MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT111	Applied Optics	3	3	0	0	0

PREREQUISITE – Nil

COURSE OBJECTIVE(s)
The objective of the course is to provide students with a fundamental understanding of the theoretical principles and mathematical frameworks governing the behavior of light and its applications in various optical systems.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Wave Propagation: Review of Maxwell's equations and propagation of waves, Plane polarized light. Reflection and refraction of EM wave, Brewster's angle, Introduction to polarization, linear, circular and elliptical polarizations, Malus's law, Anisotropic Media: Plane waves in anisotropic media, Birefringence, Uniaxial crystals; Analysis of polarized light. Quarter and half wave plates, analysis of polarized light. **(No. of lectures:19)**

Interference: Michelson interferometer; Fabry-Perot interferometer and etalon, Antireflection coatings. Diffraction: Fresnel and Fraunhofer diffraction. Single slit, circular aperture; limit of resolution. Diffraction of a Gaussian beam. **(No. of lectures:13)**

Fourier Optics: Fourier transform operation spatial frequency and transmittance function, spatial-frequency filtering, Phase contrast, microscope. Basics concepts of holography, basics concepts and ray optics considerations of optical fiber, introduction to lasers. **(No. of lectures:07)**

TEXT BOOKS:

1. A. K. Ghatak, “Optics”, 7th Edition, McGraw-Hill
2. F. A. Jenkins and H. E. White, “Fundamentals of Optics”, 4th edition, McGraw-Hill Education

REFERENCE BOOKS:

1. Born and E. Wolf, Principles of Optics, 7^{th} Edition, Cambridge University Press, 1999
2. P Hariharan, Optical Holography: Principles, Techniques and Applications. 2nd ed. Cambridge University Press; 1996.
3. A. K. Ghatak and K. Thyagarajan, Optical Electronics, Cambridge University Press

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PLEAS	22BMT922	Management Principles for Engineers	**3**	**3**	**0**	**0**	**0**

PREREQUISITE – Nil

COURSE LEARNING OBJECTIVE(s)

By the end of this course student will be able to:
1. Understand the global transition towards a new normal of management.
2. Demonstrate the managerial roles, skills and functions for responsible management.
3. Develop the understanding and cognizance of the importance of Professional management (ethical, responsible, and sustainable).
4. Perform various tools and techniques to be used in the performance of the managerial job.
5. Make effective application of acquired knowledge to diagnose and solve organizational problems and develop optimal managerial decisions.
6. Diagnoseandcommunicatethecomplexitiesassociatedwithmanagementofvariousissues In the organizations and integrate the learning in handling these complexities.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS
Management: Nature, Scope and Functions, Managerial Roles and Levels of Management; General Management Processes and Principles, Management Practices; Essentials of Planning; Strategies, policies and planning premises; Decision making; Organizing: Organizational Design & Organizational Structures; Leading: Motivation; Leadership, Power and Authority; Leadership Styles; Controlling; Steps and types of Control Process; Dimensions of Management: Ethical management, Responsible Management, Sustainable Management.

References

1. Robbins, Stephen P. And Coulter, Mary (2019) 'Management', 14th edition, 2019 Prentice Hall of India
2. Laasch, O. (2021). Principles of Management- Practicing Ethics, Responsibility, Sustainability, 2nd Edition, Sage Publications.

3. Hill, Charles WL and McShane, Steven L. (2017) Principles of Management, Special Indian Edition, McGraw-Hill Education
4. Robbins, Stephen P., Decenzo, David A. & Bhattacharya, Sanghamitra (2009) Fundamentals of Management, latest edition, Pearson Education
5. Koontz, Harold and Weihrich, Heinz & Ramachandra Aryasri A. (2016). Principles of Management, Latest edition, McGraw Hill Education

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DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT121	Mathematical Methods in Physics	**4**	**3**	**1**	**0**	**0**

PREREQUISITE COURSES

None

COURSE OBJECTIVES

1. To impart mathematical concepts and techniques required for undergraduate studies in Engineering Physics.
2. To inculcate the ability to apply these ideas in existing and novel problems and situations, including those in other mathematical disciplines.

COURSE ASSESSMENT

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit 1: Complex Analysis

Complex functions, analyticity, Cauchy-Riemann equations, complex integration, contours, Cauchy's Integral Theorem, Cauchy's Integral Formula, Taylor & Laurent series, singularities, poles vs essential singularities, residue theorem, applications of residue theorem to real and complex integrals, multi-valued functions, branch cuts (13 lectures)

Unit 2: Fourier Analysis

From Fourier series to Fourier transform, general properties, Convolution Theorem, Parseval's Theorem, Fourier transform of common functions, Dirac delta function, differential equations in Fourier space, applications to physical systems (10 lectures)

Unit 3: Functional Analysis

Functions as vectors, Inner product, norm, orthogonality, Dirac's notation, orthonormal bases & expansions, Hilbert spaces, Linear operators, differential operators, adjoint operators, self-adjoint operators and boundary conditions, eigenvalues & eigenfunctions, spectral decomposition, Sturm Liouville theory, standard orthogonal polynomials (Legendre, Hermite, Laugerre), Bessel functions (16 lectures)

TEXT BOOKS

1. *A Guided Tour of Mathematical Physics (Third Edition)*, Roel Snieder and Kasper van Wijk, (Cambridge University Press 2015)
2. *Mathematics for Physics*, Michael Stone and Paul Goldbart (Cambridge University Press) 2009

REFERENCE BOOKS

1. *A Course in Mathematics for Students of Physics Vol. 1*, Paul Bamberg and Shlomo Sternberg (Cambridge University Press 1991)
2. *Mathematical Methods for Physicists (Seventh Edition)*, George B. Arfken, Hans J. Weber, Frank E. Harris (Academic Press 2011)
3. *Mathematical Methods for Physicists: A Concise Introduction*, Tai L. Chow (Cambridge University Press 2000)
4. *Mathematical Physics: The Basics*, S. D. Joglekar (University Press 2005)
5. *Mathematical Physics: Advanced Topics*, S. D. Joglekar (University Press 2006)

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DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT122	Biophysics	2	2	0	0	0

PREREQUISITE – None

COURSE OBJECTIVE(s)
Biophysics makes use of physical concepts and techniques to address problems in biology and ecology. Physics has been very successful at illuminating fundamental aspects of biological problems at the molecular level. For example, biophysicists use thermodynamics to understand enzyme reactions and X-ray diffraction or nuclear magnetic resonance to determine the structures of biological molecules such as proteins and DNA.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit I:
Life and energy, forces and energies at nanometer scales, intermolecular interactions and electrostatic screening, chemical bonding and stability of molecules, entropy, energy and electrostatics, laws of thermodynamics, brownian motion, metabolism in animals and photosynthesis in plants, chemical composition of living systems, structure and physical properties DNA & RNA, cell membrane, protein, stability of proteins, motions within proteins, how enzymes work **(No. of lectures: 09)**

Unit II:
Nucleic acid and genetic information, deciphering the genetic code, how structure stores information, replication process, from DNA to RNA to protein, mechanics and circuits in the cell, the cell as a basic unit of life& its organization, the cell interior, brownian motion and viscosity and their influence on particle motion in the cell, basic structure of mitochondria and the generation of ATP, energy and information flow in the cell **No. of lectures: 09)**

Unit III:
The role of the cytoskeleton in cell motion, the role of motors within the cell, muscle, random walks, sense of a remarkable array of biophysical processes, from the diffusion of molecules to the swimming strategies of bacteria, life at low Reynolds number, the neuron, the role of channels and pumps, the biophysics of the synapse, two cases: muscle and retina

(No. of lectures: 09)

TEXT BOOKS:

1. Essentials of biophysics: P Narayanan (New Age International).
2. An introduction to biophysics: M.R. Rajeswari (Rastogi Publications)

REFERENCE BOOKS:

1. Biophysics: Rodney M.J (Wiley).
2. The rainbow and the worm: Mae-Wan Ho (World Scientific).
3. Newton rules biology: C.J. Pennycuick (Oxford).
4. How life learned to live: Helmut Tributsch (Cambridge).

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DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT123	Electromagnetic Theory	3	3	0	0	0

PREREQUISITES: None

COURSE OBJECTIVE(s)
This course aims to gain a deep understanding of the fundamental principles governing electrostatics, magnetostatics, and electrodynamics. Also, students learn how to develop problem-solving skills to analyze and solve complex problems in various practical scenarios, including applications in engineering, physics, and other fields.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade) will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Module 1- Overview of Electrostatics, Poisson and Laplace's equations, Boundary conditions and Uniqueness theorems, Electrostatic boundary value problems, Method of images, Multipole expansion, Approximate potentials at large distances, Electric field of a dipole, Polarization, field of a polarized object, Bound charges and its physical interpretation, Gauss's law in dielectrics and boundary conditions. **(No. of lectures- 13)**

Module 2- Overview of Magnetostatics, Magnetization, Effect of a Magnetic Field on Atomic Orbits, Field of a Magnetized Object, Bound currents, Physical Interpretation of Bound Currents, Magnetic Field Inside Matter, Ampère's Law in Magnetized Materials, Magnetic Susceptibility and Permeability, Magnetic levitation. **(No. of lectures- 09)**

Module 3- Electromagnetic wave equation, Electromagnetic waves in vacuum, Energy and Momentum in Electromagnetic Waves, Electromagnetic waves in matter, Reflection and Transmission at normal and oblique incidence, Electromagnetic waves in conductors, Wave guides, TE Waves in a Rectangular Wave Guide, Optical fibers.
(No. of lectures- 11)

Module 4- Scalar and vector potentials, Potential formulation of Maxwell's equations, Gauge transformations, Coulomb and Lorenz gauges, Retarded potentials, dipole radiation.
(No. of lectures- 6)

TEXT BOOKS:

1. Introduction to Electrodynamics: David J. Griffiths, (Prentice Hall of India).
2. Classical Electrodynamics: J.D. Jackson, (John Wiley and Sons).

REFERENCE BOOKS:

1. Elements of Electrodynamics: Matthew N. O. Sadiku
2. The Classical Theory of Fields: L.D. Landau, E.M. Lifshitz (Pergamon Press, Oxford).
3. Foundations of Electromagnetic Theory: J. Reitz and F.J. Milford (Addison-Wesley).
4. Electromagnetic Waves and Radiating Systems: E.C. Jordan (Prentice Hall of India).

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DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT211	Engineering Mechanics and Relativity	3	2	1	0	0

PREREQUISITES: None

COURSE OBJECTIVE(s)

This course aims to equip students with a fundamental understanding of advanced classical mechanics, oscillatory systems, rigid body dynamics, and the principles of special relativity, fostering analytical problem-solving skills for complex physical phenomena.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade) will be made up of the following three components;

S. No.	Component	Weightage
d)	Internal assessment (based upon assignments, quizzes and attendance)	20%
e)	Mid-term examination	30%
f)	End Semester Examination	50%

COURSE CONTENTS

Kinematics and dynamics- Polar coordinates. velocity and acceleration in polar coordinates, constraints, Generalized coordinates, Configuration space, Hamilton's action principle, Lagrangian and Lagrange's equation, velocity dependent potential and friction, phase space, Hamiltonian and Hamilton's equations, cyclic coordinates and conservation of linear and angular momentum, conservation of energy, momentum of variable mass system: motion of rocket.

(No. of lectures- 10)

Oscillations - Simple Harmonic Motion, Damped Harmonic Motion, Energy of damped oscillator, Quality factor for damped oscillator, forced oscillations: Transient and steady states, Resonance: sharpness of resonance, Energy of forced damped oscillator, resonance curve and quality factor for forced damped oscillator. **(No. of lectures- 5)**

Rotational motion- Degrees of freedom for rigid body, direction cosine and orthogonal transformations, Euler angles, Euler's theorem, infinitesimal rotations, rate of change of a vector, angular velocity as time derivative of Euler angles, non-inertial frames and Coriolis force, angular momentum, inertia tensor and kinetic energy of a rigid body, Euler's equations for rigid body motion, torque-free motion of a rigid body and precession of earth. **(No. of lectures- 7)**

Special theory of relativity: Michelson-Morley experiment**,** postulates of special theory of relativity, inertial frames, Galilean transformation, simultaneity and order of events, Lorentz transformation, time dilation and length contraction, proper time and proper length relativistic addition of velocities, relativistic momentum and relativistic energy, collisions and conservation of energy and momentum in special relativity. **(No. of lectures- 5)**

TEXT BOOKS/: -

1. Classical Mechanics –Goldstein, Poole and Safko (Pearson Education)
2. An Introduction to Mechanics, Daniel Kleppner and Robert Kolenkow (McGraw Hill Education)

REFERENCE BOOKS

1. Berkeley Physics Course Volume 1: Mechanics, Charles Kittel, Walter Knight, Malvin Ruderman, Carl Helmholz and Burton Moyer (McGraw Hill Education)
2. Mechanics, D. S. Mathur (S. Chand & Company limited)
3. Introduction to Classical Mechanics with Problems and Solutions: David Morin (Cambridge University Press)
4. Mechanics, Keith R. Symon (Addison-Wesley Publishing Company)
5. Concepts of Modern Physics, Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury (McGraw Hill Education)

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DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT212	Foundations of Quantum Theory	**3**	**3**	**0**	**0**	**0**

PREREQUISITE COURSES: None

COURSE OBJECTIVES

Upon successful completion of the course, students will be able to understand the fundamental principles of quantum mechanics based on wave mechanics, operator methods. Apply quantum mechanics to simple physical systems relevant in engineering physics. Develop sufficient understanding of basic quantum computation concepts so as to be able to continue further studies.

COURSE ASSESSMENT

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit 1: Foundations

Failures of classical physics, wavefunction, states as vectors, observables as operators, measurement postulate, expectation values, basis change, heuristics of uncertainty principle, commutation relation, Schrodinger equation, Eigenvalue problem and stationary states

(No. of lectures- 9)

Unit 2: Simple 1D systems

Free particle, need for wave-packets, continuity equation for probability, particle in an infinite well, particle in a finite well and tunneling, harmonic oscillator, applications to quantum wells, tunneling devices, and nanoscale confinement **(No. of lectures- 11)**

Unit 3: Higher-dimensional systems

Symmetries in quantum mechanics, rotations, angular momentum, angular momentum algebra, central potentials, hydrogen atom, spin, spin and SU(2) structure, Bloch sphere

(No. of lectures- 11)

Unit 4: Basics of quantum computation
Qubits, single-qubit gates, multi-qubit systems, entanglement, heuristical introduction to density matrix, Bell states, measurement **(No. of lectures-8)**

TEXT BOOKS

1. *Principles of Quantum Mechanics (Second Edition)*, R. Shankar (Springer 2011)
2. *A Modern Approach to Quantum Mechanics (Second Edition)*, John S. Townsend (University Science Books 2012)
3. *Introduction to Classical and Quantum Computing*, Thomas G. Wong (Rooted Grove 2022) https://www.thomaswong.net/introduction-to-classical-and-quantum-computing-1e3p.pdf

REFERENCE BOOKS

1. *Introduction to Quantum Mechanics (Second Edition)*, D. J. Griffiths (Cambridge India 2015)
2. *Quantum Mechanics (Third Edition)*, Eugen Merzbacher (John Wiley & Sons 1998)

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DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT213	Physics of Semiconductor Devices	2	2	0	0	0

PREREQUISITE – Fundamentals of Solid State & Quantum Mechanics

COURSE OBJECTIVE(s)

This course aims to equip the students with fundamental knowledge of semiconductor physics and explain the working and design of p-n junctions and low dimensional semiconductor structures and devices.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Introduction of crystals & carriers in semiconductors, doping, carrier concentrations, fermi level, electron & hole generation/recombination, drift & diffusion current, continuity equation

(No. of lectures- 8)

P-N junction, fabrication, equilibrium properties, space charge, capacitance of a junction, forward and reverse biased junctions, current-voltage characteristics, steady state conditions, reverse bias breakdown, graded junctions, metal-semiconductor contacts, Schottky barrier, rectifying contacts, ohmic contact, heterojunctions **(No. of lectures- 15)**

BJT- fundamentals of operation, amplification, switching, JFET – pinch off & saturation, gate control, current voltage characteristics **(No. of lectures- 5)**

TEXT BOOKS:-

1. Solid State Electronic Devices, B.G.Streetman, S. Banerjee, Prentice Hall
2. Semiconductor Physics and Devices- Basic Principles, Donald A. Neamen, 4^{th} Ed., McGraw Hill
3. Principles of Semiconductor Devices - Sima Dimitrijev, Oxford University Press

REFERENCE BOOKS :

1. Semiconductor Devices Physics and Technology, S M Sze, John Wiley and Sons, 2nd Ed.
2. Semiconductor Materials and Devices, M S Tyagi, John Wiley and Sons

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT214	Analog and Digital Electronics	3	3	0	0	0

COURSE OUTCOME (s)

This course provides a comprehensive overview of **analog and digital electronics**. Students will gain the ability to design, analyze, and implement circuits for practical applications in engineering physics.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit I – Semiconductor Devices and Analog Circuits

PN junction diode, V-I characteristics, Zener diode, rectifiers, clippers, clampers, transistor CE configuration, hybrid model, h-parameters, conversion of h-parameters, emitter follower, high-frequency effects, amplifier classification, RC-coupled amplifier response, power amplifiers (Class A, B, C), amplifier characteristics, feedback amplifiers, transfer gain, feedback topologies, negative feedback effects. **(number of lectures: 20)**

Unit II – Operational Amplifiers and Applications

Operational amplifier basics, parameters, golden rules, inverting and non-inverting amplifiers, summing, subtractor, integrator, differentiator, instrumentation amplifier, comparators, Schmitt Trigger, precision rectifiers, peak detectors, clippers, clampers, active filters, passive filters, Sallen-Key topology, second-order filters, transfer function, Bode plots, Wien bridge oscillator, phase-shift oscillator, voltage regulators, power supply design. **(number of lectures: 10)**

Unit III – Digital Systems and Microprocessors (9 Lectures)

Binary numbers and codes, error detection and correction codes, universal gates, Boolean simplification, minterms, maxterms, SOP and POS methods, Karnaugh maps, arithmetic circuits, programming logic devices, RS flip-flop, D flip-flop, JK flip-flop, preset and clear operations, race-around condition, master-slave JK flip-flop, shift registers, asynchronous counters, synchronous counters, ring counters, decade counter, D/A conversion, A/D conversion, timing circuits, display devices, microprocessor basics, microprocessor-based system design.

(number of lectures: 9)

TEXT BOOKS :

1. Electronic Principles: Malvino and Bates (McGraw Hill Education)
2. The Art of Electronics: Horowitz and Hill (Cambridge University Press)
3. Digital principles and applications By Donald P. Leach & Albert Paul Malvino,

REFERENCE BOOKS:

1. Integrated Electronics: Millman and Halkias (Tata McGraw Hill).
2. Op-Amps and Linear Integrated Circuits: Ramakanth A. Gayakwad (Prentice Hall of India)
3. Electronic Devices and Circuit Theory: Robert Boylestad and Louis Nashdsky (Prentice Hall of India)
4. Digital principles and applications By Donald P. Leach & Albert Paul Malvino,
5. Digital Fundamentals, 3rd Edition by Thomas L. Floyd
6. Digital Electronics by R.P. Jain
7. Fundamental of Digital Circuits, Anand Kumar
8. Microprocessor Architecture, Programming, and Applications with the 8085: R Gaonkar (Penram International Publishing)

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DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHP215	Analog and Digital Electronics Lab	4	0	0	8	0

PREREQUISITES: None.

COURSE OBJECTIVE(s)
This course aims to equip the students with an understanding of the theoretical concept of analogue and digital electronics through laboratory, as well as an understanding of designing and implementing various electronics circuits.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based on assignments, quizzes, and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS
1. To study the characteristics of BJT amplifiers
2. To study the characteristics of MOSFET amplifiers
3. To study the characteristics of FET amplifiers
4. To study the frequency response of transistor amplifiers
5. To study the diode clipping and clamping
6. To study the voltage regulator using Zener diode
7. To study the class B push pull power amplifier
8. To study the application of op-amps as Inverting Amplifier, Non-inverting Amplifier, and Summing Amplifier
9. To study the application of op-amps as Integrator and Differentiator
10. To study the characteristics of Filters using op-amps: Low pass, High Pass, and Band Pass
11. To study the Schmitt Trigger using op-amps (positive feedback and Hysteresis)
12. To study the Wien Bridge Oscillator using op-amps

13. To design Precision Half-Wave and Full-wave Rectifiers using op-amps
14. To study the Multivibrators using op-amps
15. To verify and design AND, OR, NOT, and XOR gates using NAND and NOR gates.
16. To derive all basic logic gates using NAND/NOR gates only
17. To design a 2-bit multiplier and implement it
18. Design half and full adder
19. Design half and full subtractor
20. Design a 4 1 Multiplexer using gates
21. To design and implement a latch using two NOR gates and verify its truth table
22. Design a counter using S-R, D/T/JK Flip-Flop
23. To realize the following shift registers using IC7474. (a) SISO (b) SIPO (c) PISO.
24. To implement a synchronous up/down counter
25. To realize 3-variable function using IC 74151
26. Clock-pulse generator: design, implement and test
27. Memory Unit: Investigate the behaviour of RAM unit and its storage capacity -16 X 4 RAM: testing, simulating and memory expansion
28. To perform 8 Bit Addition, Subtraction, Multiplication and Division by using MICROPROCESSORS (8086 Assembly Language Programming)

TEXT BOOKS:

1. Electronic Principles: Malvino and Bates (McGraw Hill Education).
2. The Art of Electronics: Horowitz and Hill (Cambridge University Press)
3. Operational Amplifiers & Linear Integrated Circuits: Theory and Application Laboratory Manual/3E, James M. Fiore (Dissident)
4. Fundamental of Digital Circuits, Anand Kumar
5. Digital principles and applications By Donald P. Leach & Albert Paul Malvino,

REFERENCE BOOKS:

1. Solid State Electronic Devices: Ben G. Streetman (PHI)
2. Integrated Electronics: Millman and Halkias (Tata McGraw Hill).
3. Op-Amps and Linear Integrated Circuits: Ramakanth A. Gayakwad (PHI)
4. Electronic Devices and Circuit Theory: Robert Boylestad and Louis Nashdsky (PHI)
5. Digital Fundamentals, 3rd Edition by Thomas L. Floyd
6. Digital Electronics by R.P. Jain

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DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT221	Thermodynamics and Statistical Mechanics	4	3	1	0	0

PREREQUISITES: Basic understanding of Physics, Chemistry and Mathematics

COURSE OBJECTIVE(s)

This course integrates macroscopic thermodynamics with microscopic statistical mechanics to explain the behaviour of many-body systems. Students would learn the laws of energy and entropy before bridging to kinetic theory and ensemble formalisms. Students will learn to derive the thermodynamic properties of both classical and quantum systems by using the partition functions for the microcanonical, canonical, and grand canonical ensembles. The curriculum concludes with advanced applications in Bose-Einstein and Fermi-Dirac statistics, providing a unified theoretical framework essential for modern physics and engineering.

COURSE ASSESSMENT
The Course Assessment (culminating in the final grade) will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Module 1: Classical Thermodynamics
Thermal equilibrium, the zeroth law, and the concept of temperature; the first law of thermodynamics and its consequences, including reversible, irreversible, and quasi-static processes; the second law of thermodynamics, heat engines, and the concept of entropy; thermodynamic potentials, Maxwell's relations, and the Joule-Kelvin effect; phase transitions, including the Clausius-Clapeyron equation, order parameters, and critical exponents; applications to magnetism, superfluidity, and superconductivity. **(No. of lectures: 10)**

Module 2: Kinetic Theory and Foundations of Statistical Mechanics
Kinetic theory of gases and transport phenomena; statistical interpretation of entropy and the Boltzmann hypothesis; macrostates, microstates, and the ergodic hypothesis; phase space dynamics and Liouville's theorem; the microcanonical ensemble and the postulate of equal a-priori probabilities; thermodynamic probability and the statistical basis of the second law.

(No. of lectures: 9)

Module 3: Classical Ensembles and Interacting Systems
The canonical ensemble, partition functions, and calculation of thermodynamic functions; applications to ideal gases, harmonic oscillators, and paramagnetism; classical entropy expressions and the Gibbs paradox; the law of equipartition of energy and its limitations regarding specific heat; the grand canonical ensemble and chemical potential; interacting systems including virial and cluster expansions, van der Waals theory, and liquid-vapor condensation.

(No. of lectures: 10)

Module 4: Quantum Statistical Mechanics
Foundations of quantum statistics involving bosons and fermions, symmetric and antisymmetric wave functions, and the density matrix formulation; quantization effects in molecular gases, phonons, and photons; Bose-Einstein distribution, Bose-Einstein condensation, and the properties of liquid He IV; Fermi-Dirac distribution law, Fermi energy, and the thermodynamic functions of a strongly degenerate Fermi gas. **(No. of lectures: 10)**

TEXT BOOKS:-

1. Statistical Mechanics, Pathria, R. K. and Beale, P. D., Academic Press. 2011 (3rd ed).
2. Fundamentals of Statistical and Thermal Physics, Reif, F., Waveland Press. 2008.

REFERENCE BOOKS:-

1. Statistical Mechanics, Huang, K., Wiley India Pvt. Limited. 2008 (2nd ed).
2. Statistical Mechanics: An Introduction, Guha, E., Narosa Publishing House. 2013.
3. Thermal Physics: Kinetic Theory, Thermodynamics and Statistical Mechanics, Garg, S.C., Bansal, R.M., and Ghosh, C.K., McGraw Hill Education (India). 2017 (2nd ed).

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT222	Physics of Energy Materials	2	2	0	0	0

PREREQUISITE – Basic understanding of Solid State Physics, Thermodynamics, Quantum Mechanics, and Electromagnetism

COURSE OBJECTIVE(s)

This course introduces the physical principles governing energy materials used in energy generation, storage, and conversion technologies. The course emphasizes electronic structure, ionic transport, electrochemical processes, semiconductor physics, nanomaterials, and interfacial phenomena relevant to batteries, supercapacitors, solar cells, fuel cells, and hydrogen energy systems. Students will also gain exposure to modern characterization techniques and emerging sustainable energy materials.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Module 1: Fundamentals of Energy Materials

Global energy scenario and sustainability; classification of energy materials; crystal structure, bonding, defects, vacancies, grain boundaries, and basic crystallography; electronic band structure, density of states, and Fermi level; electronic and thermal transport; ionic conduction, diffusion, hopping transport, ionic conductivity, grain boundary, and space-charge effects.

(No. of lectures: 6)

Module 2: Electrochemical Energy Storage Materials

Basics of electrochemistry and electrochemical cells; lithium-ion, sodium-ion, and metal-air batteries; cathode and anode materials; intercalation and deintercalation mechanisms; ion diffusion and storage; solid electrolytes and separators; qualitative introduction to supercapacitors and hybrid storage systems; SEI formation, degradation, and thermal stability. **(No. of lectures: 4)**

Module 3: Materials for Energy Conversion
Photovoltaic effect and semiconductor junctions; carrier generation, recombination, and transport; silicon, thin-film, perovskite, organic, and quantum dot solar cells; fuel cells and hydrogen energy materials; electrolysis, photocatalysis, hydrogen storage; thermoelectric and piezoelectric materials. **(No. of lectures: 4)**

Module 4: Structure and Physics of Advanced Energy Materials
Crystal structures and structure–property relationships in energy materials; layered and intercalation materials; carbon-based energy materials including graphite, graphene, carbon nanotubes, activated carbon, and carbon aerogels; spinel, olivine, and perovskite structures; MXenes and transition metal dichalcogenides; nanomaterials, quantum confinement, and nanostructured electrodes; magnetic and ferroelectric energy materials; emerging materials for solid-state batteries, tandem solar cells, and photocatalytic systems. **(No. of lectures: 8)**

Module 5: Characterization Techniques and Applications
Basic structural and physical characterization of energy materials using XRD, SEM/TEM, Raman, FTIR, UV–Visible spectroscopy, XPS, and impedance spectroscopy; electrochemical characterization using cyclic voltammetry, charge–discharge analysis, and electrochemical impedance spectroscopy; case studies, commercialization, recycling, and sustainability of energy materials. **(No. of lectures: 4)**

TEXT/ REFERENCE BOOKS: -

1. The Physics of Energy, Jaffe, R. L. and Taylor, W. 2018, Cambridge University Press.
2. Energy Materials, Eswaramoorthy, M., George, S. J., Sundaresan, A. and Rao, C. N. R. 2023, World Scientific.

REFERENCE BOOKS: -

1. Introduction to Solid State Physics, Kittel, C. and McEuen, P. 2018 (9th ed), Wiley
2. Physical Chemistry of Ionic Materials: Ions and Electrons in Solids, Maier, J. 2023 (2nd ed), Wiley.
3. Eectrochemical Energy Storage: Batteries, Fuel Cells, and Hydrogen Technologies, Petrovic, S., Kurzweil, P. and Garche, J. 2022, McGraw-Hill.

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT223	Laser and Its Applications	3	3	0	0	0

COURSE OUTCOME (s)

This course provides a comprehensive overview of laser physics and its diverse applications. Students will gain the ability to understand, design, and analyze laser systems and apply them in scientific and industrial contexts.

- **CO1**: Understand fundamentals of laser radiation, atomic transitions, and gain media.
- **CO2**: Analyze cavity resonators, stability conditions, and pulse generation techniques.
- **CO3**: Compare design issues, advantages, disadvantages, and limitations of different laser systems.
- **CO4**: Apply knowledge of lasers in spectroscopy, communication, medicine, materials processing, and nonlinear optics.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit I – Fundamentals of Laser Physics: Properties of laser radiation (spectrum, coherence), atomic levels, absorption, spontaneous and stimulated emission, Einstein coefficients, population inversion, gain media, rate equations, level broadening mechanisms. **(No. of lectures: 12)**

Unit II – Laser Systems and Resonators: Cavity modes, threshold conditions, 3-level and 4-level systems, transverse mode structure, optical resonators, time constant and quality factor, stability of resonators, Q-switching, mode-locking, ultrashort pulse generation (ns, ps, fs).
(No. of lectures: 12)

Unit III – Types of Lasers: Gas lasers (He-Ne, CO_2, Ar^+, Nitrogen), solid-state lasers (Ruby, Nd:YAG, Ti:Sapphire), dye lasers, semiconductor lasers, excimer lasers, free-electron lasers.

(No. of lectures: 9)

Unit IV – Applications of Lasers: Laser cooling, holography, optical communication (fiber lasers and amplifiers), medical applications, materials processing, spectroscopy (time-resolved, pump-probe), nonlinear optics (harmonic generation, optical parametric amplification).

(No. of lectures: 6)

TEXT BOOKS

1. O. Svelto – *Principles of Lasers*
2. W. Koechner – *Solid State Laser Engineering*
3. B.B. Laud – *Lasers and Nonlinear Optics*

REFERENCE BOOKS

1. P.W. Milonni & J.H. Eberly – *Lasers*
2. B.E.A. Saleh & M.C. Teich – *Fundamentals of Photonics*
3. Yariv – *Quantum Electronics*
4. W.T. Silfvast – *Laser Fundamentals*
5. A.E. Siegman – *Lasers*
6. D. Meschede – *Optics, Light and Lasers*
7. M. Young – *Optics and Lasers*
8. B.A. Lengyel – *Lasers*

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT224	Optoelectronics	3	3	0	0	0

COURSE OUTCOME (s)

This course provides a comprehensive overview of optoelectronic devices, optical waveguides, and communication systems. Students will gain the ability to understand, design, and analyze optoelectronic systems for practical applications in engineering physics.

- **CO1**: Understand the electronic and optoelectronic properties of semiconductors, PN junction operation, and light absorption/emission mechanisms.
- **CO2**: Study the principles of LEDs, semiconductor lasers, heterojunction lasers, quantum well lasers, VCSEL, DFB/DBR lasers, photodetectors, and solar cells.
- **CO3**: Understand total internal reflection, Snell's law, and light guiding mechanisms in planar and fiber waveguides.
- **CO4**: Design and analyze optical communication links, evaluate fiber types, and study loss and dispersion mechanisms.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit I – Planar and Fiber Waveguides: Wave propagation in planar optical waveguides, ray theory, electromagnetic mode theory, phase and group velocity, dispersion. Cylindrical fiber waveguides, modes and mode coupling, step and graded index fibers, single-mode fibers.
((No. of lectures: 10)

Unit II – Transmission Characteristics of Fibres: Attenuation, material absorption and scattering loss, bend loss, intra-modal and inter-modal dispersion in step and graded fibers, overall dispersion in single and multi-mode fibers. **(No. of lectures: 10)**

Unit III – Optical Fibre Connections: Optical fiber cables, stability of characteristics, fiber alignment; fiber splices, connectors, couplers. **(No. of lectures: 5)**

Unit IV – Optical Sources and Detectors: Absorption and emission of radiation, population inversion and laser oscillation, PN junction, recombination and diffusion, stimulated emission and lasing, heterojunctions, single-frequency injection lasers, LED structures and characteristics. Optical detection principles, PN, PIN, and avalanche photodiodes.

(No. of lectures: 8)

Unit V – Optical Communication Systems and Networks: System description and design considerations of optical fiber communication systems, noise in detection process, power budgeting, rise-time budgeting, maximum transmission distance. Optical networks: WDM concepts, SONET/SDH basics, wavelength-routed networks, nonlinear effects, EDFA systems, solitons, optical CDMA. **(No. of lectures: 6)**

TEXT BOOKS

1. J.M. Senior – *Optical Fiber Communications*
2. G. Keiser – *Optical Fiber Communications*
3. A. Ghata & K. Thyagarajan – *Introduction to Fiber Optics*

REFERENCE BOOKS

1. P.K. Cheo – *Fiber Optics and Optoelectronics*
2. J. Govar – *Optical Communication Systems*
3. A.W. Snyder & J.D. Love – *Optical Waveguide Theory*

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHP225	Laser and Optoelectronics Lab	4	0	0	8	0

PREREQUISITE: Basic understanding of laser and optoelectronic devices.

COURSE OBJECTIVE(s): To gain practical knowledge by applying the experimental methods to correlate with the Physics theory.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon practical lab records, viva, and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

Experiments

S. No.	List of Experiments
1.	To measure the beam divergence of a laser (He-Ne Laser)
2.	To find the width of the wire or the width of the slit using a diffraction pattern obtained by a He-Ne or solid-state laser.

3.	To determine the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or a solid-state laser.
4.	To demonstrate self-powered optoelectronic operation using a Piezo–Triboelectric Nanogenerator
5.	To study the characteristics of LDR.
6.	To determine the characteristics of the Diode Laser.
7.	To calculate the spectral bandwidth of LEDs
8.	To measure the piezoelectric charge constant (d33) of a ceramic sample.
9.	Study of the Fabry Perot interferometer.
10.	To measure the wavelength of light using a precision interferometer (Michelson interferometer).
11.	To plot the graph and study the birefringence with respect to applied voltage in an electro-optic crystal (Pockel Effect Apparatus)
12.	Determination of the Verdet constant of the material for a given wavelength of light (Magneto-Optic Effect) using the Faraday Effect Apparatus
13.	To measure the numerical aperture of an optical fiber
14.	To determine the refractive index of the optical fiber.
15.	To study the variation of the bending loss in a multimode fiber
16.	To determine the power loss at a splice between two multimode fiber
17.	To measure the split size of a single-mode fiber

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	22MST241	Fundamentals of Materials Science and Engineering	3	3	0	0	0

PREREQUISITE – Nil

COURSE OBJECTIVE(s)

The objective of this course is to provide basic understanding of the structure, properties and applications of materials to the undergraduate students. The course will also introduce the students to phases and enable them to understand the phenomenon pf phase transformations in materials.

COURSE OUTCOME

Upon completion of this course, the students will be able to:

1. Classify various classes of materials and explain their structures and imperfections.
2. Construct the phase diagrams of some systems and interpret the phase transformations
3. Explain the types and applications of ceramics and polymers
4. Understand and appreciate the distinctive properties of materials.

COURSE CONTENTS

Introduction: Why study materials science and engineering? Review of basic types of interatomic bonds, Classification of materials, Processing/structure/properties/ performance correlations.
(No. of lectures: 3)

Structure and Imperfections: Lattices, Unit cells, Miller indices of directions and planes for cubic and hexagonal systems, Close packing in solids, Common metallic structures, Voids in close-packed structures, Common ceramics structures – NaCl, CsCl, Diamond Cubic, Zinc Blende, Wurtzite, Rutile, Fluorite, Fullerenes, Spinel, Perovskite, etc., Polycrystalline materials, X-Ray diffraction for determination of crystal structures, Solid state diffusion – Ficks laws of diffusion, Diffusion mechanisms, Temperature dependence of diffusivity, Defects in crystals - Point defects, Dislocations, Grain boundaries and Surfaces **(No. of lectures: 10)**

Phase Diagrams and Phase Transformations: Phase rule, Solid solutions, Hume-Rothery rules, Intermediate phases and compounds, Unary and binary phase diagrams, Isomorphous and eutectic systems, Lever rule, Typical phase diagrams: Fe-C, Cu-Ni, Cu-Zn etc. Classification of phase transformations, Liquid to solid transformation, Homogeneous and heterogeneous Nucleation,

Nucleation growth and overall transformations, Kinetic considerations in solid state transformations, Microstructure evolution during solidification in isomorphous system.

(No. of lectures: 8)

Ceramics and polymers: Types and applications of Glasses, Glass- Ceramics, Clay products, Abrasives, Cements. Introduction to polymers, Types of polymerizations, Molecular weight, shape, structure and configuration, Thermoplastic and Thermosetting polymers. Glass transition, melting and glass transition temperature, factors affecting melting and glass transition temperatures. Plastics, elastomers, fibres, Advanced polymeric materials, Some applications of polymers **(No. of lectures: 7)**

Properties of Materials Mechanical Properties: Stress-strain response of metallic, ceramic and polymer materials, yield strength, tensile strength and modulus of elasticity, toughness, plastic deformation, fatigue, creep and fracture;
Electronic Properties: Free electron theory, Fermi energy, density of states, elements of band theory, semiconductors, Hall effect, dielectric behaviour, piezo, ferro, pyroelectric materials;
Magnetic Properties: Origin of magnetism in metallic and ceramic materials, paramagnetism, diamagnetism, ferro and ferrimagnetism;
Thermal Properties: Specific heat, thermal conductivity and thermal expansion, thermoelectricity.
Optical Properties: Refractive index, absorption and transmission of electromagnetic radiation in solids, electrooptic and magneto-optic materials, spontaneous and stimulated emission, gas and solid state lasers. **(No. of lectures: 11)**

TEXT BOOKS:-

1. V. . Raghavan, “Materials Science and Engineering- A First Course”, 5th Edition, PHI Learning Pvt. Ltd., New Delhi 2004
2. W. . D. Callister, Jr. and D. G. Rethwisch, “Materials Science and Engineering- An Introduction”, 10th edition, John Wiley and Sons, Inc. 2018.

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT311	Condensed Matter Physics	3	3	0	0	0

PREREQUISITE – Quantum Mechanics

COURSE OBJECTIVE(s)

This course aims to equip the students with fundamental knowledge of condensed matter physics. To explain structural, electrical, and magnetic behavior of different types of condensed phases.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Crystal Physics - Classification of condensed matter - crystalline and nanocrystalline solids, bonding in solids - ionic, covalent and metallic solids, crystal symmetry, point groups, space groups, lattices and basis, typical crystal structures, reciprocal lattice, Brillouin zone, structure factor. Bragg's law of diffraction. **(No. of lectures- 10)**

Lattice Vibrations and Thermal Properties - Monoatomic and diatomic lattices, normal modes of lattice vibration, phonons and density of states, dispersion curves, specific heat – classical, Einstein and Debye models. thermal expansion and thermal conductivity, normal and Umklapp processes. **(No. of lectures- 9)**

Band Theory of Solids - Free electron theory of metals, density of states, origin of energy bands, Fermi energy, Bloch Theorem, Kronig-Penney Model, distinction between metals, semiconductors, and insulators, Intrinsic and extrinsic semiconductors and carrier concentration, Hall effect in metals and semiconductors. **(No. of lectures- 9)**

Magnetism & Superconductivity - Introduction to magnetism, quantum theory of dia- and para-magnetism, magnetic ordering, Weiss molecular theory of ferromagnetism and antiferromagnetism. Introduction to superconductivity, Meissner Effect, concept of Cooper pairs, BCS theory, Type-I and Type-II superconductors. **(No. of lectures- 11)**

TEXT BOOKS: -

1. Introduction to Solid State Physics, Kittel C, 8th Ed. (Wiley Eastern Ltd. (2004))
2. Solid State Physics, Ashcroft N M and Mermin N D, 2nd Ed. (Holt-Saunders (2004))

REFERENCE BOOKS: -

1. Magnetism in Condensed Matter, S Blundell (Oxford University press (2001)
2. Solid State Physics, Neil W. Ashcroft and N. David Mermin, Brooks/Cole, 1976, ISBN: 978-0030839931.

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT312	Numerical Analysis through MATLAB	3	2	0	2	0

PREREQUISITE – Basics of Computer

COURSE OBJECTIVE(s)

To develop the mathematical skills of the students in the areas of numerical methods. To apply computer programming to solve numerical methods and to find the solution of algebraic equations using different methods under different conditions, and the numerical solution of a system of algebraic equations.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Basics of MATLAB programming, Array operations in MATLAB, loops and execution control, working with files: scripts and functions, plotting and program output **(No. of lectures- 10)**

Linear Equations - Linear algebra in MATLAB, Gauss Elimination. LU decomposition and partial pivoting, Iterative methods: Gauss Siedel, Special Matrices: Tri-diagonal matrix algorithm Nonlinear Equations: Nonlinear equations in single variable, Fixed-point iteration in single variable, Newton-Raphson in single variable **(No. of lectures- 9)**

Numerical Differentiation and Integration - Numerical Differentiation in single variable, Numerical differentiation: Higher derivatives, Differentiation in multiple variables, multi-step application of Trapezoidal rule, MATLAB functions for integration **(No. of lectures- 10)**

Ordinary Differential Equations (ODE) - Introduction to ODEs; Implicit and explicit Euler's methods, Second Order Runge-Kutta Methods, MATLAB ode45 algorithm in single variable, Higher order Runge-Kutta methods, Error analysis of Runge-Kutta method

(No. of lectures- 10)

TEXT BOOKS:

1. Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers by Rudra Pratap (Oxford University Press)
2. Computer Oriented Numerical Methods: V. Rajaraman (Prentice Hall of India)
3. Numerical Analysis: M. K. Jain (New Age International Publishers)

REFERENCE BOOKS: -

1. Introduction Methods of Numerical Analysis: C.S. Sastry (Prentice Hall of India)
2. Monte Carlo Simulation in Statistical Physics, Kurt Binder, Dieter W. Heermann (Springer-Verlag Berlin and Heidelberg)

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT313	Introduction to Quantum Technologies	3	3	0	0	0

PREREQUISITE – Basic Quantum Mechanics

COURSE OBJECTIVE(s)

The course aims to provide a comprehensive overview of quantum technologies, covering fundamental principles like superposition and entanglement. Students will explore hardware implementations for quantum computation, the mechanics of quantum sensing (including gravimetry and atomic clocks), and the protocols for secure quantum communications across fiber and satellite-based networks.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
d)	Internal assessment (based upon assignments, quizzes and attendance)	20%
e)	Mid-term examination	30%
f)	End Semester Examination	50%

COURSE CONTENTS

Module I: Introduction

Introduction to Quantum Technologies – four verticals and Motivation for Quantum Technologies. A qualitative overview of salient aspects of quantum physics: Quantum States, Wavefunctions, Probabilistic interpretation; Physical observables, Hermitian operators, expectation values; Heisenberg uncertainty principle; Schrodinger equation, Time evolution; distinction from classical physics, Heuristic description of Superposition, Tunnelling and entanglement; No cloning theorem; Simulating classical systems – Feynman's idea of a quantum simulator and the birth of the field **(no. of lectures- 6)**

Module II: Quantum Computation

Basics of qubits -- what is a qubit? How is it different from a classical bit? – Review of classical logic gates; Di Vincenzo criteria for realising qubits; Basics of qubit gates and quantum circuits; Physical implementation of qubits (very qualitative description); Solid State Qubits, Semiconducting Qubits – quantum dots, spins, Superconducting Qubits – charge, flux and phase, Topological Qubits – proposals and advantages, Atoms and Ions, Trapped ions, Rydberg atoms, Neutral atoms, Photonic Qubits, Conventional linear optical setups, Integrated Photonics, NMR qubits, Conventional NMR qubits, NV Centres. Overview of applications and recent achievements: RSA and Shor's algorithm; Quantum Advantage, Long term goals and strategies being followed, Error correction. **(no. of lectures- 10)**

Module III: Quantum Sensing and Quantum Communications

Basics of quantum sensing, Basics of Photon (single and entangled) generation and detection, Gravimetry, Atomic clock, Magnetometry, State of the art in Quantum Sensing. Basics of digital communication, quantifying classical information – Shannon entropy, Basic ideas of quantum communication, security, eavesdropping, Overview of quantum communication achievements, Terrestrial – fibre-based, Free space, Satellite-based **(no. of lectures- 10)**

TEXT/ REFERENCE BOOKS: -

1. Quantum Information Science – Manenti R., Motta M., 1st Edition, Oxford University Press (2023)
2. Quantum computation and quantum information – Nielsen M. A., and Chuang I. L., 10th Anniversary edition, Cambridge University Press (2010)
3. Elements of Quantum Computation and Quantum Communication, A. Pathak, Boca Raton, CRC Press (2015)
4. An Introduction to Quantum Computing, Phillip Kaye, Raymond Laflamme, and Michele Mosca, Oxford University Press (2006)
5. Quantum computing explained, David McMahon, Wiley (2008)

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT314	Thin Film Deposition and Characterization	3	2	0	2	0

PREREQUISITE

None

COURSE OBJECTIVE(s)

The course Thin Film Deposition & Characterization aims to provide a comprehensive understanding of thin film processing and analysis techniques used in modern materials and device engineering. It introduces the principles of vacuum systems and thin film deposition methods such as PVD and CVD, along with hands-on exposure to fabrication processes. The course also further focuses on the characterization of thin films to evaluate their structural, morphological, and optical properties. It enables students to understand the relationship between processing conditions and material properties, and to apply this knowledge to optimize performance in optoelectronic devices and advanced material systems.

COURSE OUTCOMES:

CO1	To understand the fundamentals of vacuum systems, including pumps, and gauges.
CO2	To explain thin film deposition processes based on underlying physical principles and process parameters.
CO3	To interpret the data obtained from different characterizations and evaluate structural, morphological, and optical properties of thin films.
CO4	To correlate processing conditions with material properties and understand their impact on performance of optoelectronic and advanced material devices.

COURSE ASSESSMENT

The Course Assessment (culminating in the final grade) will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid Term examination	30%
c)	End Term Examination	50%

COURSE CONTENTS

Unit 1: Vacuum Science and Technology [Lectures: 6, Tutorials: 0, Practical: 2]

Introduction to vacuum science and its importance in thin film processing, Creation of vacuum: rotary, diffusion, getter ion, turbo molecular, and cryo-pumps, Measurement of vacuum: Penning, Pirani, ionization gauges.

Unit II: Thin Film Deposition Techniques [Lectures: 13, Tutorials: 0, Practical: 7]

Fundamentals of thin film growth, Synthesis methods of thin films: PVD & CVD methods, Thermal evaporation, E-beam evaporation, RF magnetron sputtering, DC sputtering, Ion beam sputtering, Pulsed Laser Deposition, Spin coating, Dip coating, and Chemical vapor deposition. Film thickness measurement methods.

Unit III: Characterization of Thin Films [Lectures: 7, Tutorials: 0, Practical: 4]

Structural characterization: X-ray diffraction (XRD), Morphological characterization: Scanning electron microscopy (SEM) and atomic force microscopy (AFM), Optical characterization: UV-Visible spectroscopy.

Text Books:

1. Materials Science of Thin Films: Deposition and Structure, 2nd Edition, M. Ohring, 2001
2. Thin Film Phenomena. K. L. Chopra (*McGraw-Hill*)

Reference Books:

1. Encyclopedia of Materials Characterization: C Ricbard Brundle Charles A. Evans, Jr. Shaun Wilson, (Materials characterization series)
2. Handbook of Thin Film Technology: Maissel and Glange (McGraw Hill)
3. Basic Vacuum Technology: A. Chambers, R. K. Fitch, B. S. Halliday
4. Introduction to Nanoscience and Nanotechnology: K. K. Chattopadhyay and A.N. Banerjee, (PHI Learning Private Limited)
5. Vacuum Technology: A. Roth (North Holland)

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT315	Semiconductor Device Modelling and Simulation	3	2	1	0	0

PREREQUISITE – Basic knowledge of optics and quantum mechanics

COURSE OBJECTIVE(s)

The objectives of this course are to:

The course aims to provide a comprehensive understanding of concepts of semiconductor devices. Course objective is to develop a sound physical and intuitive understanding of semiconductor devices and achieve ability to make some key decisions while designing applications specific semiconductor devices. The course is devoted to the fundamental understanding of device modeling and numerical simulation techniques

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit I:

Metal-Semiconductor junctions, Current-Voltage Characteristics, Surface Effects. The pn junction, Step Junction, Linearly Graded Junction, Heterojunctions, Reverse-Biased p-n junctions and break down mechanism. Generation and Recombination. Basic MOSFET behaviour, MOSFET scaling and short channel model. Devices: Complementary MOSFETs (CMOS), electric fields and velocity-saturation, basic leakage currents, channel length modulation, body bias effect, threshold adjustment, sub-threshold conduction

(No. of lectures: 08)

Unit II:

Device Modeling: Limitation of long channel analysis, short-channel effects: velocity saturation, device degradation, channel length modulation, body bias effect, threshold adjustment, mobility degradation, hot carrier effects, MOSFET scaling goals, gate coupling, velocity overshoot, high field effects in scaled MOSFETs, substrate current and effects in scaled MOSFETS. Moore law, Technology nodes and ITRS, Physical & Technological Challenges to scaling, Nonconventional MOSFET – (FDSOI, SOI, Multi-gate MOSFETs) **(No. of lectures: 08)**

Unit III:

Drift-Diffusion (DD) model-1: Drift-Diffusion Model Derivation and dielectric relaxation time, Taylor series expansion and Finite Difference method, Normalization, Scaling and Linearization of Poisson's Equation and Scharfetter–Gummel Discretization of the Continuity Equation Drift-Diffusion (DD) model-2: Generation and Recombination models, Derivation of SRH model, Boundary conditions, Gummel's Iteration Method and Newton's Method, Drift-Diffusion Application example, Hydrodynamic Modeling: As extension of DD model, Carrier Balance, Energy balance and momentum balance Equations, Direct solution scheme through Monte Carlo simulations, Quantum Transport models: Tunneling, Schrodinger equation and free particle, potential step, potential barrier, Transfer Matrix Approach, Quantum Mechanical corrections to standard approach **(No. of lectures: 10)**

TEXTBOOKS:

1. Semiconductor devices- Physics and Technology, S. M. Sze and M.K. Lee (Wiley)
2. Device Electronics for Integrated circuits by Muller and Kkammins (Wiley)
3. Computational Electronics: Semiclassical and Quantum Device Modeling and Simulation, VagicaVasileska and Stephen M. Goodnick (CRC Press)

REFERENCE BOOKS:

1. Physics of Semiconductor Devices, S. M. Sze and Kwok K. Ng (Wiley)
2. Solid State Electronic Devices, Ben G. Steetman and Sanjay Banerjee (Prentice Hall)
3. Semiconductor Physics and Devices, Donald A. Neamen, (McGrawHill)
4. Semiconductor Devices- Basic Principles, Jasprit Singh (Wiley)

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHP316	**Engineering Materials Lab**	4	0	0	8	0

COURSE CONTENTS

1. Deposition of thin films using PVD/CVD techniques and analysis of band gaps
2. Synthesis of nanomaterials through physical and chemical routes, and their structure analysis
3. Effect of grinding time and rotational speed on particle size reduction.
4. (a) To plot the I-V characteristics of a solar cell and measure the short circuit current, open circuit voltage and maximum power point.
   (b) To calculate the energy conversion efficiency of a solar cell.
5. (a) To measure the Hall coefficient of a given material.
   (b) To study the temperature dependence of Hall coefficient of a given material.
6. To study the Gaussian nature of laser beams and carry out the diffraction experiments.
7. To study the speed of ultrasonic velocity in liquids and measure elasticity parameters.
8. To record a Frank Hertz curve for Mercury and measure the energy emission of free electrons in a gas filled triode.
9. To measure the magnetic susceptibility of paramagnetic solution by Quincke’s method and to find the ionic molecular susceptibility and magnetic moment.
10. To determine the Curie temperature of a given solid and study the magnetic transition.
11. To study Bragg's law by microwave diffraction.
12. To study the Faraday Effect and calculate the Verdet’s constant.
13. To study the performance of different rechargeable batteries by using Battery tester.

TEXT BOOKS: -

1. Introduction to Solid State Physics: C. Kittel, 7th Ed. (John Wiley and Sons)
2. Solid State Physics: N. Ashcroft and N.D. Mermin (Holt, Rinehart and Winston).

REFERENCE BOOKS: -

1. Solid State Physics: Azaroff (McGraw Hill).
2. Solid State Physics: A.J. Dekker (Prentice Hall of India, New Delhi).

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT321	Atomic and Molecular Spectroscopy	4	3	1	0	0

PREREQUISITE – Modern Physics, Quantum Mechanics

COURSE OBJECTIVE(s)

This course aims to equip the students with fundamental knowledge of emission and absorption spectra of atoms and molecules, the hydrogen atom, total angular momenta and dipole moment, coupling schemes of angular momenta of many-electron atoms, effects of interaction of spectra under different fields, molecular spectra and lasers and their applications.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Atomic Physics (One-electron atom)

Introduction of atomic spectra (emission and absorption), Bohr model, Bohr's quantization law, Hydrogen spectra, Rydberg formula, Vector atom model, orbital angular momentum, magnetic dipole moment of electron, space quantization, Stern–Gerlach experiment, spin & total angular momentum, Spin-orbit interaction & fine structure, Hyperfine structure, Isotope shift.

(No. of lectures- 12)

Atomic Physics (Multi-electron atom)

Identical particles: exchange symmetry, Pauli exclusion principle, Helium atom, Introduction of Central field approximation, Angular momentum coupling schemes: LS & JJ Coupling, Interaction with external fields: Zeeman and Paschen-Back effect, Stark effect, General factors influencing spectral line width and intensities. **(No. of lectures- 13)**

Molecular Physics

Born-Oppenheimer approximation, Rotational spectra of diatomic molecules, Types of molecules such as (symmetric, spherical top, etc.), Vibrational spectra, diatomic vibrating rotator, vibration rotation spectra, electronic transitions, Franck- Condon principle, Raman effect (classical and quantum), Raman spectroscopy (applications). Einstein coefficients, the basic working of lasers and applications, and other advanced topics in atomic and molecular physics

(No. of lectures- 14)

TEXT BOOKS:-

1. Atomic Physics, Foot, C. J. 2023 (Reprint ed.), Oxford University Press.
2. Fundamentals of Molecular Spectroscopy, Banwell, C. N. and McCash, E. M. 1994 (4^{th} ed.), McGraw-Hill.

REFERENCE BOOKS: -

1. Spectra of Atoms and Molecules, Bernath, P. F. 2020 (4^{th} ed.), Oxford University Press.
2. Atomic and Molecular Spectra: Lasers, Kumar, R. 2023, KNRN Publishers.
3. Introduction to Atomic Spectra, White, H. E. 1934, McGraw-Hill.
4. Physics of Atoms and Molecules, Bransden, B. H. and Joachain, C. J. 2003 (2^{nd} ed.), Pearson.

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT322	Advanced Computational Tools for Physicists	**3**	**2**	**1**	**0**	**0**

PREREQUISITE – None

COURSE OBJECTIVE(s)

To train students in statistical methods for data analysis using python programming and build strong mathematical foundations and physics understanding of experimental data from physics analysis.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Module I: Basics of Statistical and Python tools in Physics
Overview of Python and its libraries, data types in physics experiments, descriptive statistics, mean, median, mode, variance, standard deviation, probability basics, random variables, normal distribution, error representation, Plotting scientific data. **(No. of lectures: 12)**

Module II: Data Analysis techniques
Measurement errors and uncertainties, propagation of errors, confidence intervals, weighted mean, histogram analysis, curve fitting using least squares method, linear regression, chi-square test, Monte Carlo simulation basics, data handling from Physics experiments.
(No. of lectures: 15)

Module III: Advances Statistical Techniques

Hypothesis testing, p-value and significance, correlation and covariance, Poisson statistics, counting experiments, signal vs background analysis, maximum likelihood estimation, time series data analysis, Case studies: nuclear physics, solid state physics, astronomy and cosmology, space Physics and particle physics datasets. **(No. of lectures: 12)**

Books and References

1. The Elements of Statistical Learning, 2nd ed., T. Hastie, R. Tibshirani, & J. Friedman, Springer (2016)
2. Python Machine Learning - Second Edition, Sebastian Raschka, Vahid Mirjalili
3. Statistics, R J Barlow (John Wiley and Sons)

References

4. A Practical Guide to Data Analysis for Physical Science Students, L. Lyons (Cambridge University Press)
5. Data analysis techniques for HEP, Fruhwirth et al (Cambridge University Press)
6. Introduction to Machine Learning, 3rd ed., E. Alpaydin, MIT Press (2014)
7. Handbook of Radiotherapy Physics, Theory and Practice, P Mayles, A Nahum, J.C Rosenwald (Taylor & Francis)

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT323	Physics of Nuclear Radiations and Applications	3	2	1	0	0

PREREQUISITE – None

COURSE OBJECTIVE(s)

- To provide a comprehensive understanding of the physical principles governing nuclear radiations and their complex interactions with matter.
- To develop technical expertise in the operation, design, and calibration of various detection systems, including gas-filled, semiconductor, and scintillation detectors.
- To bridge the gap between theory and industry by exploring real-world applications in medical physics, nuclear power, and global high-energy research facilities.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Module I: Fundamentals of Nuclear Radiations

Introduction to the nuclear radiations, Production of nuclear radiations, Classification of nuclear radiations: Electromagnetic radiations and Particle radiations: X-rays: Bremsstrahlung x-rays and Characteristic x-rays, Gamma rays, electron, proton, neutron, Secondary radiations, alpha, beta, gamma rays, heavy ions, Important Characteristic of nuclear radiations, Interaction of nuclear radiations with matter: Ionization, excitation, Bethe-Bloch Mechanism, Energy loss by particle radiations, Radiation flux, Absorbed dose, Dose equivalent, Radiation weight factor.

(No. of lectures: 13)

Module II: Detection Methods of Nuclear Radiations

Important properties of Nuclear radiation detectors, Gas-filled detectors: Ionization, Proportional, GM counter, Semiconductor detectors: Si detectors, Pixel and Strip detectors, Scintillation detector, Classification of Scintillation materials: Inorganic and Organic, Calorimeter detector, Tracking detectors, Superconducting solenoid: Important measurements from radiation detectors: Momentum, Energy, Mass, Tracking of particles, Types of radiations and their detections.

(No. of lectures: 15)

Module III: Technological Applications of Nuclear Radiations and Detectors

Applications of nuclear radiations and detectors in medical imaging (PET, SPECT) and cancer therapy, including dosimetry and radiation safety, Use in nuclear power reactors (e.g. DHURAVA) for neutron flux measurement, control, monitoring, and safety systems, Industrial and environmental applications such as non-destructive testing (NDT), thickness measurement, food irradiation, and radiation monitoring, Advanced applications in space research (ISRO / NASA), security scanning, high-energy physics experiments, and modern detector technologies (KEK Japan, EIC at BNL US, LHC at CERN), **(No. of lectures: 11)**

Text books

1. Techniques for Nuclear and Particle Physics Experiments: W.R. Leo (Springer, 1994).
2. Radiation Detection and Measurement: G. F. Knoll (John Wiley, 1989).
3. Radiation and Detectors: Introduction to the Physics of Radiation and Detection Devices by Lucio Cerrito, Springer International Publishing AG (2017).

References books

4. Introduction to Elementary Particle Physics: David Griffith (Wiley).
5. Introduction to High Energy Physics: Donald H. Perkins (Cambridge University Press).
6. Concepts of Modern Physics: Aurthur Beiser (Mc GrawHill)
7. Particle Physics Reference Library (Detectors for Particles and Radiation) Publisher: Springer
8. Introductory Nuclear Physics: Kenneth S Keane (Wiley).

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHP324	Nuclear Radiations and Spectroscopy Lab	4	0	0	8	0

1. To calibrate and determine the resolution of the Gamma ray spectrometer.
2. Experimental studies of gamma ray spectrometer.
   (a) To calibrate the energy of the spectrometer.
   (b) To identify the unknown source.
3. (a) To study the characteristics of the GM tube and determine its operating voltage, plateau length and slope with determination of efficiency for beta and gamma radiation.
4. (b) To determine the linear and mass attenuation coefficients using gamma source using GM counter.
5. To study the electron spin resonance and to determine the Lande's g- factor.
6. To study normal Zeeman effect in transverse and longitudinal configurations.
7. To study the optical properties of polymer thin films grafted by fluorescence dye.
8. To measure the emission spectra of Hydrogen atom.
9. Lifetime of a short-lived radioactive source.
10. Compton Scattering Experiment to measure the scattering angle of scattered photons.
11. Resolving Time of G. M. Counter set-up.
12. To measure the Hydrogen Emission Spectra.
13. Alpha particle spectrometer: Energy resolved
14. Radiation Counter for Alpha and Beta Particles
15. $\chi 2$- Statistics using G. M. C
16. Cosmic radiation Detection using cloud chamber.

17. Simulated Experiments on Nuclear Radiation Detectors: To measure the nuclear radiation flux and energy loss in the detector material.

18. Experiments related to Device Physics

TEXT/ REFERENCE BOOKS:-

1. Techniques for Nuclear and Particle Physics Experiment: W. R. Leo (Springer).
2. Radiation Detection and Measurement: Glenn F. Knoll (Wiley).
3. Particle Detectors: Claus Grupen and Boris Schwartz (Cambridge University Press).
4. Physics of Particle Detectors: Dan Green (Cambridge University Press).

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	26PHT411	AI/ML for Physical Systems	**3**	**2**	**1**	**0**	**0**

PREREQUISITE – None

COURSE OBJECTIVE(s)

- Integrate fundamental physics principles with AI to enhance theoretical modeling and experimental accuracy.
- Develop proficiency in Python-driven machine learning for simulating complex quantum, semiconductor, and astrophysical systems.
- Apply AI to automate experiments, optimize space radiation shielding, and accelerate the discovery of new materials.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Module I: Fundamentals of Artificial Intelligence in Physics

Introduction to AI, History of AI, Role of AI in Physics (Theory & Experiments in Modern Physics), computational physics, understanding the data from physics experiments, for example, Particle Physics (LHC experiments), Space organizations (NASA, ISRO), Astronomy, Radiation oncology and automation of the physics experiments, building simulated experiments using AI, Basics of Python and Data visualization from physics experiments, Awareness on AI Ethics

(No. of lectures: 13)

Module II: Machine Learning Techniques in Physics

Mathematical formulation of Machine Learning, Employing Physical Concepts through ML using various techniques such as Supervised and Unsupervised learning, Regression: Linear, Non-Linear and Polynomial Regression, Classification: Logistic, KNN, SVM, Decision trees, Random Forest, Clustering (Unsupervised), Curve Fitting, Deep Learning & Neural Networks.

(No. of lectures: 14)

Module III: AI for Classical and Modern Physical Systems

Classical Physical systems: Motion prediction, Oscillation problems, Electrical load forecasting.

Modern physical systems: AI in quantum systems, semiconductor devices, detectors, space weather, solar flare data classification, radiation data prediction.

Applications: AI in Astronomy: Galaxy Classification, Satellite Image Processing, Weather forecasting, Spacecraft Radiation Shielding optimization, effect of gravitational waves on future space missions, Predicting material properties and discovering new materials.

(No. of lectures: 12)

Text Books

1. Python for data analysis (O' Reilly Media) 2022
2. Introduction to Machine Learning with Python (O' Reilly Media) 2016
3. Hands-on Machine Learning with Scikit-learn, Keras, and Tensorflow (O'Reilly Media) 2022

References

4. A.I. Ethics (MIT Press) 2020
5. Deep Learning & Physics (Springer) 2021
6. Machine Learning for Physics and Astronomy (Princeton University Press) 2023
7. Computational Physics: Problem Solving with Python (Wiley) 2015
8. Pattern Recognition & Machine Learning (Springer) 2006

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Semiconductor Devices and Circuits	3	3	0	0	0

COURSE CONTENTS

Solids: Formation of Bands, Kronig-Penny Model, Electrons and Holes, Crystals, Density of States, Fermi Function, Carrier Concentration, Doping, Recombination and Generation, Charge Transport, Continuity Equation. **(No. of lectures- 10)**

Bipolar Junction Transistors (BJT), IV Characteristics, Non-Idealities and Equivalent Circuit Modeling, Metal Oxide Semiconductor Capacitor (MOSCAP) and CV Characteristics, MOSFET: Introduction, I-V characteristics, Subthreshold swing, Additional concepts, MOSFET as a switch, Amplifiers using MOSFET, Circuits: Frequency Response, Noise, Amorphous Semiconductors, Thin Film Transistors. **(No. of lectures- 15)**

Introduction to compound semiconductor materials (e.g., GaAs, InP, GaN)., structure & properties of III-V materials and their role in high-speed & optoelectronic devices, bandgap engineering and heterojunctions, high electron mobility transistors (HEMTs), 2-D semiconductor materials

(No. of lectures - 14)

TEXT BOOKS

1. Solid State Electronic Devices (7th Edn) - Ben G. Streetman & Sanjay K. Banerjee, Pearson India
2. Semiconductor Physics and Devices: Basic Principles (4th Edn) - Donald A. Neamen, McGraw Hill
3. Principles of Semiconductor Devices - Sima Dimitrijev, Oxford University Press

REFERENCE BOOKS

1. Semiconductor Devices: Physics and Technology (3rd Edn) - Simon M. Sze & Kwok K. Ng, John Wliey & Sons
2. Semiconductor Devices and Circuits - Aloke K. Dutta, Oxford University Press
3. Compound Semiconductor Device Physics - Sandip Tiwari, Academic Press

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	**Semiconductor Device Processing and IC Fabrication**	3	3	0	0	0

COURSE CONTENTS

General Overview - history, integration and scaling trends in VLSI, IC Device Process Integration - patterning process and p-n junction diode as example devices, IC Device Process Integration CMOS Support Technologies - clean-rooms; and vacuum systems, plasma for processing, basic material and electrical chacharacterisation. **(No. of Lectures – 12)**

Substrates - silicon wafer fabrication, silicon-on-insulator wafers, alternate substrates, Additive Processes: oxidation and nitridation of silicon, Unit Additive Processes: Diffusion and Ion-Implantation, Additive Processes: Thermal evaporation, chemical vapour deposition (CVD), sputter deposition, etc., Patterning Process - photo-lithography; Subtractive Processes - wet etching, reactive ion etching, chemical-mechanical polishing (CMP), etc. **(No. of Lectures – 20)**

Process Control - statistical quality control (SQC) and design of experiment (DoE), New Trends - 3-D integration in devices and packaging, electronics printing and flexible device processing
(No. of Lectures – 7)

Books and references

1. Stanley Wolf and Richard N. Tauber, “Silicon Processing for the VLSI Era” Volume-1, Lattice Press.
2. S.M. Sze, “Semiconductor Devices Physics and Technology”, 2nd Edition, Wiley.
3. Sorab K. Ghandhi, “VLSI Fabrication Principles Silicon and Galium Arsenide”, 2nd Edition, Wiley.
4. Richard C.Jaeger, “Introduction to Microelectronic Fabrication”: Volume 5, 2nd Edition, Modular Series on Solid State Deviced, Vol 5 (Or any basic book on semiconductor fabrication)

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Semiconductor Devices for Next Generation Field-Effect Transistors	3	3	0	0	0

Course contents-

Introduction of Metal-Oxide-Semiconductor, Energy Band Diagram of MOS Capacitors, Second Order Effects in MOS Capacitors, C–V of MOS capacitor, Introduction of MOSFET, I-V and C-V Characteristics of MOSFETs, Capacitance Modeling, High and Low Frequency Modeling in Bulk MOSFET, MOSFET as Switch and Amplifier, Short Channel Effects, Introduction to 2nd Order Effects at Lower Technology Node, Gate Induced Drain Leakage (GIDL), Drain Induced Barrier Lowering (DIBL), and Subthreshold Swing (SS), Mobility and Scattering Effects, Velocity Saturation Effects, Hot Carrier Effect, Self-heating Effect **(No. of Lectures – 15)**

Introduction to Double Gate MOSFET, SOI MOSFET, Partially and Fully Depleted MOSFET, Subthreshold Swing and Transconductance, Small and Large Signal Modeling, Introduction of Junctionless MOSFET
Introduction to FinFETs Structure, Structural Classification of FinFETs, RLC FinFET Modeling, High Frequency Small Signal Modeling, Device Circuit Co-Design using FinFET with Suitable Examples **(No. of Lectures – 12)**

Introduction of III-V materials, Materials for High-Speed Devices and Circuits, High Electron Mobility Transistors (HEMT): Modelling and Simulation, III-V Semiconductor FET, Application of III-V material-based FET, Fundamental Understanding of 2D Material, Application of 2D Material, 2D-FETs **(No. of Lectures – 12)**

Books and references

1. Neamen, Donald A. Semiconductor physics and devices: basic principles. New York, NY: McGraw-Hill, 2012.
2. R. F. Pierret, Semiconductor Device Fundamentals, 1996.
3. Jean-Pierre Colinge, FinFETs and Other Multi-Gate Transistors, 2008.

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Surface Physics and Engineering	3	3	0	0	0

PREREQUISITE - None

COURSE OBJECTIVE(s)
The aim of this course is to give a comprehensive introduction of solid surfaces and interfaces and physics and chemistry on an atomic length scale. After successfully completing this course student should be able to understand the fundamental importance of surfaces, and how their structures and properties differ from that of bulk materials. They should be able to understand the results of surface science techniques such as XPS, AES, RBS, STM etc.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
g)	Internal assessment (based upon assignments, quizzes and attendance)	20%
h)	Mid-term examination	30%
i)	End Semester Examination	50%

COURSE CONTENTS

Physics of Surfaces
Introduction to surfaces and interfaces, importance of surface science, From Solid to Surface, Morphology and Structure of Surfaces, Surface thermodynamics (Surface tension and Surface energy), Surface relaxation and reconstruction, Surface Defects, Surface Creation; Surface cleaning, Adsorption (Physisorption & Chemisorption), Adsorption Isotherms, Desorption

(No. of lectures - 11)

Thin Film Deposition and Characterisation Techniques
Basics of vacuum and significance of vacuum, Vacuum pumps and vacuum gauges, Film growth modes (Volmer-Weber, Frank-van der Merwe, Stranski-Krastanov), Fundamentals of Thin Film Deposition techniques (thermal evaporation, sputtering, pulsed laser ablation), Surface modifications (Physical & chemical), Physical Vapour Deposition, Chemical Vapour Deposition, Auger Electron Spectroscopy, X-ray Photoelectron Spectroscopy, Scanning Tunneling Microscopy, Atomic Force Microscopy **(No. of lectures - 13)**

Surfaces engineering applications

Surface coatings, Functional Coatings, Advanced Coating Practices, Applications of Nano-coatings; mechanical, physical, chemical and other properties; nanostructured coatings, Tribology & Its Classification, types and laws of friction, methods to control friction, Wear & Corrosion mechanisms, Lubrication, Effect of Tribology on Surface of Nanomaterials, hard coatings and hardness measurements, optical applications of surfaces, Catalytic applications of surfaces (Heterogeneous catalysis), electrochemical and energy applications (Electrocatalysis, Fuel cells, and Batteries), Semiconducting surfaces applications and passivation, Bio-applications of surfaces

(No. of lectures - 15)

Recommended Readings

Text books –

1. Surface Science: An Introduction, Oura, K., Lifshits, V. G., Saranin, A. A., Zotov, A. V., and Katayama, M. 2003 (1st ed). (Springer).
2. Materials Degradation and its control by surface engineering, Imperial College Press, (2006)
3. Surrface Analysis: The Principal Techniques, Vickerman, J. C. and Gilmore, I. S. 2009 (2nd ed). (Wiley).

Reference books –

1. Physics of Surfaces and Interfaces, Ibach, H. 2006 (1st ed). Publisher: Springer.
2. Surface engineering in metals, CRC Press (1999) London
3. Solid Surfaces, Interfaces and Thin Films, Hans Luth (Springer) 2014/15(6th ed).

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTX XX	Advanced Micro- and Nanofabrication Technology and Process	3	2	1	0	0

PREREQUISITE – Basic knowledge of semiconductor physics

COURSE OBJECTIVE(s)

The objectives of this course are to:

The course aims to build a strong foundation in the principles of micro- and nanofabrication while developing a clear understanding of lithography and pattern transfer techniques. It further introduces advanced nanofabrication approaches and device integration strategies, enabling students to connect fundamental concepts with practical implementations.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit I:

Introduction to micro- and nanotechnology: evolution and importance, Scaling laws and physical limits at micro/nanoscale Cleanroom technology and contamination control Substrates and materials: silicon, glass, polymers, compound semiconductors, Thin film deposition techniques: Physical vapor deposition (evaporation, sputtering), Chemical vapor deposition (CVD), Atomic Layer Deposition (ALD – basics), Thermal oxidation and diffusion, Basic characterization techniques (SEM, profilometry, ellipsometry) **(No. of lectures: 09)**

Unit II:
Photolithography: working principles, photoresists, masks, exposure, development, Resolution limits, alignment, and overlay accuracy, Advanced lithography techniques: Electron beam lithography, Focused ion beam (FIB), Nanoimprint lithography, Etching processes: Wet etching (isotropic and anisotropic), Dry etching (plasma etching, RIE, ICP), Lift-off processes and pattern transfer, Process integration and defect control **(No. of lectures: 09)**

Unit III:
Bottom-up approaches: self-assembly, chemical synthesis, Top-down vs bottom-up: comparison and hybrid fabrication, Fabrication of nanostructures: nanowires, quantum dots, thin films, Introduction to MEMS and NEMS fabrication, Applications: sensors, energy devices, biomedical systems, Emerging techniques: soft lithography, 3D nanofabrication, Reliability, scalability, and industrial challenges **(No. of lectures: 09)**

TEXTBOOKS:

1. The Science and Engineering of Microelectronic Fabrication: Stephen A. Campbell (Oxford)
2. Semiconductor Lithography: Principles, Practices, and Materials (Microdevices): Wayne M. Moreau (Springer)

REFERENCE BOOKS:
1. Materials Science of Thin Films: Milton Ohring (Academic Press)
2. Fundamentals of Microfabrication and Nanotechnology: Marc J. Madou (CRC Press)

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTX XX	Nanophotonics	3	2	1	0	0

PREREQUISITE – Basic knowledge of optics and quantum mechanics

COURSE OBJECTIVE(s)

The objectives of this course are to:

The course aims to provide a comprehensive understanding of light–matter interactions at the nanoscale while building a strong foundation in photonic and plasmonic materials. It further explores the principles and design of nanophotonic and quantum photonic structures and devices, enabling students to connect fundamental concepts with advanced technologies

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit I:

Review of electromagnetic waves and classical optics, Light–matter interaction at nanoscale, Optical constants: refractive index, dielectric function, Dispersion and absorption, Surface plasmon resonance (SPR) and localized plasmons, Quantum confinement effects (quantum wells, wires, dots), Introduction to quantum optics: photons, quantization of light, coherence, Optical characterization techniques (UV-Vis, PL, Raman basics) **(No. of lectures: 09)**

Unit II:

Dielectric, semiconductor, and metallic photonic materials, Plasmonic materials (Au, Ag, Al nanostructures), Photonic crystals: 1D, 2D, 3D and photonic bandgap, Metamaterials and metasurfaces, Waveguides and optical confinement, Nanostructures: quantum wells, wires, quantum dots, Quantum materials for photonics: single-photon emitters, color centers, 2D materials, Fabrication techniques for photonic nanostructures **(No. of lectures: 09)**

Unit III:

Introduction to plasmonics, Surface plasmon polaritons (SPPs), Localized surface plasmon resonance (LSPR), Metallic nanoparticles, Surface-enhanced Raman scattering (SERS), Plasmonic waveguides, Optical nanoantennas, Applications in chemical and biosensing

(No. of lectures: 09)

TEXT/ REFERENCE BOOKS:

1. Plasmonics: Stefan Mayer (Cambridge Press)
2. Introduction to Nanophotonics: Sergey V. Gaponenko (Cambridge Press)
3. Quantum Theory of Light: Rodney Loudon (Oxford Science Publications)

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTX XX	Advanced Photonic Materials	3	2	1	0	0

PREREQUISITE – Basic knowledge of optics and quantum mechanics

COURSE OBJECTIVE(s)

The objectives of this course are to:

The course aims to provide a comprehensive understanding of light-matter interaction in engineered and nanostructured media, bridging the gap between classical optics and modern photonic device design. Students will explore the unique optical properties of photonic crystals, metamaterials, plasmonics, and emerging 2D materials, gaining a conceptual understanding of how light can be manipulated at the sub-wavelength scale.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit I:

Classification of photonic materials (Dielectrics, Semiconductors, Metals, Polymers, Nanomaterials), Two-dimensional photonic materials (Graphene, Transition metal dichalcogenides (TMDs), MXenes), Quantum dots and nanocrystals, Metal nanoparticles and localized surface plasmon resonance (LSPR), Photonic crystals, Metamaterials and metasurfaces

(No. of lectures: 08)

Unit II:

Electronic band structure and optical transitions, Direct and indirect band-gap materials, Excitons and quantum confinement, Luminescence: fluorescence, phosphorescence, electroluminescence

Optical characterization techniques (UV–Visible spectroscopy, Photoluminescence (PL), FTIR spectroscopy, Raman spectroscopy, Ellipsometry) **(No. of lectures: 08)**

Unit III:

Nanophotonic devices: LEDs, lasers, photodetectors, Plasmonic and photonic sensors, Optical sensors and biosensors, Integrated photonics and optical communication, Quantum photonic devices: single-photon sources, detectors, quantum dots in devices, Basics of quantum communication and computing (introductory concepts), Nanophotonics in solar cells and energy harvesting, Biomedical applications: imaging, therapy, Challenges, scalability, and future trends in quantum photonics **(No. of lectures: 10)**

TEXTBOOKS:

1. Advanced Photonic Materials & Devices, Jia-Ming Liu (Cambridge Press)
2. Optoelectronics and Photonics: Principles and Practices Safa O. Kasap (Pearson)

TEXT/ REFERENCE BOOKS:

1. Introduction to Nanophotonics: Sergey V. Gaponenko (Cambridge Press)
2. Fundamentals of Photonics, Bahaa E. A. Saleh and Malvin Carl Teich (Wiley)
3. Handbook of Electronic and Photonic Materials, Safa O. Kasap & Peter Capper (Springer)

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHT XXX	Medical Applications of Radiation Physics	**3**	**2**	**1**	**0**	**0**

PREREQUISITE – None

COURSE OBJECTIVE(s)

This course provides an overview of the principles and applications of physics in medicine and healthcare. Students will gain an understanding of the role of physics in modern healthcare and its impact on patient diagnosis and treatment.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments,	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit I:
History of medical physics, Ethical and safety considerations in medical physics, overview of medical imaging, and radiation therapy; Medical imaging: X-ray imaging, computed tomography (CT), magnetic resonance imaging (MRI), Mammography, Bone Mineral Density (DEXA)and ultrasound imaging, Nuclear Medicine and Positron Emission Tomography (PET).

(No. of lectures: 09)

Unit II:
Principles of radiation therapy, external beam radiation therapy, Intensity-Modulated Radiation Therapy (IMRT), Image-Guided Radiation Therapy (IGRT), Stereotactic Radiosurgery (SRS) and

Brachytherapy; Radiation safety and protection: Radiation biology, radiation dosimetry, and radiation shielding, ALARA principle, Regulatory guidelines and safety measures;

(No. of lectures: 09)

Unit III:

Biological effects of radiation, DNA damage and repair mechanisms, Nuclear medicine, laser physics, and medical robotics, Particle therapy and its Advantages, Emerging technologies in cancer treatment, Patient-specific treatment planning, Nanotechnology in radiation medicine, Artificial intelligence in medical imaging **(No. of lectures: 08)**

TEXTBOOKS:

1. Introduction to Health Physics" by Herman Cember and Thomas E. Johnson (McGraw-Hill)
2. Radiation Physics for Medical Physicists, Ervin B. Podgorsak (Springer)
3. Radiation Therapy Physics" William R. Hendee and Geoffrey S. Ibbott (Wiley)

REFERENCES BOOKS:

1. Introduction to Medical Imaging: Physics, Engineering, and Clinical Applications, NB Smith and A Webb (Cambridge)
2. The Essential Physics of Medical Imaging, JT. Bushberg, JA Seibert, EM. Leidholdt Jr., and John M. Boone (Wolters Kluwer Health)
3. Radiation Therapy Physics, William R. Hendee and Geoffrey S. Ibbott (Wiley)
4. Radiobiology for the Radiologist" Eric J. Hall and Amato J. Giaccia (Lippincott Williams & Wilkins)

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Solar Energy and Physics of Solar Cells	3	3	0	0	0

PREREQUISITE – Solid State Physics, Materials Science

COURSE OBJECTIVE(s)

This course aims to equip the students with fundamental knowledge of solar energy resource, solar energy conversion techniques, basics of semiconductor junction, design and operation of solar cells, performance testing and analyses.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Renewable and non-renewable energy resources, solar energy: origin, solar constant, spectral distribution of solar radiation, absorption of solar radiation in the atmosphere, global and diffused radiation, seasonal and daily variation of solar radiation, measurement of solar radiation, solar to thermal conversion, types of solar energy collectors, concentrating/non-concentrating solar collectors, collector efficiency and its dependence on various parameters, solar fuels: electrolysis of water, photoelectrochemical splitting of water. **(No. of lectures: 12)**

Fundamentals of solar cells: photo voltaic effect, p-n junction photodiodes, depletion region, electron and holes transports, absorption of photons, excitons and photoemission of electrons, band engineering, charge carrier generation, charge separation, recombination and other losses **(No. of lectures: 10)**

I-V characteristics, output power, efficiency, fill factor and optimization for maximum power, metal-semiconductor heterojunctions, surface structures for maximum light absorption, operating temperature vs conversion efficiency. **(No. of lectures: 10)**

Device physics, device structures, device construction, solar cell properties and design, materials for solar cells, silicon based solar cells: single crystal, polycrystalline and amorphous silicon solar cells, organic solar cells, organic-inorganic hybrid solar cells, advanced concepts in photovoltaic research, nanotechnology applications, plasmonic based solar cells. **(No. of lectures: 7)**

TEXT/ REFERENCE BOOKS: -

1. Nelson, J. The Physics of Solar Cells. Imperial College Press, 2003. ISBN: 9781860943409.
2. Solar Engineering of Thermal Process: Duffie and Beckman, John Wiley, 2013. ISBN: 9780470873663
3. Solar Energy: S. P. Sukhatme, Tata McGraw Hill, 1996. ISBN: 1259081966, 9781259081965.
4. Principles of Solar Engineering, D. Yogi Goswami, Taylor and Francis, 2015. ISBN: 9781138569478.
5. Wenham, S., M. Green, et al., eds. Applied Photovoltaics. 2nd Ed. Routledge, 2006. ISBN: 9781844074013.
6. Green, M. A. Solar Cells: Operating Principles, Technology, and System Applications. Prentice Hall, 1981. ISBN: 9780138222703.

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DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTX XX	Energy Storage Systems	3	3	0	0	0

PREREQUISITE – Basic understanding of Physics, Chemistry and Mathematics

COURSE OBJECTIVE(s)

This course provides a comprehensive overview of energy storage technologies, focusing on their physical principles, performance metrics, and grid-scale applications. Students will evaluate the integration of mechanical, thermal, and electrochemical systems into modern energy infrastructures while analyzing the economic and safety frameworks required for sustainable deployment.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
d)	Internal assessment (based upon assignments, quizzes and attendance)	20%
e)	Mid-term examination	30%
f)	End Semester Examination	50%

COURSE CONTENTS

Module 1: Fundamentals and Classification of Energy Storage

Introduction to energy storage necessity and renewable integration; classification by mechanical, electrical, thermal, and chemical types; analysis of energy/power density, efficiency, and performance metrics; comparative evaluation of storage technologies for grid stability.

(No. of lectures: 8)

Module 2: Mechanical and Thermal Energy Storage

Principles, working advantages, and limitations of pumped hydro, compressed air, and flywheel storage; thermal energy storage methods including sensible and latent heat; application of phase change materials; system-level material considerations for grid and industrial heat management.

(No. of lectures: 8)

Module 3: Electrical and Chemical Energy Storage Systems

Mechanics and characteristics of capacitors and supercapacitors; technical overview of battery chemistries (Li-ion, Na-ion, flow, and Zn–air); hydrogen production and fuel cell system-level integration; comparative analysis of electrochemical storage applications.

(No. of lectures: 9)

Module 4: Energy Storage Integration and Applications

Grid integration strategies for solar and wind balancing; deployment in microgrids and distributed systems; electric vehicle (EV) storage requirements; operational roles in peak shaving and backup power; design and optimization of hybrid storage systems. **(No. of lectures: 8)**

Module 5: Economics, Safety, and Future Trends

Economic cost analysis and lifecycle modeling; safety protocols and thermal management; environmental impact and sustainable recycling practices; overview of emerging materials and future industry outlook. **(No. of lectures: 6)**

TEXT BOOKS: -

3. Engineering Energy Storage, Lamb, J. J. and Burheim, O. S. 2024 (2nd ed).
4. Renewable Energy - Volume 4: Energy Storage Systems - Mechanical, Hydro, and Thermal, Olabi, A. G. (Ed.). 2025 (1nd ed).

REFERENCE BOOKS: -

1. Energy Storage and Conversion Materials: Properties, Methods, and Applications, Tran, N. T. T., Jan, J. S., Hsu, W. D., Lin, M. F., and Huang, J. L. 2023 (1nd ed).
2. Materials for Sustainable Energy: A Collection of Peer-Reviewed Research and Review Articles, Dusastre, V. 2011 (1nd ed).

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DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTX XX	Hydrogen Energy and Fuel Cells	3	3	0	0	0

PREREQUISITE – Basic understanding of Physics, Chemistry and Mathematics

COURSE OBJECTIVE(s)

The objective of this course is to provide students with an understanding of hydrogen energy as an energy carrier, from sustainable production and storage methods to the electrochemical principles of various fuel cell technologies. This course aims to develop an understanding of the fundamental principles, performance characteristics, and practical challenges of hydrogen-based energy systems. The course also highlights the role of hydrogen and fuel cells in sustainable energy and future energy technologies.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
g)	Internal assessment (based upon assignments, quizzes and attendance)	20%
h)	Mid-term examination	30%
i)	End Semester Examination	50%

COURSE CONTENTS

Module 1: Introduction, Production & Storage of Hydrogen

Basic Introduction to energy systems, hydrogen economy, properties of hydrogen, hydrogen versus conventional fuels, Sustainability and environmental impact, hydrogen production technologies: Alkaline & PEM electrolysis, basics of steam reforming, thermochemical & photochemical methods, Hydrogen Storage: high-pressure compressed gas and liquid hydrogen, Solid-state storage methods (metal hydrides, MOFs etc. handling, storage challenges and safety.

(No. of lectures: 17)

Module 2: Fuel Cell Technology

Introduction to Fuel Cells: History, Operating Principles, and Advantages, thermodynamics and efficiency of Fuel Cells, Nernst equation (conceptual use). Polarization and losses, Characterization techniques: Polarization curves (I-V curves) and Electrochemical Impedance

Spectroscopy (EIS), Types of Fuel Cells: PEM fuel cells, DMFC, basics of SOFC and AFC, Operating conditions and characteristics, performance comparison, advantages and limitations.

(No. of lectures: 16)

Module 3: Applications, Economics & Policy
Stationary Power: Micro-CHP (Combined Heat and Power) and Backup Power, Mobile Applications such as Fuel Cell Electric Vehicles (FCEVs), Integration with renewables, Economics: Levelized Cost of Hydrogen and market drivers, Global Policies, Standards, and Roadmap for the future.

(No. of lectures: 6)

TEXT BOOKS: -

5. Fuel Cell Systems Explained, Larminie, J. and Dicks, A.. 2018 (3rd ed).
6. Hydrogen and Fuel Cells: Emerging Technologies and Applications, Sorensen, B., and Spazzafumo, G., Academic Press. 2018 (3rd ed).

REFERENCE BOOKS: -

1. Fuel Cell Fundamentals, O'Hayre, R., Cha, S. W., Colella, W., & Prinz, F. B., , John Wiley & Sons, 2016 (3rd ed).
2. Research review articles (Renewable and Sustainable Energy Reviews 146 (2021) 111180, Energy Environ. Sci., 2019, 12, 463—491, etc.

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DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Physics of Renewable Energy Conversion	3	3	0	0	0

PREREQUISITE – None

COURSE OBJECTIVE(s)

This course aims to develop a fundamental understanding of the physical principles governing renewable energy conversion by integrating concepts from thermodynamics, electromagnetism, quantum physics, optics, fluid mechanics, and electrochemistry. It enables students to analyze diverse energy conversion mechanisms from first principles, evaluate the efficiency limits and transport phenomena underlying renewable energy technologies, and gain insight into emerging physical mechanisms for sustainable energy harvesting and conversion.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit I: Thermodynamics of Energy Conversion

Global energy landscape, Forms of renewable energy, Energy and exergy, First and Second Laws of Thermodynamics, Entropy generation, Carnot efficiency, Irreversibility in energy conversion, Thermodynamic limits of renewable energy systems. **(No. of lectures: 07)**

Unit II: Radiation-Matter Interaction & Photonic Energy Conversion

Solar radiation and solar spectrum, Blackbody radiation, Optical absorption, Beer-Lambert law, Photon-material interaction, Semiconductor bandgap, Carrier generation and recombination, Photovoltaic conversion, Shockley-Queisser efficiency limit. **(No. of lectures: 08)**

Unit III: Transport Phenomena in Renewable Energy Systems

Heat transport, Charge transport, Diffusion, Fluid mechanics fundamentals, Wind formation, Lift and drag, Betz limit, Electromagnetic induction in generators, Hydroelectric energy conversion.

(No. of lectures: 08)

Unit IV: Electrochemical & Thermal Energy Conversion

Electrochemical potential, Nernst equation, Electrochemical interfaces, Charge transfer, Ion diffusion, Butler-Volmer kinetics (qualitative), Fuel cells, Electrolyzers, Thermoelectric effect, Seebeck effect, Figure of merit (ZT). **(No. of lectures: 08)**

Unit V: Emerging Energy Conversion Physics

Piezoelectric energy harvesting, Triboelectric nanogenerators, Pyroelectric energy conversion, Magnetocaloric energy conversion, Thermionic conversion, Thermophotovoltaics, Hybrid energy harvesting, Future sustainable energy technologies. **(No. of lectures: 08)**

TEXT/ REFERENCE BOOKS: -

1. David J. C. MacKay, Sustainable Energy – Without the Hot Air, UIT Cambridge Ltd., 2009. ISBN: 978-0954452933.
2. John Twidell and Tony Weir, Renewable Energy Resources, 4th Edition, Routledge, 2021. ISBN: 978-0367654597.

REFERENCE BOOKS: -

1. D. Yogi Goswami, Frank Kreith and Jan F. Kreider, Principles of Solar Engineering, 3rd Edition, CRC Press, 2015. ISBN: 978-1466563780.
2. David M. Rowe (Ed.), Thermoelectrics Handbook: Macro to Nano, CRC Press, 2005. ISBN: 978-0849322648.
3. Gilbert M. Masters, Renewable and Efficient Electric Power Systems, 2nd Edition, Wiley, 2013. ISBN: 978-1118074480

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Battery Technology and Electric Vehicles	3	3	0	0	0

PREREQUISITE – None

COURSE OBJECTIVE(s)

The objectives of this course are to:

Introduce fundamentals of electric vehicles and their architecture, develop understanding of battery technologies and performance characteristics, explain battery pack design and Battery Management Systems (BMS), familiarize students with EV powertrain and charging systems, and provide exposure to industry practices, safety standards, and emerging trends.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit I: EV Systems & Industry Overview

Evolution of EVs and market trends; Types: BEV, HEV, PHEV; EV architecture and subsystems; Performance metrics: range, efficiency, cost; EV vs IC engine vehicles; EV ecosystem (OEMs, suppliers, infrastructure). **(No. of lectures: 06)**

Unit II: Battery Technology

Basics of electrochemistry; Battery types: Lead-acid, NiMH, Lithium-ion; Li-ion chemistries (LFP, NMC, NCA); Battery parameters: energy density, power density, C-rate; Charging/discharging characteristics; Battery degradation and lifecycle; Thermal behavior; Battery selection for EVs; Introduction to solid-state batteries. **(No. of lectures: 09)**

Unit III: Battery Pack Engineering & BMS

Cell → module → pack design; Mechanical and electrical integration; Thermal management systems; Safety issues (thermal runaway, protection); BMS architecture and functions; State estimation (SoC, SoH); Cell balancing techniques; Fault detection and diagnostics; Case study of EV battery pack. **(No. of lectures: 09)**

Unit IV: EV Powertrain & Charging Systems

Electric motors (BLDC, PMSM, Induction); Motor control basics; Power electronics (inverters, converters); EV drivetrain; Regenerative braking; Charging systems (AC/DC); Charging standards (CCS, CHAdeMO, Bharat EV); Vehicle-to-Grid (V2G). **(No. of lectures: 08)**

Unit V: Industry Practices & Future Trends

EV safety standards and testing; Battery manufacturing overview; Cost and supply chain considerations; Battery recycling and second-life applications; EV maintenance and diagnostics; Emerging technologies (solid-state, wireless charging); Future trends in EVs.

(No. of lectures: 07)

TEXT/ REFERENCE BOOKS: -

1. Electric and Hybrid Vehicles: Design Fundamentals. Iqbal Husain, CRC Press (Taylor & Francis Group), 2021, ISBN: 978-0367693930.
2. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design. Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz M. Ebrahimi, CRC Press, 2018, ISBN: 978-1498761772.
3. Battery Management Systems, Volume I: Battery Modeling. Gregory L. Plett, Artech House, 2015. ISBN: 978-1630810238.
4. Battery Management Systems, Volume II: Equivalent-Circuit Methods. Gregory L. Plett, Artech House, 2015. ISBN: 978-1630810276.
5. Electric Vehicle Technology Explained. James Larminie, John Lowry, Wiley, 2012, ISBN: 978-1119942733.
6. Hybrid Electric Vehicles: Energy Management Strategies. Simona Onori, Lorenzo Serrao, Giorgio Rizzoni, Springer, 2015, ISBN: 978-1447167815.
7. Advances in Battery Technologies for Electric Vehicles. Bruno Scrosati, Jürgen Garche, Werner Tillmetz, Woodhead Publishing (Elsevier), 2015, ISBN-13: 978-1782423775.

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTX XX	Nuclear Energy Systems and Sustainable Power Generation	3	3	0	0	0

PREREQUISITE – None

COURSE OBJECTIVE(s)

To provide a comprehensive understanding of fundamental reactor physics, advanced power plant engineering, safety systems, and the integration of modern nuclear technologies into sustainable energy grids.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments,	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Module 1: Fundamentals of Nuclear Energy and Reactor Physics
Atomic structure, binding energy, radioactivity, fission and fusion, chain reactions, multiplication factor, neutron life cycle, moderation and diffusion, reactor kinetics, Types of reactors (PWR, BWR, PHWR, fast breeder), reactor components, materials, control mechanisms

(Number of Lectures: 12)

Module 2: Nuclear Power Plant Engineering and Safety Systems
Nuclear plant layout, working of Pressurized Water Reactor, Boiling Water Reactor, Pressurized Heavy Water Reactor, fuel cycle, thermal hydraulics, cooling systems, moderators, control rods,

shielding Radiation detection, safety systems, nuclear accidents, waste management and disposal, environmental protection **(Number of Lectures: 14)**

Module 3: Grid-Level Integration and Energy Applications of Nuclear Power generation, turbines and generators, grid-level integration, power system stability, hybrid systems (solar/wind with nuclear) Smart grids, economic analysis, sustainability, environmental impact, present and future technologies (SMRs, fusion, Dhruva reactor) **(Number of Lectures: 13)**

Textbooks

1. Lewis, E. E. (2008). *Fundamentals of Nuclear Reactor Physics*. Academic Press.
2. Glasstone, S., & Sesonske, A. (1994). *Nuclear Reactor Engineering: Reactor Systems Engineering*. Springer.
3. Lamarsh, J. R., & Baratta, A. J. (2022). *Introduction to Nuclear Engineering*. Pearson.
4. Shultis, J. K., & Faw, R. E. (2016). *Fundamentals of Nuclear Science and Engineering*. CRC Press / Wiley.

Reference Books

5. Todreas, N. E., & Kazimi, M. S. (2011). *Nuclear Systems Volume I: Thermal Hydraulic Fundamentals*. CRC Press.
6. Nag, P. K. (2014). *Power Plant Engineering*. McGraw Hill Education.
7. Kothari, D. P., & Nagrath, I. J. (2019). *Modern Power System Analysis*. McGraw Hill Education.

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Engineering Biomaterials	3	2	1	0	0

PREREQUISITE – Basic knowledge of biology, materials science, and engineering principles is required to comprehend the course material effectively

COURSE OBJECTIVE(s)

The objectives of this course are to:

This course aims to gain insight into biological and bioinspired materials, nanotechnology, and tissue engineering, with a focus on understanding design principles and applications in biomedical engineering.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit I:
Introduction to biological and bio inspired materials, biomimetic and bioinspired engineering, inspiration from nature, bio-inspired designs, biological engineering principles, basic building blocks found in biological materials, adhesive surfaces, gecko inspired adhesion, lotus surface, nature against nature: repellency against adhesion, bio-inspired nanostructures

(No. of lectures: 09)

Unit II:
Introduction to nanotechnology, surface engineering, bio-inspired nanoparticles, polymer-reinforced and ceramic-toughened composites, lightweight biological and bioinspired materials, bio-functional interfaces, components of a bio-functional interface and fabrication, biocompatibility

vs. bio-functionality, bio-inspired functional interfaces, characterization of bio-functional interfaces

(No. of lectures: 09)

Unit III

Introduction to tissue engineering, bio-inspired scaffolds for tissue engineering, self-healing and adaptive materials, bio-sensing, components of a biosensor, nature-inspired sensing, drug delivery, smart targeted drug delivery, micro and nano robots, lab-on-chip devices, examples of bio-inspired lab on chip devices, examples of organs on chips, modelling diseases on a chip

(No. of lectures: 09)

TEXT BOOKS:

1. Bio and bioinspired nanomaterials: Daniel Ruiz-Molina, F. Novio, C. Roscini (WileyVCH).
2. Bioinspired approaches for human-centric technologies: Roberto Cingolani (Springer).

REFERENCE BOOKS:

1. Biological materials science: M. A. Meyers and P-Y. Chen (Cambridge).
2. Biomimetics, biologically inspired technologies: Yoseph Bar-Cohen (Taylor and Francis).
3. Materials design inspired by nature: P. Fratzl, J. W. C. Dunlop and R. Weinkamer (RSC).
4. Nanobiotechnology: Oded Shoseyov and Ilan levy (Human Press)

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Organic Electronics Material and Devices	3	2	1	0	0

PREREQUISITE – Basic knowledge of semiconductor physics

COURSE OBJECTIVE(s)

The objectives of this course are to:

The course Organic Electronics – Materials and Devices aims to provide students with a fundamental understanding of organic semiconducting materials and their role in electronic devices. It covers the structure, properties, and charge transport mechanisms of organic materials, along with common fabrication and characterization techniques.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit I:

Introduction to Organic Electronics: scope, advantages, and limitations, Electronic structure of organic materials: π-conjugation, HOMO–LUMO levels, Charge transport mechanisms: hopping and band transport, Optical properties: absorption, photoluminescence, excitons, Types of organic semiconductors: small molecules, polymers, oligomers, Conducting polymers (e.g., Polyaniline, Polypyrrole, Polythiophene), Doping mechanisms in organic semiconductors, Thin film fabrication techniques: spin coating, printing, evaporation, Structure–property relationships and morphology effects **(No. of lectures: 09)**

Unit II:

Device physics: charge injection, transport, recombination, Organic Light Emitting Diodes, (OLEDs): structure, working principles, Organic Photovoltaics (OPVs): exciton dissociation, bulk heterojunctions, Organic Field Effect Transistors (OFETs): device design and operation, Electrode materials and interface engineering, Device fabrication and patterning techniques, Performance parameters: efficiency, mobility, stability, Degradation mechanisms and lifetime issues, Flexible and wearable organic electronics **(No. of lectures: 09)**

Unit III:

Introduction to polymer-based sensors: principles and classifications, Conducting polymer sensors using Polyaniline, Polypyrrole, PEDOT:PSS, Sensing mechanisms: chemiresistive, capacitive, electrochemical, Gas sensors: detection of NH_3, NO_2, VOCs using polymer composites, Biosensors: enzyme-based and affinity-based detection, Polymer nanocomposites for sensing (polymer–metal oxide hybrids), Flexible and wearable sensors, Fabrication techniques: printing, coating, nanostructuring, Performance parameters: sensitivity, selectivity, response time, stability, Applications: environmental monitoring, healthcare diagnostics, Emerging trends: self-powered sensors, smart sensing systems **(No. of lectures: 09)**

TEXT BOOKS:

1. Organic Electronics Materials and Devices: Shuichiro Ogawa (Springer)
2. Organic Electronics for Electrochromic Materials and Devices: Hong Meng (Wiley)
3. Organic Electronics, Foundations to Applications: Stephen R. Forrest (Oxford).

REFERENCE BOOKS

1. Polymeric Sensors and Actuators: Johannes Karl Fink (Wiley)
2. Sensors: An Introductory Course: Kourosh Kalantar-zadeh (Springer)

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTX XX	Biomaterials and Tissue Engineering	3	2	1	0	0

PREREQUISITE – Basic knowledge of material science

COURSE OBJECTIVE(s)

The course Biomaterials and Tissue Engineering aim to provide students with a fundamental understanding of the design, properties, and applications of biomaterials in biological systems, along with the core principles of Tissue Engineering. It focuses on the interactions between materials and living tissues, scaffold-based regeneration strategies, and the role of cells and signaling in tissue repair.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit I:

Introduction to biomaterials: definition, history, and classification, Types of biomaterials: metals, ceramics, polymers, and composites, Structure–property relationships in biomaterials, Concept of Biocompatibility, biofunctionality, and biodegradability, Host response to biomaterials: inflammation, immune response, toxicity, Surface properties: wettability, roughness, surface energy, and protein adsorption, Biomaterial–tissue interactions and interfacial phenomena, Mechanical properties: strength, elasticity, fatigue, and wear, Nanostructured biomaterials and nanoparticle–tissue interactions, Bio-inspired surfaces for enhanced cell adhesion and anti-fouling behavior

(No. of lectures: 09)

Unit II:

Introduction to Tissue Engineering and regenerative medicine, Key components: cells, scaffolds, and signaling molecules, Types of cells: stem cells, progenitor cells, primary cells, Extracellular matrix (ECM): composition and role in tissue regeneration, Scaffold design criteria: porosity, biodegradability, mechanical integrity, Scaffold materials: natural polymers, synthetic polymers, hybrid systems, Fabrication techniques: electrospinning, 3D printing, freeze-drying, solvent casting, Nanocomposite scaffolds (polymer–nanoparticle hybrids), Smart scaffolds with stimuli-responsive behavior **(No. of lectures: 09)**

Unit III:

Regenerative medicine and engineered tissues, Applications: bone, cartilage, skin, and cardiovascular tissue engineering, Drug delivery systems: controlled and targeted delivery, Nanobiomaterials for drug delivery and diagnostics, Bioactive and smart biomaterials (self-healing, stimuli-responsive systems), Biosensors in biomedical applications: principles and components, Integration of Nanotechnology in healthcare, Bio-functional interfaces and surface engineering for implants, 3D bioprinting and organ fabrication, Implantable biosensors and real-time physiological monitoring, Nanomaterial-based sensing platforms for disease detection

(No. of lectures: 09)

TEXT/ REFERENCE BOOKS:

1. Biomaterials and Tissue Engineering: Christophe Egles, Oguzhan Gunduz, Román A Pérez (Springer)
2. Tissue Engineering, Clemens van Blitterswijk (Academic Press)
3. Biomaterials for Neural Tissue Engineering: Oguzhan Gunduz, Cem Bulent Ustundag , Mustafa Sengor (Elsevier)

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Wearable Sensors for Healthcare	3	2	1	0	0

PREREQUISITE – N/A

COURSE OBJECTIVE(s)

The objectives of this course are to:

The course aims to develop a fundamental understanding of Wearable Sensors and their role in modern healthcare systems. It focuses on the design, materials, and fabrication of flexible and stretchable sensing platforms, along with the integration of electronics, data acquisition, and communication technologies.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit I:

Introduction to wearable healthcare technologies and their significance, Basics of Wearable Sensors, Physiological parameters: heart rate, temperature, respiration, motion, biochemical markers, Types of sensors: physical, chemical, and biosensors, Materials for wearable sensors: flexible polymers, textiles, nanomaterials, Conductive materials: graphene, carbon nanotubes, metallic nanowires, Flexible and stretchable electronics: design principles, Substrates and encapsulation materials for wearables, Skin–sensor interface and ergonomics, Signal acquisition and noise considerations

(No. of lectures: 09)

Unit II:

Sensor design principles and device architecture, Fabrication techniques: printing, coating, lithography, laser patterning, Flexible and stretchable sensor fabrication methods, Integration with electronics: circuits, microcontrollers, Power sources: batteries, energy harvesting (piezoelectric, triboelectric), Wireless communication: Bluetooth, NFC, IoT integration, Data acquisition systems and embedded electronics, Packaging and durability of wearable devices, Calibration, sensitivity, selectivity, and response time, Reliability and long-term stability **(No. of lectures: 09)**

Unit III:
Wearable sensors for vital sign monitoring, Biochemical sensing: sweat, saliva, glucose monitoring, Motion and activity tracking, Smart textiles and e-skin technologies, Implantable vs wearable sensors, Integration with Nanotechnology for enhanced performance, Biosensing platforms and real-time monitoring, Data analytics, AI, and machine learning in healthcare monitoring, Telemedicine and remote healthcare systems, Challenges: biocompatibility, data security, regulatory issues, Emerging trends: self-powered sensors, soft robotics, digital health

(No. of lectures: 09)

TEXTBOOKS:

1. Wearable Electronics Sensors: Subhas C. Mukhopadhyay (Springer)
2. Wearable Physical Chemical and Biological Sensors: Eden Morales-Narvaez, Can Dincer (Elsevier)

REFERENCE BOOKS:
1. Portable and Wearable Sensing Systems: Qingjun Liu (Wiley)
2. Wearable Sensors: Fundamentals, Implementation and Applications: Edward Sazonov (Academic Press)

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Nano-engineering of Soft Materials	3	2	1	0	0

PREREQUISITE
Basic understanding of soft materials

COURSE OBJECTIVE(s)

The purpose of this course is to discuss fundamentals and the types of soft (polymer, organic, and biological) nanomaterials and corresponding hybrid nanostructures that have been discovered and synthesized for prospective applications in nanotechnology. It will also help to learn how to create nano patterns on Soft Surfaces, particularly on Polymer films by various techniques such as lithography and finally about Atomic Force Microscopy (techniques widely used for polymer based nanostructures)

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
j)	Internal assessment (based on assignments, quizzes, and attendance)	20%
k)	Mid-term examination	30%
l)	End Semester Examination	50%

COURSE CONTENTS

Unit:1
Introduction to soft materials, Chemical composition/structures, polymers/biopolymers, Surface and interfacial organization, Colloidal assemblies, Nanoparticles, Molecular films and Polymer Brushe, Layer-by-layer assemblies, block copolymers, Responsive nanomaterials, self-healing, Hybrid nanoparticles, Soft membranes, Soft nanocomposites **(No. of Lectures: 09)**

Unit:2

Polymer blends and its composites, Polymer recycling, Physics of polymer degradation, recycling methods, and the circular economy, Polymers in packaging, electronics, and medicine, Polymer extrusion, injection molding, and blow molding; Biodegradable polymers, Polymer-based nanomaterials, nanofibers, and nanocomposites, Polymer based drug delivery systems, Controlled release of drugs from polymer matrices, polymer-based hydrogels **(No. of Lectures: 09)**

Unit:3
Different Nano Fabrication Regimes including self-assembly, Lithography, Discussion on Photo Lithography: Photo Resists, Spin Coating, Exposure, Development, Soft Lithography: Introduction, Different Soft Lithography Techniques, Basic Concepts of Atomic Force Microscopy Different Imaging Modes of Atomic Force Microscopy **(No. of Lectures: 09)**

TEXTBOOKS:

1. Fundamentals of Polymer Physics by M. Rubinstein and R. P. Colby (Cambridge University Press)
2. Creating Micro and Nano Patterns on Polymeric Materials, A del Campo and E. Arzt (Wiley)
3. Processing of Polymer-based Nanocomposites, Suprakas Sinha Ray (Springer)

REFERENCE BOOKS:
1. Atomic Force Microscopy Understanding Basic Modes And Advanced Applications Haugstad G (Wiley)
2. Nanofabrication: Techniques and Principles; Maria Stepanova & Steven Dew (Springer)

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Soft Materials	3	2	1	0	0

PREREQUISITE – Basic knowledge of materials science, particularly in polymers and colloidal systems, is recommended.

COURSE OBJECTIVE(s)

This course provides an introduction to the fundamentals of various soft matters like polymers, biopolymers, colloids and gels. Soft matter and applications

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Unit 1:

Introduction to soft materials and soft matter, generic aspects of soft materials, classification in terms of their thermal, mechanical, and often unusual physical properties. examples of soft systems: are polymers, foams, granular media, colloids, liquid crystals, micelles, vesicles and biological membranes, polymers in solution, gels, emulsions, and foams **(No. of lectures- 9)**

Unit 2:

Shape and directional interaction, crystal structure, effect on maximum packing density, anisotropic and directionally interacting colloids, complex shape particles, deforming and stretching, soft lithography and micro molding. Building blocks for self-assembled soft materials, learning from small molecules, block copolymers, phase diagram, experimental methods for study of block copolymers. **(No. of lectures- 12)**

Unit 3:
Soft matter in nature. Applications of soft matter: Soft matter in materials science, biology, and medicine; active matter **(No. of lectures- 6)**

TEXT/ REFERENCE BOOKS:

1. Fundamentals of soft matter science: Linda S. Hirst (CRC).
2. Introduction to soft matter: Ian W. Hamle (Wiley).

REFERENCE BOOKS:

1. Polymer surfaces and interfaces: M Stamm (Springer).
2. Soft condensed matter: R.A.L. Jones (Oxford)
3. Soft materials: structure and dynamics: John R. Dutcher, A. G. Marangoni (CRC).

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHT XXX	Quantum Communication	**3**	**2**	**1**	**0**	**0**

PREREQUISITE – Basic Quantum Mechanics and Optics courses

COURSE OBJECTIVE(s)

The course aims to provide a foundational understanding of polarization optics, advanced photodetection, and classical information theory. Students will master key quantum communication protocols and analyze hardware implementations across fiber, free-space, and satellite networks for the future quantum internet.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
1.	Internal assessment (based upon assignments, quizzes and attendance)	20%
2.	Mid-term examination	30%
3.	End Semester Examination	50%

COURSE CONTENTS

Module 1:

Basics of Polarization optics, Quarter and half-wave plates, Polarizing beam splitters, Basics of linear and square-law detectors, Quadrature amplitude modulation, Heterodyne and Homodyne demodulation and linear detectors, Intensity measurements and square law detectors, Photomultipliers, Avalanche Photo diodes etc. **(No. of lectures- 9)**

Module II:

Digital communication – information theory (basics), Information entropy, Noiseless channel encoding, Noisy channel encoding, No cloning theorem, Quantum Memories, Quantum repeaters, Entanglement and Bell Theorems, Bell Measurements and Tests. **(No. of lectures- 7)**

Module III:

Quantum Teleportation protocol, Quantum Dense coding, Introduction to Quantum Key Distribution protocols, Quantum Networks and Quantum Internet. Survey of Hardware implementations, Free space communications, Satellite based communications, Fibre optics-based communications. **(No. of lectures- 10)**

TEXT/ REFERENCE BOOKS: -

1. Quantum computation and quantum information – Nielsen and Chuang Cambridge University Press, Cambridge (2010)
2. A Pathak, Elements of Quantum Computation and Quantum Communication, Boca Raton, CRC Press (2015).

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHPXXX	Quantum Technology Lab	3	0	0	6	0

COURSE CONTENTS

Note: Students need to perform minimum 8 selected experiments

1. To measure the de Broglie wavelength of the electrons.
2. To study the interference of polarized beams using a Mach-Zehnder-interferometer
3. To study the Single-Photon Interference using Quantum Eraser.
4. To measure sub-shot-noise phase sensitivity in an optical interferometer using squeezed states of light.
5. Quantum Sensing of Magnetic Fields using Nitrogen-Vacancy (NV) Centers in Diamond.
6. To calculate and validate the quality factor of series and parallel RLC circuits using theoretical and experimental data.
7. To observe and quantify the thermal noise generated by resistors at varying temperatures using a spectrum analyser.
8. To study and compare the principles of homodyne and heterodyne signal demodulation techniques.
9. To perform data acquisition and digitization using Analog-to-Digital Converters (ADCs), and to analyse the effects of under-sampling (aliasing), oversampling, and quantization noise on signal reconstruction.
10. To deposit a high-quality thin film of $SrTiO_3$ or $BaTiO_3$ onto a single-crystal substrate using Pulsed Laser Deposition, and to optimize the film thickness by controlling the laser pulse count and repetition rate.
11. To synthesize large-area, high-quality monolayer graphene on a catalytic copper foil substrate via methane decomposition in a thermal CVD furnace.
12. To identify and characterize the layer count, structural defects, and doping levels of exfoliated 2D materials using Raman effect.
13. To fabricate a functional quantum electronic device by patterning source, drain, and gate contacts onto a CVD-grown 2D material using optical lithography and metal evaporation techniques.
14. To study the time-resolved absorption of quantum dots and graphene-based materials.
15. To synthesize and evaluate the electrochemical performance of quantum dot/2D material-based heterostructures as electrodes for high-capacity lithium-ion batteries and supercapacitors.

16. To evaluate the surface roughness, grain size distribution, and step-terrace morphology of a thin film or a transferred 2D material flake using AFM.
17. To simulate a single qubit on the Bloch sphere and visualize the state transformations under the action of Pauli and Hadamard gates using Qiskit.
18. To compute and analyse the electronic band structure of 2D materials using open-source Density Functional Theory (DFT) software.
19. To design, execute, and validate a quantum entanglement circuit on a real cloud-based IBM Quantum processor.
20. To simulate a 2D ferromagnetic Ising model and study its phase transitions using the Metropolis-Hastings algorithm.
21. To solve the time-independent Schrödinger equation for non-trivial potentials using Python-based numerical eigenvalue solvers.
22. To map out the current-voltage characteristics of a superconducting Josephson junction to observe the DC Josephson effect and AC Josephson effect.
23. Measurement & study characteristics of a single photon detection system using Quantum Simulations.

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHPXXX	Quantum Sensing and Metrology	3	3	0	0	0

PREREQUISITE – Basic Quantum Mechanics

COURSE OBJECTIVE(s)

The course aims to provide a foundational understanding of classical and quantum measurement theories, including Cramer-Rao bounds and Fisher information, quantum states of light, tomography, and advanced sensing applications like gravimetry and magnetometry using atomic and spin-based systems for high-precision technologies.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
4.	Internal assessment (based upon assignments, quizzes and attendance)	20%
5.	Mid-term examination	30%
6.	End Semester Examination	50%

COURSE CONTENTS

Module 1: Classical Foundations and Sensitivity Limits

Classical sensing: Photo detection, Classical noise: Johnson Noise, Telegraph noise, flicker or 1/f noise, Sensitivity of classical measurements, Classical Fisher information, Cramer-Rao bounds, Information theory basics. **(No. of lectures- 7)**

Module II: Quantum Measurement Theory and States of Light

Quantum measurements: Projective/orthogonal and Approximate/non-orthogonal measurements, Weak continuous measurements, Error-disturbance relations, Standard quantum limits, Quantum non-demolition measurements, States of light: Fock states, Coherent states, and Squeezed states, Tomography, Wigner quasi-probability distribution, P-distribution, and Husimi Q function.

(No. of lectures- 11)

Module III: Quantum Detection and Sensing Applications

Quantum photo detection: Square-law detectors, Intensity measurements, and Photo-detection, Linear Detectors and Quadrature Measurements, Quantum Cramer-Rao bounds, Single photon-based sensing applications, Entanglement based sensing applications, Atomic state-based sensing, Solid-state spin-based sensing applications: Metrology, Gravimetry and Magnetometry.

(No. of lectures- 8)

TEXT/ REFERENCE BOOKS: -

1. Quantum Measurement and Control, Howard Wiseman and David Milburn, Cambridge University Press (2014)
2. Quantum Measurement, Vladimir Braginsky and Farid Ya Khalili, Cambridge University Press (1995)
3. Quantum Information Science – Manenti R., Motta M., 1st Edition, Oxford University Press (2023)

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Quantum Materials and Devices	3	3	0	0	0

PREREQUISITE – Basic Quantum Mechanics and Condensed Matter Physics

COURSE OBJECTIVE(s)

The course aims to provide students with a comprehensive understanding of electronic band theory, superconductivity, and magnetism. Students will explore 2D materials like graphene and TMDCs, master the basics of topological phases, and learn practical material growth techniques, including MBE, CVD, and lithography for quantum technology applications.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
m)	Internal assessment (based upon assignments, quizzes and attendance)	20%
n)	Mid-term examination	30%
o)	End Semester Examination	50%

COURSE CONTENTS

Module 1: Basics of Material's Physics

Review of band theory basics: Metals, Semiconductors, and Insulators, Band structure of solids, Correlated systems, Review of magnetism: Para and ferro magnetism basics, Magnetic measurements, Hall effect, and Magnetoresistance, Faraday and Kerr effects. Survey of semiconducting and superconducting devices for quantum technologies (electronic, quantum optical devices and principle of operation). **(No. of lectures- 7)**

Module II: Superconductivity and Topological Phases

Superconductivity: BCS theory and Ginzburg Landau theory, Josephson Effect: AC and DC Josephson effects, Survey of superconducting devices for quantum technologies, Basics of Topology, Geometric phases: Berry Phase, Aharonov Bohm effect, Topological phases of matter.

(No. of lectures- 8)

Module III: Low-Dimensional Materials and Growth Techniques

2D materials: Graphene and its properties (single and few layers), Transition Metal Dichalcogenides: Electronic and Optical Properties, Survey of material growth techniques: Molecular beam epitaxy (MBE), Chemical vapor deposition (CVD) and MOVPE, Pulsed laser deposition (PLD), Crystal growth techniques. Materials to devices: lithography for device fabrication. **(no. of lectures- 11)**

TEXT/ REFERENCE BOOKS: -

4. Condensed Matter Physics, M P Marder, 2nd Edition, John Wiley and Sons (2010)
5. Introduction to Superconductivity, Michael Tinkham, standard ed., Medtech (2017)
6. Topological Phases of Matter, Roderich Moessner, Joel E. Moore, 1st Edition Cambridge University Press (2021)

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHT XXX	**Quantum Optics**	**3**	**2**	**1**	**0**	**0**

PREREQUISITE – Basic Quantum Mechanics and Electrodynamics

COURSE OBJECTIVE(s)

The course aims to provide a rigorous understanding of electromagnetic field quantization and optical coherence. Students will master phase-space representations, analyze light-matter interactions via the Jaynes-Cummings model to model decoherence for advanced photonic applications.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
1.	Internal assessment (based upon assignments, quizzes and attendance)	20%
2.	Mid-term examination	30%
3.	End Semester Examination	50%

COURSE CONTENTS

Module I: Field Quantization and Optical Coherence

Electromagnetic field quantization, Number, coherent, and squeezed states, Hanbury-Brown and Twiss experiments (Photon bunching and anti-bunching), Hong-Ou-Mandel interference, Young's double slit experiment and first order coherence, Coherence functions of arbitrary order, Operator ordering (Normal, symmetric, and anti-normal), Interferometry **(No. of lectures- 13)**

Module II: Phase-Space Representations and Non-Classicality

Wigner distribution, P-function and the notion of non-classicality with some examples of nonclassical states like squeezed states and their applications, Husimi Q function

(No. of lectures- 6)

Module III: Light-Matter Interaction and Open Quantum Systems

Classical model of light-matter interaction, Semi-classical model of light-matter interaction, Quantum light-matter interaction, Rabi Model, Jaynes-Cummings model, Fermi's golden rule, Born-Markov Lindblad Master Equation. **(No. of lectures- 7)**

TEXT BOOKS: -

1. Introductory Quantum Optics, Christopher Gerry and Peter Knight, Cambridge University Press (2004)
2. Quantum Optics, D. F. Walls, Gerard J. Milburn, 2^{nd} Edition, Springer (2008)

REFERENCE BOOKS: -

3. Quantum Optics: An introduction, Mark Fox, Oxford University Publishers (2006)
4. Quantum Optics for Beginners, Z. Ficek and M. R. Wahiddin, 1^{st} edition, Jenny Stanford Publishing (2014)

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Foundation of Quantum Computation	3	3	0	0	0

PREREQUISITE – None

COURSE OBJECTIVE(s)

- To develop a strong mathematical foundation required for quantum computing, including vector spaces, linear algebra, and Hilbert space formalism.
- To understand the fundamental principles of quantum mechanics relevant to computation, such as qubits, superposition, entanglement, and measurement.
- To introduce quantum operators, gates, and circuit models used in quantum information processing.
- To familiarize students with multi-qubit systems, tensor products, and quantum correlations like entanglement.
- To provide basic knowledge of quantum algorithms and their physical interpretation.
- To enable students to simulate quantum systems using modern tools like Qiskit.
- To understand the impact of noise, decoherence, and errors in practical quantum computing systems.
- To build a foundation for advanced study or research in quantum computing and quantum information science.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Module I: Mathematical Foundation
Vector spaces and complex Hilbert spaces, Dirac notation (bra-ket formalism), Inner products and norms, Linear operators and matrix representation, Eigenvalues and eigenvectors, Unitary and Hermitian operators, Tensor products and composite systems, Basic probability theory and entropy (introductory level), Matrix decomposition. **(No. of lectures: 11)**

Module II: Physics of Quantum Systems
Qubits and state representation, Measurement postulate and probabilities, Bloch sphere representation, Multi-qubit systems and tensor structure, Quantum entanglement and Bell states, Quantum gates (Pauli, Hadamard, Phase, CNOT), Quantum circuits and unitary evolution, Density matrix formalism (basic introduction), Interaction with environment and decoherence (introductory) **(No. of lectures: 13)**

Module III: Quantum Computing using Qiskit
Quantum circuit model, Circuit composition and measurement, Basic quantum algorithms (Deutsch, teleportation, superdense coding), Introduction to Qiskit, Building and simulating quantum circuits, Visualization of results, Variational Quantum Eigensolver (introductory concept), Noise and error in quantum systems (basic understanding) **(No. of lectures: 14)**

Text books

1. Nielsen, M. A., & Chuang, I. L. (2010). *Quantum computation and quantum information* (10th anniversary ed.). Cambridge University Press.
2. Hidary, J. D. (2019). *Quantum computing: An applied approach*. Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-030-23922-0
3. Griffiths, D. J., & Schroeter, D. F. (2018). *Introduction to quantum mechanics* (3rd ed.). Cambridge University Press.
4. Zettili, N. (2009). *Quantum mechanics: Concepts and applications* (2nd ed.). John Wiley & Sons.

Reference Books

1. Javadi-Abhari, A., Treinish, M., Krsulich, K., Wood, C. J., Lishman, J., Gacon, J., Martiel, S., Nation, P., Bishop, L. S., Cross, A. W., Johnson, B. R., & Gambetta, J. M. (2024). *Quantum computing with Qiskit*. arXiv:2405.08810. https://doi.org/10.48550/arXiv.2405.08810
2. IBM Quantum. (2024). *IBM Quantum documentation*. IBM Corporation. https://docs.quantum.ibm.com
3. Bernhardt, C. (2019). *Quantum computing for everyone*. The MIT Press.

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Quantum Computing for Physical Systems	3	2	1	0	0

PREREQUISITE – None

COURSE OBJECTIVE(s)

- To train the UG students about Quantum Computing and Simulations, and compare the results with the classical simulations.
- Bridge the gap between theoretical quantum mechanics and the mathematical framework of quantum computing.
- Implement core quantum algorithms and Hamiltonian-mapping techniques for physical-system simulations.
- Gain hands-on expertise in using Qiskit to solve variational problems (VQE/QAOA) and model real-world problems of Physical systems and modern physics applications.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Module 1: Foundations of Quantum Computing in Physics

Introduction to quantum computing and limitations of classical computing, Four Postulates of Quantum mechanics, Hilbert Spaces, State Vectors and Dirac notation, Density Matrix, Operators and Matrices: Hermitian, Unitary and Projection operators, Composite systems (Tensor products), Multiparticle Physical system, State in Quantum computing, Single Qubit Gates: Pauli-X, Y, Z, Hadamard (H) and Phase gates (S, T), Multi-Qubit Gates: Controlled-NOT (CNOT) and Controlled-U gates, Universal Quantum Gates, Design and analysis of basic quantum circuits and the concept of "Quantum Parallelism" in solving the combinatorial optimization problem in Physics.

(No. of lectures: 14)

Module 2: Quantum Algorithms & Tools for Quantum Simulations

SparsePauliOp: Decomposing complex Hamiltonians into weighted sums of Pauli strings (X, Y, Z, I), Fermionic-to-Qubit Mapping: The necessity of mapping, Jordan-Wigner (JW) Mapping, Bravyi-Kitaev (BK) Mapping, Parity Mapping, Binary mapping, Initial Quantum algorithms: Quantum parallelism, Deutsch's algorithm, The Deutsch–Jozsa algorithm, Quantum Phase Estimation (QPE), Introduction to Variational Algorithms (eg. VQE, QAOA etc), Hamiltonian Simulation Theory: Trotter-Suzuki Decomposition: Approximating e^{-iHt} for non-commuting operators.

(No. of lectures: 14)

Module 3: Qiskit Implementation for Physics Problems

Gates and simple & complex circuits for Physical systems, Variational Algorithms in Practice: VQE (Variational Quantum Eigensolver): Implementation using Ansatz circuits (like RealAmplitudes or EfficientSU2), Optimising parameters using classical routines (COBYLA, SLSQP), Dynamics and Evolution, using qiskit_algorithms. QUBO, QAOA for various applications, Simulating real-world conditions using FakeBackend. Trotterization using Pauli Evolution Gate.

(No. of lectures: 11)

Textbooks

1. Nielsen, M. A., & Chuang, I. L. (2010). *Quantum Computation and Quantum Information* (10th Anniversary ed.). Cambridge University Press.
2. Zettili, N. (2009). *Quantum mechanics: Concepts and applications* (2nd ed.). John Wiley & Sons.
3. Kaye, P., Laflamme, R., and Mosca, M. (2007). *An Introduction to Quantum Computing*. Oxford University Press.

References

1. Asfaw, A., Bello, L., Müller, M., Marquardt, F., & Siraichi, L. (2022). *Qiskit Pocket Guide: Swift Machine Learning with Quantum Computing*. O'Reilly Media.
2. Bernhardt, C. (2019). *Quantum Computing for Everyone*. MIT Press.
3. Combarro, E. F., & González-Castillo, S. (2023). *A Practical Guide to Quantum Computing with Qiskit*. Packt Publishing.
4. Griffiths, D. J., & Schroeter, D. F. (2018). *Introduction to Quantum Mechanics* (3rd ed.). Cambridge University Press.
5. Hidary, J. D. (2019). *Quantum Computing: An Applied Approach*. Springer.
6. IBM Quantum. (2026). *Qiskit Documentation*. https://docs.quantum.ibm.com/

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Astronomy and Astrophysics	3	3	0	0	0

COURSE OBJECTIVES:

1. To impart fundamentals and application based knowledge education to Masters' students of Physics, primarily in areas: Astronomy & Astrophysics.
2. To enable students to solve problems independently based on these concepts.
3. To equip students with the basics of the field so that they may pursue it as a career.
4. To have periodic evaluation of students through class work sessional / mid-term and end term examinations.

PREREQUISITES:

1. Basic Mathematics (+2 Level).
2. Basic Thermodynamics & Classical Mechanics (Graduation Level).
3. Basic Quantum Mechanics. (Graduation Level).

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
1.	Internal assessment (based upon assignments, quizzes and attendance)	20%
2.	Mid-term examination	30%
3.	End Semester Examination	50%

COURSE CONTENTS

Astronomy - Coordinate Systems For Celestial Objects & Their Interrelations, Cardinal Points In The Sky, Time Measurements in Astronomy, Proper & Peculiar Motion of Stars, Parallaxes, Photometry, Magnitude System, Distance Modulus, Color Indices. **(No. of lectures- 15)**

Astrophysics- - Stellar spectra and Structure, Ionization Equation & Elemental Abundances, H-R Diagram, Stellar Evolution, Nucleosynthesis and Formation of Elements, Variable stars, Compact stars, Star clusters and Binary stars; **(No. of lectures- 11)**

AstroLab- Astronomy softwares. Descriptive Astronomy & Planetary motions (Stellarium). Distance & Age of Open Cluster (Topcat), Double line Binary Star (Splatview). Handling of Photometers, CCD imaging devices & Telescopes. Astro-Python (Astropy & Sunpy) – Measurement of Solar Differential Rotation. Spotting GW events in the sky (Aladin)

(No. of Lab-sessions- 13)

TEXT BOOKS/ REFERENCE BOOKS: -

1. An Introduction to Modern Astrophysics : by B. W. Carrol & D. A. Ostlie (Addison Wesley)
2. Textbook of Astronomy & Atrophysics with Elements of Cosmology : V. B. Bhatia (Narosa)
3. An introduction to astronomy & cosmology: by Ian Morrisson (John Wiley)
4. An Introduction to Astrophysics, B. Basu, T. Chattopadhyay, S.N. Biswas

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Advanced Quantum Mechanics for Engineers	3	3	0	0	0

PREREQUISITE
Quantum Mechanics

COURSE OBJECTIVE(s)
This is an advanced level course in Quantum mechanics which objects to teach about various approximation methods in physics to calculate the approximate values of energy for various systems. Students will be able to learn the methods to find transition probability for absorption and emission. The objective is to give them ideas about laboratory and center of mass frame and study the scattering phenomena in both these frames. This course will let students appreciate the beauty of quantum mechanics in the form of the Born approximation and its validity. Students will be able to study the wave functions of system of identical particles.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Module- I
Time Independent perturbation theory, First order correction to the energy, First order correction to the wave function, Second order correction to the energy, Second order correction to the wave function, Example of stationary state perturbation theory, Example of Time-Independent perturbation theory (non-degenerate case), Variational principle, Example of variational principle, WKB method. **(No. of lectures- 10)**

Module- II
Time dependent perturbation theory, first order perturbative expression for the transition amplitude and probability, harmonic perturbations, transition probability under constant perturbation, Fermi's golden rule. **(No. of lectures-10)**

Module-III

Interaction of radiation with matter, spontaneous emission, absorption, induced emission, dipole transitions, selection rules, identical particles, Pauli exclusion principle. **(No. of lectures- 10)**

Module-IV

Non-relativistic scattering, solution of scattering problem by the method of Green's function, Born approximation and its validity for scattering problems, partial wave analysis, optical theorem.

(No. of lectures-9)

TEXT BOOKS/ REFERENCE BOOKS: -

1. L. I. Schiff, Quantum Mechanics, 3rd edition, (McGraw Hill Book Co., New York 1968).
2. E. Merzbacher, Quantum Mechanics, 3rd edition, (John Wiley & Sons, Inc1997)
3. Quantum Mechanics, Nouredine Zettili, Wiley
4. A. Ghatak & S. Lokanathan, Quantum Mechanics: Theory and Applications, 5th Edition, (Macmillan India, 2004)
5. Quantum Mechanics A Modern Approach: A. Das and A. C. Milissiones (CRC Press).
6. Advanced Quantum Mechanics: J.J. Sakurai (Addison Wesley Publishing Co.)
7. Principles of Quantum Mechanics: R. Shankar.
8. Introduction to Quantum Mechanics: David J. Griffiths (Pearson Education).
9. Quantum Mechanics by Mathews and Venkatesan (McGraw Hill)

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DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Introduction to General Relativity	3	3	0	0	0

PREREQUISITE
Quantum Mechanics

COURSE OBJECTIVE(s)
After successfully completing this course student should be able to understand the equivalence principle and description of gravity as geometry. In addition, student should be able to understand applications of general relativity in astophysics and cosmology.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Module 1
Geometrical approach to special theory of relativity: Inertial observers, Minkowski metric, spacetime diagrams, light cone, invariant hyperbolae, length contraction and time dilation using spacetime diagrams, Lorentz transformations, Four-vector formulation of special relativity, Tensors and tensor manipulation, Energy and momentum in special relativity and energy-momentum tensor for perfect fluid. **(No. of lectures- 9)**

Module 2
Curved Spacetime: manifolds and coordinates, curves and surfaces, coordinate transformations, vector and tensor fields, metric tensor and tensor densities, partial derivative of a tensor, the affine connection and covariant derivative, parallel transport and geodesics, Riemann curvature tensor and its properties, Ricci tensor and scalar, Weyl tensor. geodesic deviation. **(No. of lectures-12)**

Module 3
Equivalence principle, principle of general covariance, gravity as a curvature of spacetime, geodesics as trajectories under the influence of gravitational field, Einstein's field equation and its properties. **(No. of lectures- 4)**

Module 4
Schwarzchild solutions of Einstein's field equation, motion of a particle in Schwarzchild metric, experimental tests of general relativity: precession of the perihelion, bending of light, correction to GPS satellites due to general and special relativity, singularities, horizons, black holes.
(No. of lectures- 7)

Module 5
Gravitational radiation, weak-field approximation, gauge transformations, plane gravitational waves, generation of gravitational waves, quadrupole radiation, detection of gravitational waves.
(No. of lectures-7)

REFERENCES

Text Books:

1. A First Course in General Relativity: Bernard Schutz (Cambridge University Press).
2. Introducing Einstein's Relativity: Ray D'Inverno (Oxford University Press)
3. Gravity: An introduction to Einstein's General Relativity; J. B. Hartle (Pearson India Education).

Reference Books:.)

1. Spacetime and Geometry: An Introduction to General Relativity, Sean M. Carroll (Pearson Indian Education)
2. General Relativity: R. M. Wald (University of Chicago Press).
3. Gravitation and Cosmology: S. Weinberg (Wiley India PVT. LTD).
4. Classical Theory of Fields: L. D. Landau and E. M. Lifshitz (CBSP

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Group Theory and Applications	3	3	0	0	0

PREREQUISITES:
1. Basic Nuclear Physics (Graduation Level).
2. Basic Quantum Mechanics (Graduation Level).
3. Basic Spectroscopy (Graduation Level).

COURSE OBJECTIVES

- To introduce the fundamental concepts of group theory and algebraic structures.
- To develop skills in using symmetry groups for physical systems.
- To explore representation theory and its applications in quantum mechanics and solid-state physics.
- To apply group theory to engineering problems in materials science, crystallography, and spectroscopy.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
1.	Internal assessment (based upon assignments, quizzes and attendance)	20%
2.	Mid-term examination	30%
3.	End Semester Examination	50%

COURSE CONTENTS

Unit 1

Introduction to Groups, Sets and mappings; Binary operations; Groups, subgroups, and cyclic groups; Lagrange's theorem; Cosets and normal subgroups; Quotient groups.

(No. of lectures- 6)

Unit 2
Group Structure and Permutation Groups, Symmetric and alternating groups; Dihedral groups; Conjugacy classes; Centre of a group; Group actions. **(No. of lectures- 6)**

Unit 3
Representation Theory, Representations of groups; Matrix representations; Reducible and irreducible representations; Schur's lemma; Orthogonality theorems. **(No. of lectures- 6)**

Unit 4
Character Theory, Characters of representations; Orthogonality of characters; Character tables; Burnside's lemma for counting orbits. **(No. of lectures- 6)**

Unit 5
Point Groups and Symmetry, Finite point groups; Crystallographic point groups (C_n, C_{nv}, D_n, etc.); Space groups; Continuous groups (SO(3), SU(2)). **(No. of lectures- 10)**

Unit 6
Applications in Physics, Selection rules in quantum mechanics; Molecular vibrations and spectroscopy; **(No. of lectures- 5)**

Textbooks

1. Group Theory in a Nutshell for Physicists by A. Zee (Princeton University Press, 2016) – Primary text for physics applications.
2. Group Theory and Its Application to Physical Problems by Morton Hamermesh (Dover Publications, 1962; Reprint) – Classic introductory text.

Reference Books

1. Finite Group Theory by M. Aschbacher (Cambridge University Press, 2000) – For deeper algebra.
2. Group Theory: Birdtracks, Lie's, and Exceptional Groups by P. Cvitanović (Princeton University Press, 2008) – Advanced applications.
3. Symmetry and Group Theory in Physics by M. S. Dresselhaus et al. (Lecture Notes, MIT OpenCourseWare or similar).
4. Molecular Symmetry and Spectroscopy by P. R. Bunker and P. Jensen (NRC Research Press, 1998) – For molecular applications.

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DETAILS OF THE COURSE

Course Type	Course code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHT XXX	Particle Detectors and Its Technology	3	2	1	0	0

PREREQUISITE – None

COURSE OBJECTIVE(s)

This course aims to equip the students with fundamental knowledge of Particle Detector and Technology.

COURSE ASSESSMENT

The Course Assessment (culminating in the final grade) will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Module 1

Overview of the detector technology used in particle physics experiments starting from the Rutherford scattering experiment to the present world's largest experiments at the Large Hadron Collider (LHC), basic concept of energy loss by excitation and ionization, Bethe-Bloch formula, density effects, mean energy loss as a function of velocity, fluctuations in energy loss, interaction of electrons with matter: Bremsstrahlung, interaction of photon with matter: photo-electric effect, Compton scattering, pair production. **(No. of lectures- 6)**

Module 2

Fundamental physics principle of particle detectors: ionization and excitation, construction, working, and operational characteristics of particle detectors: gaseous detectors, ionization chambers, proportional counters, drift chambers, bubble chambers, semiconductor detectors: introduce silicon detectors technology, pixel and strip detectors, CCDs, electromagnetic calorimetry, hadronic calorimetry, general characteristics of particle detectors, development of a detector system concept. **(No. of lectures- 11)**

Module 3

Signal formation, electronic noise, optimization of signal-to-noise ratio, pulse processing electronics, amplification, applications: position, tracking, and energy measurements in modern particle physics experiments, radiation detection in space applications: advanced space radiation detector technology at NASA/ISRO, radiation detectors for medical imaging: beam monitoring and 3D imaging, nuclear techniques for material analysis. **(No. of lectures- 9)**

TEXTBOOKS-

1. Techniques for Nuclear and Particle Physics Experiment: W. R. Leo (Springer).
2. Radiation Detection and Measurement: Glenn F. Knoll (Wiley).
3. Semiconductor Radiation Detectors, Device Physics: Gerhard Lutz (Springer).
4. Particle Detectors: Claus Grupen and Boris Schwartz (Cambridge University Press).

REFERENCE BOOKS

1. Physics of Particle Detectors: Dan Green (Cambridge University Press).
2. Evaluation of Silicon sensor technology in particle physics: Frank Hartmann (Springer).
3. Handbook of Particle Detection and Imaging: Grupen, Claus, Buvat, Irene (Springer).

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTXXX	Plasma Science and Technology	3	3	0	0	0

PREREQUISITES:

1. Basic Mathematics (+2 Level).
2. Basic Fluid Dynamics (Graduation Level).
3. Basic Electrodynamics (Graduation Level).

COURSE OBJECTIVES

- To introduce the fundamental concepts of plasma as the fourth state of matter.
- To understand plasma behavior using single-particle, fluid, and kinetic models.
- To explore plasma waves, instabilities, and confinement techniques.
- To familiarize students with plasma technologies and applications in engineering, such as fusion energy, plasma processing, and propulsion.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
1.	Internal assessment (based upon assignments, quizzes and attendance)	20%
2.	Mid-term examination	30%
3.	End Semester Examination	50%

COURSE CONTENTS

Unit 1

Introduction to Plasmas, Definition and characteristics of plasma; Debye shielding; Plasma parameters (density, temperature); Criteria for plasmas (Debye length, plasma frequency).

(No. of lecture – 6)

Unit 2

Single Particle Motion in Plasmas, Motion in uniform E and B fields (E × B drift, gradient B drift, curvature drift); Adiabatic invariants; Magnetic moment. **(No. of lecture – 6)**

Unit 3

Fluid Description of Plasmas, Plasma as a fluid; MHD equations; Frozen-in flux theorem; Alfven waves; Magnetosonic waves; Pinch effect; Theta pinch and Z-pinch. **(No. of lecture – 8)**

Unit 4

Kinetic Theory and Waves, Plasma Wave generation and EMW propagation; Vlasov equation; Landau damping; Plasma waves (Langmuir, ion acoustic, electromagnetic); Dispersion relations; Cold and warm plasma approximations. **(No. of lecture - 8)**

Unit 5

Plasma Confinement and Instabilities, Magnetic confinement (tokamaks, stellarators); Inertial confinement; Two Stream & Weibel instability; (RT & kink instability optional); Bootstrap current **(No. of lecture - 6)**

Unit 6

Plasma Technologies and Applications: Fusion plasmas (ITER, tokamak physics); Plasma processing (etching, deposition, PECVD); Plasma propulsion; Glow discharges; **(No. of Lecture – 5)**

Textbooks

1. Introduction to Plasma Physics and Controlled Fusion by F. F. Chen (3rd Edition, Springer, 2016) – Primary text.
2. Plasma Physics: An Introduction to Plasma Theory by Richard Fitzpatrick (Available online, CRC Press).

Reference Books

1. Principles of Plasma Discharges and Materials Processing by M. A. Lieberman and A. J. Lichtenberg (Wiley, 2005).
2. Physics of Plasmas by J. D. Callen (Online notes from University of Wisconsin).
3. Fusion: The Energy of the Universe by Garry McCracken and Peter Stott (Academic Press, 2005).

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	26PHTX XX	Accelerators and Applications	3	3	0	0	0

PREREQUISITE –

COURSE OBJECTIVE(s)

To provide a comprehensive understanding of the fundamental physics, advanced engineering systems, and diverse real-world applications of particle accelerators across research, medicine, and industry.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Module 1: Basic Principles and Beam Dynamics
Introduction to particle accelerators, History and evolution (Cyclotron, Synchrotron), Classification of accelerators (electrostatic, linear, circular), Motion of charged particles in electric and magnetic fields, Lorentz force and beam trajectory, Basic beam optics (focusing and defocusing, quadrupole magnets), Phase stability and acceleration mechanisms, RF cavities and resonance

(No. of Lectures 12)

Module 2: Advanced Accelerator Systems and Components
Linear accelerators (LINAC), Circular accelerators (synchrotrons and storage rings), Magnetic systems (dipole, quadrupole, sextupole magnets), RF systems and accelerating structures, Beam

diagnostics and instrumentation, Vacuum systems, Beam injection and extraction techniques, Superconducting accelerators and cryogenics, Large-scale facilities (CERN, Large Hadron Collider)
(No. of Lectures 14)

Module 3: Industrial, Medical, and Research Applications
High-energy physics applications, Nuclear physics and material science applications, Medical applications (Proton therapy, radioisotope production), Industrial applications (material modification, sterilization, imaging), Space radiation studies and simulation, Accelerator-driven systems (ADS), Synchrotron radiation applications, Future trends (compact accelerators, plasma wakefield acceleration) **(No. of Lectures 13)**

TEXT BOOKS: -

1. Wiedemann, H. (2015). *Particle Accelerator Physics* (4th ed.). Springer.
2. Wille, K. (2000). *The Physics of Particle Accelerators: An Introduction*. Oxford University Press.
3. Lee, S. Y. (2018). *Accelerator Physics* (4th ed.). World Scientific.
4. Edwards, D. A., & Syphers, M. J. (1993). *An Introduction to the Physics of High Energy Accelerators*. Wiley-VCH.

REFERENCE BOOKS

1. Appleby, R., Burt, G., Clarke, J., & Owen, H. (2020). *The Science and Technology of Particle Accelerators*. CRC Press.
2. Myers, S., & Schopper, H. (Eds.). (2020). *Particle Physics Reference Library: Volume 3: Accelerators and Colliders*. Springer.
3. Minty, M. G., & Zimmermann, F. (2003). *Measurement and Control of Charged Particle Beams*. Springer.

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
B. Tech Minor	26PHTXXX	Fundamentals of Space Physics and Applications	3	3	0	0	0

PREREQUISITE – None

COURSE OBJECTIVE(s)

- To gain a foundational knowledge of space weather and cosmic radiations in space.
- To be aware of the current space missions of NASA and ISRO organisations
- To train the students about experimental data analysis for practical pathways for student research and internships.
- To examine how space radiation interacts with sensors, materials, and electronics to understand radiation detection and its effects on materials and sensors.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Module I: Fundamentals of Space Radiation Environment and Space Weather:
Introduction to space environment, Earth atmosphere, Magnetosphere, Ionosphere, Van Allen radiation belts, Solar radiation, Solar wind, Galactic Cosmic Rays, Solar Energetic Particles,

Radiation environment in Low Earth Orbit, Geostationary Orbit and Deep Space, Introduction to space weather, Sunspots, Solar flares, Coronal Mass Ejections, Geomagnetic storms, Auroras, Solar cycle, Effects on satellites and astronauts **(No. of lectures: 18)**

Module II: Overview of Space Missions and Exploration:
Introduction to space agencies, ISRO overview: Chandrayaan missions, Mangalyaan, Aditya-L1, Gaganyaan, NASA overview, Apollo missions, International Space Station, Mars Rover missions, Artemis mission, Future lunar and Mars exploration missions, Opportunities for students' visit to ISRO/NASA Space Centre (s) for internships OR research. **(No. of lectures: 12)**

Module III: Effect of Space Radiations on Sensors & Materials:
Radiation sensors: Silicon detectors, Geiger Muller counter, Scintillation detectors, Dosimeters for spacecraft, Shielding materials used in space, Aluminum, Polymers and composites, Metal Hydride, and Carbon composites, Interaction of radiation with materials, Ionization, Excitation, Energy loss, Secondary radiations, Radition damage in electronics, Absorbed dose, Equivalent dose, Dose units Gray and Sievert, Radiation protection methods
Applications: Satellite communication, Space weather forecasting, Radiation monitoring, Spacecraft protection, Human space missions, Defence systems, Disaster warning, Agriculture monitoring **(No. of lectures: 09)**

Text Books

1. Moldwin, M. (2022). *An Introduction to Space Weather* (2nd ed.). Cambridge University Press
2. Tascione, T. F. (2010). *Introduction to the Space Environment* (2nd ed.). Krieger Publishing.
3. Kivelson, M. G., & Russell, C. T. (Eds.). (1995). *Introduction to Space Physics*. Cambridge University Press.

Reference Books

1. Sellers, J. J. (2005). *Understanding Space: An Introduction to Astronautics* (3rd ed.). McGraw-Hill Education.
2. Indian Space Research Organisation (ISRO). (2023). *Aditya-L1: First Indian Mission to Study the Sun*[Booklet/Technical Report]. ISRO Media.
3. Knoll, G. F. (2023). *Radiation Detection and Measurement* (4th ed., Indian Adaptation). Wiley India.
4. Pisacane, V. L. (2016). *The Space Environment and Its Effects on Space Systems* (2nd ed.). AIAA.
5. Koskinen, H. E. J., & Kilpua, E. (2022). *Physics of Earth's Radiation Belts: Theory and Observations*. Springer.
6. Radiation and Detectors: Introduction to the Physics of Radiation and Detection Devices by Lucio Cerrito