etc., MOS structure, Different MOS structures, Operation of MOS at high and low frequency, Accumulation, Inversion, strong inversion regions, Metal-Oxide Semiconductor Field Effect Transistors (MOSFET), MOSFET as a Capacitor, MOSFET as a resistor and related circuits. [9]

Semiconductor Memory Device: Semiconductor memory organization, Random Access Memory (RAM) (static and dynamic), CMOS memory circuits, Charge Coupled Devices (CCD). [6]</td></tr>
</table>

Text Books, and/or reference material	**Text Books** 1. Physics of Semiconductor Devices, S M SZE. 2. Solid State Electronic Devices, Ben G Streetman & Banerjee 3. Microwave Solid-State Devices, S Y Liao **References:** 1. Semiconductor Physics and Devices, Donald A. Neamen. 2. Microwave Engineering, David M.Pozar. 3. Integrated Electronics, Millman-Halkias.

Mapping of CO (Course outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	1	2	1		1	1	1				2	-	-	1
CO2	3	2	1	1	1	1	1	1	1	1		2	1	1	1
CO3	3	3	2	1	1	1	1	1	1	1	1	1	2	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS381	**Semiconductor Devices Laboratory**	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods: (Continuous (CT) and end assessment (EA)):
PHS 51 in 1st year.	CT, EA Examination

Course Outcomes	At the end of the course, a student will be able to: CO1. Calculate different characteristic parameter of semiconductor materials. CO2. Measure and understand different characteristic of semiconductor devices. CO3. Draw the current-voltage characteristics of solar cell for calculation of conversion efficiency.
Topics Covered	**List of Experiments:** 1. To determine the energy bandgap of a semiconductor. 2. Measurement of resistivity of semiconductors by four-probe method at different temperatures. 3. Determination of Hall coefficient of a given semiconductor and its temperature dependence. 4. To determine the value of e/m of an electron by using a cathode ray tube and a pair of bar magnet. 5. Determination of Stefan's constant. 6. Study of p-n junction diode characteristics. 7. Study of Zener diode characteristics and voltage regulator. 8. Determination of photo conversion efficiency of a Solar cell.
Text Books, and/or reference material	**Text Books** 1. An advanced course in practical physics, Chattapadhyay and Rakshit. 2. Advanced Practical Physics, B. Ghosh and K. G. Mazumdar

Mapping of CO (Course outcome) and PO (Programme Outcome)

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1					1	1	1		2	1		1
CO2	3	2	1					1	1	1		2	1		1
CO3	3	2	1		1	1	1	1	1	1		2	2		1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC332	**Electromagnetic Field Theory**	PCR	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term assessment (MTA) and end assessment (EA))
NIL	CT+MTA+EA

Course Outcomes	CO1: Able to apply fundamental knowledge of different co-ordinate systems to describe the spatial variations of the physical quantities dealt in electromagnetic field theory. CO2: Able to explain fundamental laws governing electromagnetic fields and evaluate the physical quantities of electromagnetic fields (Field intensity, Flux density etc.). CO3: Gain an integrative overview of electromagnetic waves, its propagation in different media and different phenomena related to electromagnetic wave propagation. CO4: Acquire basic knowledge related to wave guides and transmission line.
Topics Covered	**Concept of Field and Maxwell's Equations** Vector field, Divergence of vector field, Divergence of electrostatic field, Gauss's divergence theorem, Gauss's Law of electrostatics and its applications, Laplace's equation, Poisson's equation, Continuity equation. [7] Curl of a vector field, Stoke's theorem, Curl of magnetic field, Ampere's Circuital law and its applications, Curl of electric field and divergence of magnetic field, Concepts of scalar and vector potentials. [7] Faraday's law of electromagnetic induction, Self-Inductance, Mutual-Inductance, L-C-R Circuit, Concept of displacement current, Maxwell's equation in free space, Poynting theorem. Some examples. [9] **Electromagnetic Waves** Derivation of the electromagnetic wave equation. Plane waves in vacuum. Energy, Momentum and intensity of electromagnetic waves. Electromagnetic waves in isotropic, Anisotropic medium, Conducting medium. Skin effect. Propagation of electromagnetic waves in ionized gases, Reflection, Refraction and Dispersion of electromagnetic waves, Fresnel's equations. Some examples. [12] **Wave Guide** Wave guides, TE, TM and TEM waves, Transmission line and Telegrapher's equation. [7]
Text Books, and/or reference material	**TEXT BOOKS:** 1. Introduction to Electrodynamics, David J. Griffiths, Prentice-Hall International, Inc., Englewood Cliffs. 2. Foundations of Electromagnetic Theory, J. R. Reitz, F. J. Milford and R. W. Christy, Addison-Wesley Publishing Company, Inc. 3. Introduction to Electromagnetic Theory – A Modern Perspective, T. L. Chow, Jones and Bartlett Publishers, Inc. **REFERENCE BOOKS:** 1. Classical Electricity and Magnetism, W. K. H. Panofsky and M. Phillips, Addison-Wesley. 2. Classical Electrodynamics, W. Greiner, Springer International Edition 3. Classical Electrodynamics, J. D. Jackson, John Wiley

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC332	CO1	3	2	-	1	1	-	-	-	2	1	-	1
	CO2	3	2	1	1	-	1	-	-	1	1	-	1
	CO3	3	2	1	1	1	-	-	-	1	1	-	1
	CO4	3	2	1	-	-	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
PHS382	**Advanced Physics Laboratory**	PCR	**0**	**0**	**3**	**3**	**1.5**

Pre-requisites	Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))
PHS51	CE+EA

Course Outcomes

CO1: To realize and apply different techniques for measuring resonance, Q-factor of series L-C-R circuit.
CO2: To determine the Self-Inductance, Mutual Inductance and verification of Faraday's law.
CO3: To determine the thermoelectric power of a given thermocouple.
CO4: To apply the concepts to measure the horizontal component of the earth's magnetic field using a vibrational and deflection magnetometer
CO5: To calculate the loss of a magnetic specimen by B-H loop measurement.

Topics Covered

1. Study of series L-C-R Resonant Circuit: (i) To draw the resonance curve (ii) To determine the Q- Factor of the circuit (iii) To study the variation of impedance with frequency (iv) verification of maximum power transfer theorem.
2. Verification of Faraday's law.
3. To determine the mutual inductance (M) of two coils.
4. Determination of Self-Inductance of a coil.
5. To verify Fresnel's equation for reflection of electromagnetic waves.
6. Draw the (Thermo EMF) – Temperature curve of given thermocouple and hence find thermoelectric power at a given temperature.
7. Determination of horizontal component of the earth's magnetic field using a vibrational and deflection magnetometer.
8. To draw the B-H loop of a given specimen.

Text Books, and/or reference material

SUGGESTED BOOKS:

1. A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh
2. Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS382	CO1	3	2	1	-	2	1	1	2	3	2	1	1
	CO2	3	2	1	-	2	1	1	2	3	2	1	1
	CO3	3	2	1	1	2	1	1	2	3	2	1	1
	CO4	3	2	1	-	2	1	1	2	3	2	1	1
	CO5	3	2	1	1	1	1	1	1	2	1	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC333	**Physics of Engineering Materials**	**PCR**	**3**	**0**	**0**	**3**	**3**

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term assessment(MTA) and end assessment (EA))
NIL	CT+MTA+EA

Course Outcomes	
	CO1: To understand fundamental theory of metal CO2: To comprehend theory and device applications of semiconductor materials CO3: To be familiar with fundamental of laser and its applications. CO4: To know about the super conductivity, dielectric and mechanical properties of material

Topics Covered

Electron Theory of Metals

Fermi-Dirac Statistics and Fermi energy, Density of states, Concept of density of states in nanomaterials, Electrical conduction in metals and alloys, Current density, Drift velocity, Mobility etc., Classical electron theory of metal (Drude-Lorentz Theory), Quantum mechanical consideration (Sommerfeld Model). Origin of band gap (Kronig-Penny Model), Brillouin zone, Resistivity of pure metals and alloys, Electronic specific heat of metals, Thermal conductivity of metals, Factors affecting electrical conductivity, Resistivity of pure metals and alloys, Solders, Soft and hard and the use of fluxes and their classifications. [12L]

Semiconductors

Intrinsic and extrinsic semiconductors, Fermi level, Calculation of number density of carriers and their temperature dependence, Conductivity, Mobility and its temperature dependence, Hall effect. Compound semiconductors, Direct and indirect bandgap semiconductors. Applications of semiconductor material; Semiconductor devices, p-n diode, Zener diode, Tunnel diode, Solar cell. Semiconductor device fabrication (Mention only techniques). Double heterostructure LED (ILED). [10L]

Materials for Optical Applications

Optical materials for Light Emitting Diode, Laser- Solid-state lasers, Liquid & Gas lasers. Semiconductor Laser, Band diagram, Pumping mechanism, Operation. Examples of nonlinear optical materials [4L]

Superconductors

Superconductivity; Electrical & magnetic properties of superconducting materials, Zero resistance property, Meissner effect, A.C. resistance, BCS Theory (Qualitative), Josephson's junction, Engineering applications of superconducting materials. [5L]

Dielectrics

Definitions, The local field, The Clauius-Mossoti relation, Sources of polarizability, Dipolar polarizability, Debye equation and study of molecular structure, Electronic polarizability, Ionic polarizability (Brief), Measurement of dielectric constant, Electrets, Piezoelectricity, Ferroelectricity and comparison with piezoelectricity, Applications of ferroelectric materials. [5L]

	Mechanical Behaviour of Materials Bonding of solids, Crystal structure, Crystal imperfections, Estimation of theoretical strength, Introduction of stress and strain, Hooke's law, elasticity, plasticity, Fracture of materials, (Fracture, Fatigue, Creep), Strengthening mechanism, Composites. [6L]
Text Books, and/or reference material	**TEXT BOOKS:** 1. Introduction to Modern Physics, H. S. Mani & G. K. Mehta 2. Solid State Electronic Devices, B. G. Streetman 3. Solid State Physics, S. O. Pillai **REFERENCE BOOKS:** 1. Introduction to Solid State Physics, C. Kittel 2. Introduction to Materials Science for Engineers, J. F. Shackelford & M. K. Muralidhara 3. Electronic Properties of Metals, E. Hamuel

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC333	CO1	3	1	2	3	1	1	2	1	-	1	1	2
	CO2	3	3	2	3	-	1	2	1	-	-	-	1
	CO3	3	3	2	3	-	1	2	1	1	1	1	2
	CO4	3	2	2	3	1	1	2	2	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Physics								
Course Code	**Title of the course**	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours**				**Credit**	
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**		
PHS383	**Physics of Engineering Materials Laboratory**	PCR	**0**	**0**	**3**	**3**	**1.5**	
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))						
PHS51		CE+EA						

Course Outcomes	CO1: To realize and apply different techniques for measuring characteristics of p-n junction and application of Zener diode as voltage regulator. CO2: To determine the properties (carrier concentration and type) of semiconductor by Hall-effect experiments. CO3: To apply the knowledge to determine the properties (bandgap and resistivity) of semiconductor materials by four-probe method at different temperatures. CO4: To determine the characteristics of solar cell. CO5: To determine the physical parameter such as e/m of an electron and Stefan's constant.
Topics Covered	1. Determination of Stefan's constant. 2. Study of Hall voltage and Hall coefficient of a given material. 3. Measurement of electrical conductivity of a semiconductor. 4. To determine the energy bandgap of a semiconductor. 5. To study the variation of thermo emf of a thermo-couple with temperature and determine its thermo-electric power. 6. Determination of power conversion efficiency of a solar cell 7. To study the quantization of energy (Frank Hertz Experiment). 8. To determine the value of e/m of an electron by using a cathode ray tube and a pair of bar magnet.
Text Books, and/or reference material	**SUGGESTED BOOKS** 1. A Text Book on Practical Physics – K. G. Majumdar and B. Ghosh 2. Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS383	CO1	3	2	2	3	2	2	3	2	2	1	3	2
	CO2	3	2	2	2	-	1	2	2	2	1	3	2
	CO3	3	1	1	2	-	1	2	2	2	1	3	2
	CO4	3	1	3	3	-	3	3	2	2	1	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
PHC334	**Physics II**	PCR	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term assessment(MTA) and end assessment (EA))
NIL	CT+MTA+EA

Course Outcomes	CO1: Able to understand the principles of classical mechanics apply to solve classical problems related to solving Lagrange’s and Hamilton’s equations of motion. CO2: Able to apply fundamental knowledge of different co-ordinate systems to describe the spatial variations of the physical quantities dealt in electromagnetic field theory. CO3: Able to explain fundamental laws governing electromagnetic fields and evaluate the physical quantities of electromagnetic fields (Field intensity, Flux density etc.). CO4: Gain an integrative overview of electromagnetic waves, its propagation in different media and different phenomena related to electromagnetic wave propagation..
Topics Covered	**Classical Mechanics**: D’Alembert's principle, Lagrange’s equation of motion, Some applications of Lagrange’s equation of motion, Hamilton’s equation of motion, Some applications of Hamilton’s equation of motion and its physical significance. [6L] **Vector Analysis**: Vector field, Divergence and curl of a vector field and their physical significance, Gauss’s divergence theorem, Stoke’s theorem, Green’s theorem, Different coordinate systems (Cartesian, spherical and cylindrical) [8L] **Electrostatics**: Divergence of electrostatic field, Gauss’s Law of electrostatics and its applications, Laplace’s equation, Poisson’s equation, Continuity equation, Capacitor. [6L] **Magnetostatics**: Curl of magnetic field, Ampere’s Circuital law and its applications, Curl of electric field and divergence of magnetic field, Concepts of scalar and vector potentials. [7L] Electromagnetic Induction and Maxwell’s Equation: Faraday’s law of electromagnetic induction, Concept of displacement current, Maxwell’s equation in free space, Poynting Theorem. Some examples. [7L] **Alternating Current**: L-R, C-R, L-C-R series and parallel circuits, Q- factor, Resonance, Maximum power transfer theorem, Voltage magnification factor, Band width of circuit. [8L]
Text Books, and/or reference material	**TEXT BOOK**: 1. Vector Analysis: Murray Spiegel (Author), Seymour Lipschutz, Dennis Spellman 2. Introduction to Electrodynamics: David J. Griffith 3. Introduction to Classical Mechanics: R. G. Takwale & P. S. Puranik **REFERENCE BOOKS**: 1.Classical Mechanics: N. C. Rana & P. S. Joag 2.Classical Mechanics: H. Goldstein 3. Electricity and Magnetism: D. Chattopadhyay & P. C. Rakshit

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC334	CO1	3	2	1	2	-	1	1	-	1	1	-	1
	CO2	3	2	-	1	1	-	-	-	2	1	-	1
	CO3	3	2	1	1	-	1	-	-	1	1	-	1
	CO4	3	2	1	1	-	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
PHS384	**Physics II Laboratory**	PCR	**0**	**0**	**3**	**3**	**1.5**

Pre-requisites	Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))
PHS51	CE+EA

Course Outcomes	CO1: To realize and apply different techniques for measuring resonance, Q-factor of series L-C-R circuit. CO2: To determine the Self-Inductance, Mutual Inductance and verification of Faraday's law. CO3: To determine the thermoelectric power of a given thermocouple. CO4: To apply the concepts to measure the horizontal component of the earth's magnetic field using a vibrational and deflection magnetometer CO5: To calculate the loss of a magnetic specimen by B-H loop measurement.
Topics Covered	1. Study of series L-C-R Resonant Circuit: (i) To draw the resonance curve (ii) To determine the Q- Factor of the circuit (iii) To study the variation of impedance with frequency (iv) verification of maximum power transfer theorem. 2. Verification of Faraday's law. 3. To determine the Mutual-Inductance (M-I) of two coils. 4. Determination of Self-Inductance of a coil. 5. To verify Fresnel's equation for reflection of electromagnetic waves. 6. Draw the (Thermo EMF) – Temperature curve of given thermocouple and hence find thermoelectric power at a given temperature. 7. Determination of horizontal component of the earth's magnetic field using a vibrational and deflection magnetometer. 8. To draw the B-H loop of a given specimen.
Text Books, and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Majumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS382	CO1	3	2	1	-	2	1	1	2	3	2	1	1
	CO2	3	2	1	-	2	1	1	2	3	2	1	1
	CO3	3	2	1	1	2	1	1	2	3	2	1	1
	CO4	3	2	1	-	2	1	1	2	3	2	1	1
	CO5	3	2	1	1	1	1	1	1	2	1	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PHO441</td><td>Quantitative Biology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term assessment(MTA) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+MTA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To see living systems from the perspective of engineering, physics, mathematics and computer science.
CO2: To understand systems based approaches in biological sciences.
CO3: To use web-based resources that will help them in modeling complex biological processes.
CO4: To choose an appropriate modeling technique for a complex biological system</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Nonlinear Phenomena
One-dimensional systems and elementary bifurcations, Two-dimensional systems; phase plane analysis, limit cycles, Nonlinear Oscillators, qualitative and approximate asymptotic techniques, Hopf bifurcations, chaos, strange attractors and fractals. [12]

Biological Networks and Motifs
Basic concepts in networks and chemical reactions. Input function of a gene, Michaelis-Menten kinetics, and cooperativity, Autoregulation, feedback and bistability, Introduction to synthetic biology and stability analysis in the toggle switch, Oscillatory genetic networks, Feed-forward loop network motif. [9]

Stochastic Modeling of Biological Systems
Concept of probability, Introduction to stochastic gene expression, Causes and consequences of stochastic gene expression, Markov processes and Markov Models, Stochastic modeling—The master equation, Fokker-Planck Equation, and the Gillespie algorithm, Survival in fluctuating environments, Robustness in development and pattern formation. [12]
Population Dynamics & evolutionary games
Interspecies interactions, the Lotka-Volterra model, and predator-prey oscillations, Ecosystem stability, critical transitions, and the maintenance of biodiversity, Infectious disease spread: SIR and other models, Introduction to microbial evolution experiments, and optimal gene circuit design, Fitness landscapes, Evolutionary games. [9]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">TEXT BOOKS:
1. Alon, Uri. An Introduction to Systems Biology: Design Principles of Biological Circuits. Chapman & Hall / CRC, 2006. ISBN: 9781584886426.
2. Strogatz, Steven H. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering. Westview Press, 2014. ISBN: 9780813349107.
3. Network Science, A-L. Barabasi, Cambridge University Press
REFERENCE BOOKS:
1. Nowak, M. A. Evolutionary Dynamics: Exploring the Equations of Life. Belknap Press, 2006. ISBN: 9780674023383.
2. Alberts, Bruce. Essential Cell Biology. Garland Science, 2009. ISBN: 9780815341291.</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHO441	CO1	3	2	2	1	-	-	2	-	-	-	-	1
	CO2	3	2	2	2	-	-	2	-	-	-	-	1
	CO3	3	2	2	3	3	2	1	-	1	1	1	1
	CO4	3	2	2	3	2	2	1	1	1	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHO541	**Thin Film Technology**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term assessment(MTA) and end assessment (EA))
NIL	CT+MTA+EA

Course Outcomes	CO1: To understand growth mechanism of thin film CO2: To comprehend application of thin film in modern devices CO3: To be familiar with characterization technique of thin film CO4: To know about the industrial applications of thin film
Topics Covered	**Introduction:** Basic of Thin films and Nanostructures, Role of thin films in Devices. [2] **Nucleation, film growth and structure**: Thermodynamics of Nucleation, Nucleation theory: Capillarity Model and Statistical Model, Comparison of two models, Film growth: Volmer-Waber growth, Frank-Vander-Merwe and Stranski-Krastonav growth, Dissociations, Doping and diffusion effects, Film thickness. [9] **Deposition Technique**: Thermal Evaporation: Resistive heating, Flash evaporation, Arc evaporation, Laser evaporation, rf heating, Electron bombardment heating, Sputtering: Glow discharge sputtering, Low pressure sputtering, Reactive sputtering, rf sputtering, Chemical Methods: Electro-deposition, Electrolytic deposition, Chemical Vapour deposition, Liquid phase epitaxy, Molecular beam epitaxy, Spin coating, Sol gel, Langmuir Blodgett (LB) Techniques. [12] **Thin Film Characterization:** X-ray diffraction and G-XRD method, Atomic force microscope (AFM) method for determination of surface roughness, Scanning tunneling microscopy (STM), Thickness measurement techniques (ellipsometer), Field emission scanning electron microscopy (FESEM), Transmission electron microscopy (TEM), Hall effect, UV-vis spectroscopy, photo luminance process, Schottky contact, Ohmic contact, Photocurrent and photocapacitance measurement. [12] **Thin film Devices:** Applications of different thin films in modern technology, Photo diode, LED and Solar cell. [7]
Text Books, and/or reference material	**TEXT BOOKS:** 1. Thin Film Phenomena, K. L. Chopra 2. An Introduction to Physics and Technology of Thin Films, Part – I & II, A. Wagendristel & Y. Wang. 3. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley, Mark Geoghegan **REFERENCE BOOKS:** 4. Thin Film Fundamentals, A. Goswami 5. Handbook of Thin Film Technology, Maissel and Glange 6. Thin Film Solar Cells, S. R. Das and S. P. Singh

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHO541	CO1	3	1	2	3	1	-	-	1	-	-	-	1
	CO2	3	3	2	2	-	-	2	1	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	1	1	1
	CO4	3	2	2	2	1	1	1	2	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PHO741</td><td>Nuclear Reactor Technology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term assessment(MTA) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+MTA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand basic properties of a nucleus and nuclear reaction.
CO2: To procure knowledge of the action of nuclear reactor.
CO3: To understand neutron physics and diffusion theory.
CO4: To learn the utility, protection and control of nuclear reactor.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">General Nuclear Properties:
Nuclear mass, Mass defects, Binding energy, Liquid drop model, Semi-empirical mass formula, Energy losses by charged particles and gamma rays. [6]
Nuclear Reaction:
Types of nuclear reaction, Cross-section of a nuclear reaction, Neutron induced reactions, Nuclear fission, Separation energy and fissionability, Fission cross section for slow and fast neutrons, Energy release in fission, Fission fragments and energy distribution, Nuclear fusion and thermo-nuclear reaction. [6]
Neutron Physics and Diffusion Theory:
Properties of neutron, Neutron sources, Slowing down of neutrons, Neutron scattering, Moderating ratio, Diffusion of thermal neutrons, Diffusion equation, Slowing down without absorption, Slowing down and diffusion, Critical size of reactors slabs, Cubical, Spherical and cylindrical reactors. Variation of neutron cross-section with neutron energy. [10]
Chain Reaction & Fuel Cycle:
Criticality factor, Moderating ratio, Four-factor formula, Reactor kinetics, Reactor poisons, Nuclear fuel cycle, Enrichment of uranium, Back end of fuel cycle. [6]
General Features of a Nuclear Reactor:
Classification of reactors, Basic components. Outlines of BWR, PWR, GCR and FBR with their basic features and characteristics. [6]
Nuclear Reactor Materials:
Fuel fabrication, Moderators, Heavy water production, Control elements, Structural materials. Reactor protection and control. [8]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">TEXT BOOKS:
1. Nuclear Reactor Engineering, Glasstone & Sesonske.
2. Atomic & Nuclear Physics, S. N. Ghoshal.
3. Nuclear & Particle Physics, S. L. Kakani, S. Kakani.
REFERENCE BOOKS:
1. Introduction to Nuclear Reactor Theory, J. R. Lamarsh.
2. Nuclear Physics, I. Kaplan.
3. Nuclear Energy, David Bodansky.
4. Nuclear Physics, D. C. Tayal.</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHO741	CO1	3	1	1	2	1	1	2	1	-	1	-	2
	CO2	3	3	1	2	-	1	2	2	-	1	-	3
	CO3	3	3	2	2	-	2	2	1	-	1	-	2
	CO4	3	3	3	3	1	3	3	3	-	1	1	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PHO841</td><td>Quantum Physics</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term assessment(MTA) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+MTA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To be proficient in the fundamental mathematical languages used, such as matrix algebra, in quantum information theory
CO2: To understand and implement basic quantum algorithms (Shor, Deutsch-Jozsa etc)
CO3: To understand limitations to quantum computation introduced by quantum decoherence
CO4: To be knowledgeable about advanced topics such as teleportation, Bell’s inequalities and EPR paradox.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Quantum Mechanics Introduction
History of quanta, base states and superposition, structural randomness, measurement: how long is a qubit?, Heisenberg's Uncertainty Principle, waveform collapse in the macroscopic limit [9]
Matrix Algebra
Basis vectors and orthogonality, inner product and Hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation [8]

Fundamentals of Quantumness
Abramsky-Coecke semantics, no-cloning theorem, quantum entanglement (‘spooky action at a distance’), Bell states and Bell inequalities [7]

Quantum Circuits
Pauli, Hadamard, phase, CNOT, Toffoli gates, quantum teleportation, universality of two-qubit gates, reversible computing [6]

Quantum Algorithms
Deutsch-Josza algorithm, Simon’s problem, quantum Fourier transform, Shor’s period-finding algorithm, quantum key distribution (BB84, E91) [6]

Quantum Error Correction
Error correction codes [3]
Quantum Computers
Physical qubits, noise and decoherence [3]</td></tr>
</table>

Text Books, and/or reference material	**TEXT BOOKS:** 1. Phillip Kaye, Raymond Laflamme, and Michele Mosca (2007). An Introduction to Quantum Computing. Oxford University Press. 2. Michael A. Nielsen and Isaac L. Chuang (2000). Quantum Computation and Quantum Information. Cambridge University Press. 3. Mermin, N. David (2007). Quantum Computer Science: An Introduction. Cambridge University Press. **REFERENCE BOOKS:** 1. Yanofsky, Noson S. and Mirco A. Mannucci (2008). Quantum Computing for Computer Scientists. Cambridge University Press. 2. McMahon, David (2008). Quantum Computing Explained. John Wiley & Sons, Inc. 3. Quantum Computing for Everyone

Mapping of CO (Course outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	1	1	1	1	1	1
CO2	3	3	3	3	3	1	1	1	1	1	1	1
CO3	3	3	3	2	2	1	1	1	1	1	1	1
CO4	3	3	2	2	2	2	1	1	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PHO 851</td><td>Fiber-Optics Communication</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), midterm assessment (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of the course, the student is able to
CO1: Distinguish and identify different types of fibers and there potential application in different fields of optical communication and sensing.
CO2: Explain different characteristics of optical fiber along with dispersion and attenuation.
CO3: Understand and classify the working principle of different optical sources and detectors.
CO4: Acquire basic knowledge of short haul, long haul and advanced optical transmission systems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Optical Fiber Communications:
Transmission speed, Evolution of Fiber Optic Systems, Elements of an Optical Fiber Transmission Link. [3]
Optical Fibers: Structures, Waveguide and Fabrication:
Ray propagation through SI and GI fiber, Pulse broadening- multipath dispersion and material dispersion, Maxwell’s Equations, TE and TM mode wave equations. Wave propagation in rectangular slab and circular waveguides, Propagation modes, Power Flow in rectangular slab waveguide, Single-mode fibers; Mode-field diameter. Fiber fabrication; overview of different methods of fabrication. [14]

Signal Degradation in Optical Fibers:
Signal attenuation, Absorption, Scattering Losses, Bending Losses, Core and cladding losses, coupling loss. Group Velocity Dispersion, Material Dispersion, Waveguide Dispersion, Polarization-Mode dispersion, Intermodal Distortion. [7]

Optical Sources and Detectors: Review of semiconductor Physics. Light Emitting Diodes (LEDs); Structure, Materials, Quantum Efficiency and LED Power, Modulation of an LED. Laser Diodes; Threshold conditions, Rate equations, Quantum efficiency, Resonant frequencies, Structure and radiation patterns, Single-mode lasers, Modulation, Effects of temperature. Optical detectors- p-n junction, P-I-N, APD, Phototransistor, PMT detectors. [12]

Power launching and coupling: Source-to-Fiber power launching lensing schemes for coupling improvement, Fiber splicing, Optical fiber connectors and optical devices, etc. [6]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">TEXT BOOKS:
1. Fiber Optics and Optoelectronics, R. P. Khare, Oxford University Press
2. Optical Fiber Communications (3rd Ed.), Gerd Keiser- McGraw-Hill
3. Optoelectronics Photonics , S.O. Kasap
REFERENCE BOOKS:
1. Introduction to Fiber Optics, Ajoy Ghatak & K. Thyagarajan, Cambridge University Press
2. Fiber-Optic Communications Technology, D. K. Mynbaev & L. L. Scheiner, Pearson Education
3. Optical Communication Components & Systems, J. H. Franz & V. K. Jain.</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHO851	CO1	3	1	1	1		2	2	1	1	1	1	1
	CO2	2	2	2	1	1	1	1	1	1	1	1	2
	CO3	2	2	3	2	2	1	1	1	2	1	1	1
	CO4	2	2	2	1	1	1	1	1	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PHO852</td><td>Optical Instrumentation</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To realize fundamental concepts of optics such as reflection, refraction and diffraction in designing optical elements.
CO2: To learn basics and working principle of some optoelectronic devices.
CO3: To gain an integrative overview and applications of different optical microscopes, telescopes and spectroscopes.
CO4: To acquire fundamental knowledge of interferometry and apply it in optical metrology.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Optical elements: Reflective and Refractive optical elements, Diffractive optical element, Holographic Optical Element, Grating, Prism. [6]

Microscopy: Bright field microscopy, Dark field microscopy, Phase-Contrast microscopy, Polarized light microscopy, Differential Interference contrast microscopy, Fluorescence microscopy, Confocal microscopy, Digital Holographic microscopy. [8]

Spectroscopy: Atomic Absorption Spectroscopy, UV-Vis-NIR Spectroscopy. [4]

Optical Interferometer: Common path interferometer, Multiple-Beam interferometer, Multiple wavelength interferometer, Shearing interferometer, Speckle interferometer. [6]

Optoelectronic devices: Photomultiplier Tubes, Photodiodes, CCD, acousto-optic modulator, electro optic modulator [6]

Optical Instruments: Optical Coherence Tomography, Particle Image Velocimetry. [6]

Optical Metrology: Moire, fringe projection, Holography and Speckle techniques. [6]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">TEXT BOOKS
1. Optical Shop Testing, D. Malakara, Wiley & Sons, Inc. 2007.
2. Practical Holography, G. Saxby, CRC Press, 2017.
3. Materials Characterization, Yang Lang, Wiley-VCH, 2013.

REFERENCE BOOKS
1. Fundamental of Photonics, B. E. A. Saleh, M. C. Teich, Wiley, 2007.
2. Optics, E. Hecht, Addison-Wesley, 2001.
3. Optics, A. Ghatak, Tata McGrawHill, 2005.</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHO852	CO1	3	2	2	2	1	1	1	1	1	-	1	1
	CO2	3	1	-	1	1	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	2	1	1	1	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)