

This course is designed with fundamentals of electromagnetism and properties of materials for advanced courses in their respective engineering branches. It introduces electromagnetic theory with relevant mathematical tools, optical fibres and their propagation characteristics, properties of dielectric and magnetic materials. It also introduces principles of semiconductors and some widely used semiconductor devices for various applications.

Course Objectives

- To introduce mathematical principles to estimate forces, fields and waves.
- To familiarize students with electromagnetics in modern communication systems.
- To impart knowledge concerning the electrical behaviour of dielectric materials.
- To demonstrate the properties of magnets.
- To introduce semiconductor physics and devices.

UNIT I: Basics of Electromagnetics

9 L

Electrostatic field: Coulomb's law and Gauss' law, derivation of Coulombs law from Gauss' law, applications of Gauss' law (line charge, thin sheet of charge and solid charged sphere), Gauss' law of electrostatics in dielectric medium, divergence and curl of electric fields, electric potential, relation between potential and force, Poisson's and Laplace equations.

Magnetostatic field: Biot–Savarts' law, divergence and curl of magnetic fields, Faraday's and Ampere's laws in integral and differential form, displacement current, continuity equation, Maxwell's equations.

Learning Outcomes:

- apply Coulomb's and Gauss' laws to electric field configurations from charge distributions (L3)
- apply the Biot-Savarts' law to derive magnetostatic field distributions (L3)
- use vector calculus to describe electromagnetic phenomena(L2)
- relate the law of conservation of charge to continuity equation(L3)
- illustrate the Maxwell's equations, Maxwell's displacement current and correction of Ampere's law(L2)

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT II: Fiber Optics

7 L

Introduction, advantages of optical fibers, principle and structure, acceptance angle, numerical aperture, modes of propagation, classification of fibers, fiber optic communication, importance of V-number, fiber optic sensors (Temperature, displacement and force), applications.

Learning Outcomes:

After completion of this unit, the student will be able to

- apply the principle of propagation of light in optical fibers(L3)
- explain the working and classification of optical fibers(L2)
- analyse propagation of light through optical fibers based on the concept of modes (L4)
- summarize applications of optical fibers in medical, communication and other fields(L2)

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT III: Dielectric, Magnetic and superconducting Materials**10 L**

Dielectric materials: Introduction, electric polarization, dielectric polarizability, susceptibility and dielectric constant, types of polarizations (qualitative treatment only). Magnetic materials: Introduction, magnetic dipole moment, magnetization, magnetic susceptibility and permeability, origin of permanent magnetic moment, classification of magnetic materials, Weiss theory of ferromagnetism (qualitative), domain theory, hysteresis, soft and hard magnetic materials. Superconductivity: definition –Meissner effect –type I & II superconductors –BCS theory (qualitative) –high temperature superconductors –Josephson effects applications.

Learning Outcomes:

After completion of this unit, the student will be able to

- explain the concept of dielectric constant and polarization in dielectric materials (L2)
- interpret dielectric loss, Lorentz field and Claussius-Mosotti relation (L2)
- classify the magnetic materials(L2)
- explain the phenomenon of hysteresis for a ferromagnetic material and summarize the properties of hard and soft magnetic materials (L2)
- understand the concept of superconductivity (L2)

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT IV: Semiconductor Physics**8 L**

Introduction, origin of energy band, intrinsic and extrinsic semiconductors, mechanism of conduction in intrinsic semiconductors, generation and recombination, carrier concentration in intrinsic semiconductors, variation of intrinsic carrier concentration with temperature, n-type and p-type semiconductors, carrier concentration in n-type and p-type semiconductors, Drift and diffusion currents in semiconductors.

Learning Outcomes:

After completion of this unit, the student will be able to

- outline the properties of semiconductors(L2)
- interpret expressions for carrier concentration in intrinsic and extrinsic semiconductors(L2)
- assess the variation of carrier concentration in semiconductors with temperature (L5)

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT V: Semiconductor Devices**8 L**

Zener Diode, Tunnel diode, Hall effect and its applications, magnetoresistance, p-n junction layer formation and V-I characteristics, direct and indirect band gap semiconductors, construction and working of photodiode, LED, solar cell.

Learning Outcomes:

After completion of this unit, the student will be able to

- explain the drift and diffusion currents and formation of junction layer (L2)
- state Einstein's relations(L1)
- explain Hall effect and its applications(L3)
- illustrateandinterprettheV-Icharacteristicsofap-njunctiondiode(L2)
- describe applications of p-n junction diodes in photodiodes, LEDs and solar cells (L3).

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

Text Book(s)

1. David J.Griffiths, “Introduction to Electrodynamics”, 4/e, Pearson Education, 2014.
2. Charles Kittel, “Introduction to Solid State Physics”, Wiley Publications, 2011.
3. M. N. Avadhanulu, P.G. Kshirsagar, “A Text book of Engineering Physics”, 11/e, S. Chand Publications, 2019.

Reference book(s)

1. Principles of Physics, 10ed, ISV, Jearl Walker, David Halliday, Robert Resnick, Wiley India.
2. Gerd Keiser, “Optical Fiber Communications”, 4/e, Tata Mc Graw Hill, 2008.
3. S.O.Pillai, “Solid StatePhysics”, 8/e, New Age International, 2018.
4. S.M. Sze, “Semiconductor Devices-Physics and Technology” , Wiley, 2008.

Journal(s):

1. <https://aapt.scitation.org/doi/abs/10.1119/1.3317450>
2. <https://aapt.scitation.org/doi/full/10.1119/1.5144798>
3. <https://aapt.scitation.org/doi/abs/10.1119/1.1511591>

PHYSICS LABORATORY

List of Experiments

1. To determine the magnetic field along the axis of a circular coil carrying current.
2. To determine the numerical aperture of a given optical fiber and hence to find its acceptance angle
3. To determine magnetic susceptibility by Quincke’s tube method
4. To determine the Hall coefficient using Hall effect experiment
5. To determine the resistivity of semiconductor by Four probe method
6. To determine the energy gap of a semiconductor.
7. To study the characteristics of PN Junction diode.
8. To study magnetic hysteresis loop (B-H curve).
9. To determine the dielectric constant of a substance by resonance method.
10. To determine hysteresis loss by CRO.
11. To study the characteristics of Photodiode
12. To study the characteristics of Solar Cell
13. To study the characteristics of Zener diode
14. To study the resonance of LCR circuit

Text Book:

1. S. Balasubramanian, M.N. Srinivasan “A Text book of Practical Physics”- S Chand Publishers,2017

PHYS1011: PRINCIPLES OF QUANTUM MECHANICS

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This course is designed with principles of Quantum mechanics for advanced courses in their respective engineering branches. It introduces Quantum mechanics with relevant mathematical tools and provides a basis for further study of quantum mechanics. It also introduces basics of Qubits for Quantum computing applications.

Course Objectives

- To introduce the basic principles of quantum mechanics.
- To introduce wave equation and significance of wave function.
- To teach solving the Schrödinger's equation for spinless particles moving in one-dimensional potential.
- To develop an understanding of concepts of angular momentum.
- To introduce Dirac bra-ket formalism and the concept of QUBITS.

UNIT – I: Introduction to Quantum Physics

(10 Hours)

Introduction, Classical Mechanics vs Quantum Mechanics, Planck's quantum theory (qualitative), Photo-electric effect. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them, Wave-particle duality, Heisenberg uncertainty principle: ground state energy of hydrogen atom.

Learning Outcomes:

After completion of this unit, the student will be able to

- Get a grasp on the elementary aspects of energy and momentum of a photon and de Broglie wavelength of a particle.
- Know about the uncertainty principle for position and momentum and for energy and time.
- To study the basic principles of quantum mechanics

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT – II: Properties of Matter Waves

(8 Hours)

Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization.

Learning Outcomes:

After completion of this unit, the student will be able to

- understand the significance of Schrodinger's time independent wave equation.
- explain the operator formulation of quantum mechanics.
- learn the concept of wave function

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT – III: Quantum Tunneling

(8 Hours)

One dimensional infinitely rigid box-energy eigenvalues and eigenfunctions, normalization; Quantum dot as example; Quantum mechanical tunnelling in one dimensional rectangular potential barrier, 1D linear harmonic oscillator (no derivation required, only eigen function, eigen values and zero-point energy).

Learning Outcomes:

After completion of this unit, the student will be able to

- Derive wave functions with reflection and transmission coefficients
- The concept of quantum mechanical tunneling
- solve time-independent Schrödinger equation for simple potentials

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT - IV Quantum Properties of Electrons (9 Hours)

Electron angular momentum, angular momentum operator, Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect, Stark Effect, Gyromagnetic Ratio and Bohr Magneton (qualitative)

Learning Outcomes:

After completion of this unit, the student will be able to

- understand spin magnetic moment and total angular momentum
- relate the eigenvalue problems for energy, momentum and angular momentum explain the idea of spin
- explain the interaction between spin of electron and magnetic field
- understand the interaction between electron and electric field

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT – V: Qubits for Quantum Computing (10 Hours)

Introduction to Dirac Bra-Ket notation, Introduction to Pauli spin matrices, Quantum Superposition, Interference, Quantum Measurement, Decoherence, Entanglement, Bloch sphere, Qubits, and multiple qubits, Qubits Vs classical bits, representation of a qubit probability.

Learning Outcomes:

After completion of this unit, the student will be able to

- apply Bra-Ket notation in obtaining eigen values
- understand quantum entanglement
- describe the fundamentals of the quantum computing

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

Textbook(s):

1. Quantum Mechanics, G. Aruldas, 2ndEdn. 2002, PHI Learning of India.
2. Quantum Mechanics, Satya Prakash, 2016, Pragati Prakashan.
3. Quantum Computing for Everyone, Chris Bernhardt, 2019, The MIT Press,

Reference Book(s):

1. Introduction to Quantum Mechanics, D.J. Griffith, 2ndEd. 2005, Pearson Education.
2. Quantum Computing: An Applied Approach, Jack D. Hidary, 2019,

Springer Journal(s):

1. <https://aapt.scitation.org/doi/full/10.1119/1.4897588>
2. <https://aapt.scitation.org/doi/full/10.1119/1.3639154>

Websites:

1. <https://www.intechopen.com/online-first/73811>
2. <https://www.quantum-inspire.com/kbase/what-is-a-qubit/>