ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: M.Sc., Programme: Physics, Duration: 2 years (Four Semesters)

Subject Code Format:

A1	A2	B3	C4	C5	C6
School/ Dept. (Offering) **BH:** Basic Sciences and Humanities **CS:** Computer Sciences **EE:** Electrical Sciences **EI:** Electronic Sciences **IP:** Infrastructure and Planning **MS:** Mechanical Sciences **BT:** Biotechnology **TE:** Textile Engineering		**Level** **1:** UG/ Int. Msc. (1st Year) **2:** UG/ Int. Msc. (2nd Year) **3:** UG/ Int. Msc. (3rd Year) **4:** UG/ Int. Msc. (4th Year) **5:** UG/ Int. Msc. (5th Year) **6:** PG (1st Year) **7:** PG (2nd Year) **8:** Ph.D.	**0:** AC **1:** PC **2:** PE **3:** OE **4:** MC **5:** LC **6:** PR **7:** SE **8:** **9:**	**Serial Number (01 to 99)** 01/ 03/…/ 19: Odd Sem. (CHEM) 21/ 23/…/ 39: Odd Sem. (HUM) 41/ 43/…/ 59: Odd Sem. (MATH) 61/ 63/…/ 79: Odd Sem. (PHY) 81/ 83/…/ 99: Odd Sem. () 02/ 04/…/ 20: Even Sem. (CHEM) 22/ 24/…/ 40: Even Sem. (HUM) 42/ 44/…/ 60: Even Sem. (MATH) 62/ 64/…/ 80: Even Sem. (PHY) 82/ 84/…/ 98: Even Sem. ()	

Abbreviation used:

PC:	Professional Core	IA*:	Internal Assessment	L:	Lecture
PE:	Professional Elective	EA:	End-Semester Assessment	T:	Tutorial
OE:	Open Elective	PA:	Practical Assessment	P:	Practical
MC:	Mandatory Course	PR:	Project/ Seminar/ Practical		
LC:	Lab Course	AC:	Audit course		

1st SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-1	BH6161	Classical Mechanics	4	0	0	4	40	60	-	100
PC-2	BH6163	Mathematical Methods In Physics	4	0	0	4	40	60	-	100
PC-3	BH6165	Quantum Mechanics-I	4	0	0	4	40	60	-	100
PC-4	BH6167	Electrodynamics	4	0	0	4	40	60	-	100
PC Lab-1	BH6561	General Physics Laboratory	0	0	3	1.5	-	-	100	100
SEC-1	CS6481	Fundamentals Of Computer And Programming In C	3	0	0	2	40	60	-	100
SEC Lab-1	CS6581	Programming In C Laboratory	0	0	3	1.5	-	-	100	100
		Total credit	**19**	**0**	**6**	**21**	**200**	**300**	**200**	**700**

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: M.Sc., Programme: Physics, Duration: 2 years (Four Semesters)

2nd Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-5	BH6162	Statistical Mechanics	3	0	0	3	40	60	-	100
PC-6	BH6164	Physics Of Semiconductor Devices	4	0	0	4	40	60	-	100
PC-7	BH6166	Quantum Mechanics-II	4	0	0	4	40	60	-	100
PC-8	BH6168	Experimental Techniques	3	0	0	3	40	60	-	100
PC-9	BH6170	Electronics	3	0	0	3	40	60	-	100
PC Lab-2	BH6562	Electromagnetic And Optics Laboratory	0	0	3	1.5	-	-	100	100
PC Lab-3	BH6564	Basic Electronics Laboratory	0	0	3	1.5	-	-	100	100
		Total credit	**17**	**0**	**6**	**20**	**200**	**300**	**200**	**700**

3rd Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-10	BH7161	Advanced Quantum Mechanics And Quantum Field Theory	4	0	0	4	40	60	-	100
PC-11	BH7163	Nuclear And Particle Physics	4	0	0	4	40	60	-	100
PC-12	BH7165	Basic Condensed Matter Physics	4	0	0	4	40	60	-	100
PC-13	BH7167	Nano Science And Technology	3	0	0	3	40	60	-	100
SEMINAR	BH7761	Literature Review And Seminar	0	0	4	2	-	-	100	100
PC Lab-4	BH7561	Advanced Electronics Laboratory	0	0	3	1.5	-	-	100	100
PC Lab-5	BH7563	Basic Condensed Matter Physics Laboratory	0	0	3	1.5	-	-	100	100
		Total credit	**15**	**0**	**10**	**20**	**160**	**240**	**300**	**700**

4th Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-14	BH7162	Atomic And Molecular Physics	3	0	0	3	40	60	-	100
PE-1	BH7262 / BH7264	Advanced Condensed Matter Physics / Advanced Particle Physics	4	0	0	4	40	60	-	100
PE-2	BH7266 / BH7268	Vacuum Technology And Cryogenics / Material Science	3	0	0	3	40	60	-	100
PROJECT	BH7662	Project	0	0	6	6	-	-	100	100
PC Lab-6	BH7562	Modern Physics Laboratory	0	0	3	1.5	-	-	100	100
PE Lab-1	BH7564 / BH7566	Advanced Condensed Matter Physics Laboratory / Advanced Particle Physics Laboratory	0	0	3	1.5	-	-	100	100
		Total credit	**10**	**0**	**12**	**19**	**120**	**180**	**300**	**600**

School of Basic Sciences & Humanities
Course: M.Sc., Programme: Physics, Duration: 2 years (Four Semesters)
FIRST Semester

Classical Mechanics

Marks-100

Course Objective:

- Know the physical concepts and become familiar with classical mechanics and also its mathematical form.
- Develop skills in formulating and solving problems of different systems using classical mechanics.

Course Outcome:

1. Define and understand the basic concepts of mechanical systems.
2. Describe and understand the motion of a rigid body and understand the motion of a mechanical system using Lagrange and Hamilton formalism.
3. Demonstrate the working knowledge of classical mechanics and its application to standard problems such as (a) central forces, (b) the dynamics of the system of particles, (c) the motion of the rigid body.
4. Demonstrate the working knowledge of (a) Hamilton Jacobi theory, (b) Small oscillation problems, (c) complicated mechanical systems, (d) Chaos.

MODULE-I

(8 hours)

Mechanics of a system of particles:
Lagrangian Formulation, Velocity dependent potentials and Dissipation Function, conservation theorems and symmetry properties, Homogeneity and Isotropy of space and Conservation of linear and Angular momentum, Homogeneity of time, and conservation of energy.

Hamiltonian Formulation:
Calculus of variations and Euler-Lagrange's equation, Brachistochrone problem, Hamilton's principle, extension of Hamilton's principle to non-holonomic systems, Legendre transformation and the Hamilton equations of motion, physical significance of Hamiltonian, Derivation of Hamilton's equations of motion from a variational principle, Routh's procedure, Principle of least action.

MODULE-II

(9 hours)

Canonical transformations:
Canonical Transformation, types of generating function, conditions for Canonical Transformation, integral invariance of Poincare, Poisson's theorem, Poisson and Lagrange bracket, Poisson and Lagrange Brackets as canonical invariant, Infinitesimal canonical Transformation and conservation theorems, Liouville's theorem.

Hamilton -Jacobi Theory:
Hamilton - Jacobi equation for Hamilton's principal function, Harmonic oscillator and Kepler's problem by Hamilton - Jacobi method, Action angle variables for the completely separable system, Kepler's problem in Action angle variables, Geometrical optics and wave mechanics.

MODULE-III

(14 hours)

Small oscillation:
Problem of small oscillations, Example of two coupled oscillators, General theory of small oscillations, Normal coordinates and Normal modes of vibration, Free vibrations of a linear Tri-atomic molecule.

Rigid body motion:
The independent coordinates of a rigid body, orthogonal transformations, The Euler's angles, The Cayley-Klein parameters, Euler's theorems on the motion of a rigid body, infinitesimal rotations, rate of change of a vector, The Coriolis Force.

MODULE-IV

(9 hours)

Rigid body dynamics:
Angular momentum, and kinetic energy of motion about a point. The Inertia Tensor, momentum of Inertia, Eigen-values of Inertia Tensor and the principal Axis transformation. The Heavy symmetrical Top with one point Fixed.

Non-Linear Systems:
Elementary idea about non-linearity, and chaos.

Text Book:

- Classical Mechanics: H. Goldstein.

Reference Book:

- Mechanics: L. D. Landau and E. M. Liftshitz.
- Classical Mechanics: H. C. Corben and P. Stehle.
- Classical Dynamics: J. B. Marion and S. T. Thornton.
- Analytical Mechanics: L. N. Hand and J. D. Finch.
- Classical Mechanics: J. C. Upadhyaya.

Mathematical Methods in Physics

Marks-100

Course Objective:

- Provide basic skills necessary for the application of mathematical methods in physics.
- Develop an understanding of how to use methods within the field of study of research and in the field of scientific knowledge to work independently.

Course Outcome:

1. Define the utility and limitations of a variety of powerful calculation techniques, and provide a deeper understanding of the mathematics useful in theoretical physics.
2. Understand elementary ideas in linear algebra, special functions and complex analysis.
3. Apply these to solve problems in classical, statistical, and quantum mechanics, electromagnetism as well as solid state physics.

MODULE-I

(7 hours)

Complex Variables:
Cauchy's Integral Theorem, Cauchy's integral formula, Calculus of Residues, Cauchy's residue theorem, Evaluation of definite integrals.

MODULE-II

(11 hours)

Tensor Analysis:
Cartesian tensors in three-space, Curves in three-space and Frenet formula, General Tensor Analysis, Covariant derivative, Levi-Civita and Christoffel symbol, Riemann & Ricci tensor.

MODULE-III

(11 hours)

Special Functions:
Solutions of Bessel, Laguerre, Hypergeometric, and Confluent Hypergeometric Equations by generating function methods and their properties. Solutions of inhomogeneous Partial Differential Equations by Green's function method.

MODULE-IV

(11 hours)

Groups and Group representation:
Definition of groups, Finite groups, example from solid state physics, sub groups and classes, Group Representation, Combining Representation (Chlebsch Gorden) Characters, Infinite groups and Lie groups, Lie algebra and application, Irreducible representation of SU(2), SU(3)and O(3).

Text book:

- Mathematical Methods for Physicists: G.B.Arfken, H.J.Weber (2013, 7th Edn., Elsevier).
- Mathematical Physics: H. K. Dass, Dr. Rama Verma (S. Chand Publishing).

Reference Book:

- Methods of Theoretical Physics: P.M. Morse and H. Feshbach Vol-I, Vol-II.
- Mathematical methods for physicists: P. Dennery & A. Krzywicki.
- Group Theory and Its Application to Physical Problems: M. Hamermesh.
- Mathematical methods of physics: J. Mathews & R. L. Walker.

Quantum Mechanics-I

Marks-100

Course Objective:

- The objective of this course is to study the fundamental postulates and formalism of quantum mechanics. Along with this the student will be familiarized with operator algebra. This course also extends the discussion to study Schrodinger equation in Hydrogen atoms, harmonic oscillator etc.

Course Outcome:

1. State basic postulates of quantum mechanics in linear vector space.
2. Indicate the properties of different operators such as Hermitian operators, projection operators, unitary operators etc.
3. Solve Schrodinger's equation of harmonic oscillator problem completely by the operator method.
4. Analyze the addition of angular momentum theorems, orbital angular momentum and spin angular momentum statistics.
5. Evaluate the energy eigenvalue and eigen-function for the hydrogen atom using the Schrodinger equation.

MODULE-I

(10 hours)

General principle of Quantum mechanics:
Linear Vector Space Formulation: Linear vector Space (LVS) and its generality. Vectors: Scalar product, metric space, basis vectors, linear independence, linear superposition of general quantum states, orthonormality of basis vector, completeness relation, Schmidt's orthonormalization procedure, Dual space, Bra and Ket vectors.

Operators:
Linear, Adjoint, Hermitian, Unitary, inverse, anti-linear operators, Non-commutativity and uncertainty relation, complete set of compatible operators, simultaneous Measurement, Projection operator, eigenvalue and Eigenvector of linear, Hermitian, Unitary operators, Matrix representation of vectors and operators, matrix elements, eigenvalue equation and expectation value, algebraic result on Eigenvalues, transformation of basis vectors, similarity transformation of vectors and operators, diagonalization. Vectors of LVS, and wave function in co-ordinate, momentum, and energy representations.

MODULE-II

(6 hours)

Quantum Dynamics:
Time evolution of quantum states, time evolution of operators and their properties, Schrodinger picture, Heisenberg picture, Dirac/Interaction picture, Equation of motion, Operator method of solution of 1D Harmonic oscillator, time evolution and matrix representation of creation and annihilation operators.

MODULE-III

(14 hours)

Rotation and orbital angular momentum:
Rotation matrix, Angular momentum operators as the generation of rotation, components of angular momentum Lx, Ly, Lz and L^2 and their commutator relations, Raising and lowering operators L+ and L-; Lx, Ly, Lz and L^2 in spherical polar co-ordinates, eigenvalue and eigenfunction of Lz and L^2 (operator method), Spherical harmonics, matrix representation of Lz, L+, L_ and L^2.

Spin angular momentum:
Spin 1/2 particle, Pauli spin matrices and their properties, Eigenvalues and Eigen function, Spinor transformation under rotation.

Addition of angular momentum:
Total angular momentum J, Eigenvalue problem of Jz and J^2, Angular momentum matrices, Addition of angular momentum, and C. G. Coefficients, Angular momentum states for the composite system in the angular momenta (1/2, 1/2) and (1, 1/2).

MODULE-IV

(10 hours)

Motion in Spherical symmetric Field:
The hydrogen atom, Reduction to one-dimensional one-body problem, radial equation, Energy eigenvalue and Eigen function, degeneracy, radial probability distribution. Free particle problem in incoming, and outgoing spherical waves, expansion of plane waves in terms of spherical waves. Bound states in a 3-D square well potential, particle in a sphere.

Text book:
- Quantum Mechanics: S. Gasiorowicz.
- Quantum Mechanics: J. Sukurai/L-I Schiff/ E.Merzbacher/ A.Messiah, Vol.I.
- Quantum Mechanics: N. Zettili.
- Quantum Mechanics: R. Shankar.
- Quantum Mechanics: S. N. Biswas.
- Quantum Mechanics: A. Ghatak and S. Lokanathan.

Reference Book:
- Quantum Mechanics: A. Das.
- Quantum Mechanics (Non-Relativistic theory): L. D. Landau and E. M. Lifshitz.
- Elementary Theory of Angular Momentum: M. E. Rose.
- Principles of Quantum Mechanics: P. A. M. Dirac.

Electrodynamics

Marks-100

Course Objective:

- To understand the basic ideas and underlying mathematical formalism of electromagnetic fields.
- Use of electromagnetic field equations in vacuum and various media in different shapes and forms.

Course Outcome:

1. Define and analyze Maxwell’s wave equation in different media.
2. Derive scalar and vector potential in the presence of different sources, Poynting theorem.
3. Apply the Gauge invariance condition to Maxwell’s equation. Derive Maxwell’s equation in co-variant form.
4. Analyze different modes of electromagnetic waves in waveguides.
5. Evaluate the angular distribution of radiation and power emitted by the dipole.
6. Show that accelerating charge produces electromagnetic radiation.

MODULE-I

(12 hours)

Maxwell’s equation:
Maxwell’s equations in free space; Magnetic charge; Maxwell’s equations inside matter; Displacement current; Vector and scalars potentials; Wave equation for potentials; Lorentz and Coulomb gauge conditions; Wave equation for Electric and Magnetic fields in the absence of sources.

Covariant formulation of Maxwell’s equation:
Lorentz transformation; Scalars, vectors and Tensors; Maxwell’s equations and equations of continuity in terms of $A\mu$ and $J\mu$; Electromagnetic field tensor and its dual; Covariant form of Maxwell’s equations; Lagrangian for a charged particle in the presence of external electromagnetic field and Maxwell’s equation as Euler-Lagrange equations.

MODULE-II

(12 hours)

Plane waves in non-conducting media:
Plane waves in non-conducting media; velocity of wave propagation and energy flow; linear, circular and elliptic polarisation; Reflection and refraction of electromagnetic waves at a plane interface between dielectrics; normal and oblique incidence; total internal reflection and polarisation by reflection; waves in dispersive media, Kramer-Kronig relation.

Plane waves in conduction media:
Plane waves in conduction media; Reflection and transmission at a conducting surface; Cylindrical cavities, and wave guides; Modes in rectangular wave guide and resonant cavities.

MODULE-III

(10 hours)

Green's function solution for retarded potential:
Green's function solution of the potential form of Maxwell's equations, Retarded and advanced Green's functions.

Multipole radiation:
Potential, Fields and radiation due to an oscillating electric dipole; radiation due to a centre-fed linear antenna; angular distribution of power radiated; Rayleigh scattering. Magnetic dipole and electric quadrupole radiation.

MODULE-IV

(6 hours)

Radiation by point charge:
Lienard-Weichert potential, Field due to a point charge, Angular distribution of radiation and total power radiated by an accelerated charge, Larmor's formula, Thomson's scattering.

Text book:

- Classical Electrodynamics: J. D. Jackson.
- Introduction to Electrodynamics: D. J. Griffiths.

Reference Book:

- Classical Theory of Fields: L. Landau and E.M. Lifshitz.
- Principles of Optics: M. Born and E. Wolf.
- Introduction to Electrodynamics: A. Z. Capri and P.V. Panat.

Fundamentals of Computer and Programming in C

Mark-100

Course Objectives:

- To solve physics problems through different numerical techniques.
- Use computer programming for simulation and data analysis.

Course Outcomes:

1. Explore algorithmic approaches to problem solving.
2. Ability to analyze a problem and devise an algorithm to solve it.
3. Able to formulate algorithms, pseudo codes and flowcharts for arithmetic and logical problems.
4. Ability to implement algorithms in the 'C' language.
5. Develop modular programs using control structures and arrays in 'C'.

MODULE-I

(10 hours)

Introduction

Algorithm, flowchart, Structured Programming Approach, structure of C program (header files, C preprocessor, standard library functions, etc.), identifiers, basic data types and sizes, Constants, variables, arithmetic, relational and logical operators, increment and decrement operators, conditional operator, bitwise operators, assignment operators, expressions, type conversions, conditional expressions, precedence and order of evaluation. Input-output statements, statements and blocks, if and switch statements, loops: while, do-while and for statements, break, continue, goto, programming examples.

MODULE-II

(10 hours)

Designing structured programs:

Functions, parameter passing, storage classes- extern, auto, register, static, scope rules, user-defined functions, recursive functions. Arrays- concepts, declaration, definition, accessing elements, and functions, two-dimensional and multi-dimensional arrays, applications of arrays. pointers- concepts, initialization of pointer variables, pointers and function arguments, address arithmetic, Character pointers and functions, pointers to pointers, pointers and multidimensional arrays, dynamic memory management functions, command line arguments.

MODULE- III

(10 hours)

Derived types-structures:

Declaration, definition and initialization of structures, accessing structures, nested structures, arrays of structures, structures and functions, pointers to structures, self-referential structures, unions, typedef, bit fields, and C program examples. Input and output – concept of a file, text files and binary files, streams, standard I/O, Formatted I/O, file I/O operations, error handling, C program examples.

Text books:

- "C Programming": E. Balagurusamy, Tata McGraw-Hill.
- Computer Fundamental & Programming in C": P. Dey & M. Ghosh, "-Oxford University Press.
- "C How to programme": P. Deitel H. Deitel, Pearson Publication.

Reference Book

- Let us C: Y. Kanetkar.

General Physics Laboratory

Marks-100

Course Objective:
- Develop fundamental laboratory skills and the ability to design experiments to analyze various phenomena associated with general physics.
- Develop strong quantitative skills to analyze data, including graph plotting, curve fitting, and error calculation through experiments.

Course Outcome:
1. Acquire practical laboratory skills as well as develop the ability to think critically, analyze data, and communicate the findings effectively.
2. Relate experimental observations to theoretical physics concepts, fostering a deeper understanding of the subject.

Experiments List:
1. To calculate the velocity of ultrasonic sound through a solid medium using an ultrasonic interferometer.
2. To calculate the adiabatic compressibility of the given solid using an ultrasonic interferometer
3. Verification of Stefan's law and Stefan's constant measurement.
4. Determination of magnetic susceptibility of a paramagnetic solution using Quinck's tube method.
5. Measurement of dielectric constant by plate capacitor.
6. To determine the Planck's constant using LEDs of at least 4 different colours.
7. To study different flip-flops.
8. Measurement of very small resistance using Precision Kelvin double bridge (Maxwell double bridge).
9. To determine the wavelength and angular spread of the He-Ne laser using plane diffraction grating.
10. Calibration of an oscilloscope using standard waveform.
11. Determination of particle size of lycopodium powder by light scattering.
12. To study the dependency of the magnetic field on coil diameter and number of turns using different solenoids.
13. To study the Resonance absorption of a passive RF oscillator circuit.
14. Determining the refractive index and dispersion of liquids using a hollow prism and a light source.
15. To verify the relationship of speed of light with permeability and permittivity of air.
16. Determination of specific charge of the electron (e/m)
17. Determination of electrical permittivity of free space and dielectric constant of various materials.

Programming in C Laboratory

Marks-100

Course Objectives:

- Able to do programme in C language
- Able to understand and implement algorithm of scientific programmes.

Course Outcomes:

1. Construct suitable algorithm for mathematical formula
2. Write programmes in C language for simple mathematical formulations
3. Plot the data if obtained analyze the data.
4. Do the analysis

Experiments List:
(Minimum 10 programs to be done covering 8 Experiments)

Experiment No. 1

1. Write a C program to find the sum of individual digits of a positive integer.
2. A Fibonacci sequence is defined as follows: the first and second terms in the sequence are 0 and 1. Subsequent terms are found by adding the preceding two terms in the sequence. Write a C program to generate the first n terms of the sequence.
3. Write a C program to generate all the prime numbers between 1 and n, where n is a value supplied by the user.

Experiment No. 2

1. Write a C program to calculate the following Sum: Sum=1-x2 /2! +x4 /4!-x6 /6!+x8 /8!-x10/10!
2. Write a C program to find the roots of a quadratic equation.

Experiment No. 3

1. Write C programs that use both recursive and non-recursive functions i) To find the factorial of a given integer. ii) To find the GCD (greatest common divisor) of two given integers. iii) To solve the Towers of Hanoi problem.

Experiment No. 4

1. Write a C program to find both the larges and smallest numbers in a list of integers.
2. Write a C program that uses functions to perform the following: i) Addition of Two Matrices ii) Multiplication of Two Matrices

Experiment No. 5

1. Write a C program that uses functions to perform the following operations: i) To insert a sub-string into to given main string from a given position. ii) To delete n Characters from a given position in a given string.
2. Write a C program to determine if the given string is a palindrome or not

Experiment No. 6

1. Write a C program to construct a pyramid of numbers.
2. Write a C program to count the lines, words and characters in a given text.

Experiment No. 7

1. Write a C program that uses functions to perform the following operations:
   i. Reading a complex number
   ii. Writing a complex number
   iii. Addition of two complex numbers
   iv. Multiplication of two complex numbers (Note: represent complex numbers using a structure.

Experiment No. 8

1. Write a C program that copies one file to another.
2. Write a C program to reverse the first n characters in a file. (Note: The file name and n are specified on the command line.

Text books:

- "C Programming": E. Balagurusamy, Tata McGraw-Hill.
- Computer Fundamental & Programming in C": P. Dey & M. Ghosh, "-Oxford University Press.
- Project Using C Scitech Publisher.
- Programming Concepts in C, DS, C++, Java: K.V.R. Rao.
- Numerical analysis, A programming approach: V. Vachharajani.

Reference Book

- Let us C: Y. Kanetkar.
- "C How to programme": P. Deitel H. Deitel, Pearson Publication.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: M.Sc., Programme: Physics, Duration: 2 years (Four Semesters)

SECOND Semester

Statistical Mechanics

Marks-100

Course Objective:
- Understand postulates of classical and quantum statistical mechanics
- Understand phase transitions and the Ising model to study ferromagnetism

Course Outcome:
1. State postulates of classical and quantum statistical mechanics
2. Differentiate between microstate and macrostate
3. Use the significance of Gibb's paradox and indistinguishability in statistical mechanics
4. Analyze Planck's blackbody radiation relation, electronic specific heat in metals and Bose-Einstein condensation
5. Summarize the thermodynamics of phase transition and formulate the Ising model of phase transitions for ferromagnetism.

MODULE-I

(10 hours)

Classical Statistical Mechanics:
Classical statistical Mechanics: Postulate of classical statistical mechanics, Liouville's theorem, micro canonical ensemble, review of thermodynamics, equipartition theorem, classical ideal gas, Gibb's paradox, Canonical ensemble and energy fluctuation, grand canonical ensemble and density fluctuation, Equivalence of canonical and grand canonical ensemble.

MODULE-II

(10 hours)

Quantum Statistical Mechanics:
The density matrix, ensembles in quantum statistical mechanics, Ideal gas in micro, canonical and grand canonical ensembles, and Equation of states for ideal Fermi gas. Theory of white dwarf stars, Equation of state of an ideal Bose gas, Photons and Planck's radiation law, Bose-Einstein condensation and thermodynamics in condensed state. Phonons and behaviour of specific heat of solids at different temperatures.

MODULE-III

(10 hours)

Ising model and Phase transition:
Definition of Ising model, One-dimensional Ising model, and its application to Ferromagnetism. Phase Transition: Thermodynamics description of Phase Transitions, Phase Transitions of the first and second kind, Discontinuity of specific heat, and change in symmetry in a phase transition of the second kind.

Text books:

- Statistical Physics: K. Huang.
- Statistical Physics: B. B. Laud.
- Topics in Statistical Mechanics: B. Cowan.
- Statistical Physics: R. K. Pathria.

Reference Books:

- Physics Transitions & Critical Phenomena: H. E. Stanley.
- Fundamental of statistical & Thermal physics: F. Reif.
- Elementary Statistical Physics: C. Kittel.
- Statistical Physics: F. Mohling.
- Statistical Physics: L. D. Landau and E. M. Lifsitz.

Physics of Semiconductor Devices

Marks-100

Course Objective:
- Understand the basics of semiconductor physics, analyze the charge conduction through pn junctions & BJT.
- To develop the understanding on physics of metal-semiconductor junctions, metal-insulator -semiconductor junctions & CMOS.

Course Outcome:
1. Describe the basic materials and properties of semiconductors with application to the p-n junction.
2. Understand the application of Field-Effect Transistors.
3. Use the application of Bipolar Junction Transistors.
4. Analyse the physics of semiconductor junctions, metal-semiconductor junctions and metal-insulator-semiconductor junctions, MOS transistor.

MODULE-I

(10 hours)

Introduction to the quantum theory of solids:
Basics of Semiconductor Physics: Formation of energy bands, K-space diagram (two and three-dimensional representation), conductors, semiconductors and insulators. Electrons and Holes in semiconductors: Silicon crystal structure, Donors and acceptors in the band model, electron effective mass.
Equilibrium Carrier concentration: Density of states, Thermal equilibrium, Fermi-Dirac distribution function for electrons and holes, Fermi energy. Equilibrium distribution of electrons & holes: derivation of n and p from D(E) and f(E), Fermi level and carrier concentrations, The np product and the intrinsic carrier concentration. General theory of n and p, Carrier concentrations at extremely high and low temperatures: complete ionization, partial ionization and freeze-out. Energy-band diagram and Fermi-level, Variation of E_F with doping concentration and temperature.

MODULE-II

(5 hours)

Motion and Recombination of Electrons and Holes: Carrier drift: Electron and hole mobilities, Mechanism of carrier scattering, Drift current and conductivity. Motion and Recombination of Electrons and Holes: Carrier diffusion: diffusion current, Total current density, relation between the energy diagram and potential, electric field. Einstein's relationship between diffusion coefficient and mobility. Electron- hole recombination, Thermal generation.

MODULE-III

(12 hours)

PN Junction:
Building blocks of the pn junction theory: Energy band diagram and depletion layer of a pn junction, Built-in potential; Depletion layer model: Field and potential in the depletion layer, depletion-layer width; Reverse-biased PN junction; Capacitance-voltage characteristics; Junction breakdown: peak electric field. Tunnelling breakdown and avalanche breakdown; Carrier injection under forward bias-Quasi equilibrium boundary condition; current continuity equation; Excess carriers in forward- biased pn junction; PN diode I-V characteristic, Charge storage. Application of PN Junction: Solar Cell: Types, Principle, Working Mechanism, Parameters (Jsc, Voc)

Metal-Semiconductor Junction:
Schottky Diodes: Built-in potential, Energy-band diagram, I-V characteristics, Comparison of the Schottky barrier diode and the pn-junction diode. Ohmic contacts: tunnelling barrier, specific contact resistance.

MODULE-IV

(13 hours)

The Bipolar Transistor:
Introduction, Modes of operation, Minority Carrier distribution, Collector current, Base current, current gain, Base width Modulation by collector current, Breakdown mechanism, Equivalent Circuit Models - Ebers-Moll Model.

MOS Capacitor:
The MOS structure, Energy band diagrams, Flat-band condition and flat-band voltage, Surface accumulation, surface depletion, Threshold condition and threshold voltage, MOS C-V characteristics, Q in MOSFET.

MOS Transistor:
Introduction to the MOSFET, Complementary MOS (CMOS) technology, V-I Characteristics, Surface mobilities and high-mobility FETs, JFET, MOSFET V_t, Body effect and steep retrograde doping, pinch-off voltage.

Text book:
- Physics of Semiconductor Devices: D. A. Neumann.
- Physics of Semiconductor Devices: B. B. Swain.
- Solid state Electronics Devices Bhattacharya: Rajnish Sharma.
- Semiconductor Materials and Devices: J. B. Gupta.
- Physics of Semiconductor Devices: J. J. Mohanty.

Reference Book:
- Physics of Semiconductor Devices: S. M. Sze. (Wiley).
- Solid state Electronics Devices: Ben G. Streetman and S. Banerjee.
- Physics of Semiconductor Devices: A. Acharya.
- Physics of Semiconductor Devices: Calvin Hu.
- Physics of Semiconductor Devices: Dilip K Roy.
- Fundamentals of Semiconductor Devices: M. K. Achthan and K. N. Bhatt.

Quantum Mechanics-II

Marks-100

Course Objective:

- The objective of this course is to understand various approximation methods such as perturbation theory, variational principles, and WKB method to solve simple systems.
- Along with this the student will be familiarized with scattering theory.

Course Outcome:

1. Define the energy and wave function for physical systems using time-independent perturbation theory.
2. Explain the Stark effect, the origin of polarizability and dipole moment, the fine structure of hydrogen atoms and the Zeeman effect.
3. Apply the variational principle to interpret ground state energy in diverse physical systems and solve for quantization rules for bound states and tunneling probabilities using WKB connection formula.
4. Analyze the transition probability under time-dependent perturbation theory and hence infer dipole selection rules in various atomic transitions.
5. Evaluate the scattering cross-sections for various scattering processes such as black sphere scattering, hard-sphere scattering and inelastic scattering.

MODULE-I

(13 hours)

Approximation Method for stationary states:
Rayleigh - Schrodinger Method for Time-independent Non-degenerate Perturbation theory, First and second order correction, perturbed harmonic oscillator, An-harmonic oscillator, The Stark Effect, Quadratic Stark Effect and polarizability of a Hydrogen atom, Degenerate perturbation theory, Removal of Degeneracy, parity selection rule, the linear stark effect of hydrogen atom, Spin-orbit Coupling, Relativistic correction, ne structure of Hydrogen like atom, normal and anomalous Zeeman effect, The strong- field Zeeman effect, The weak-field Zeeman effect and Lande's g-factor.

MODULE-II

(10 hours)

Variational Methods:
Rayleigh-Ritz variational technique and its application to ground State He-atom, one-dimensional harmonic oscillator, and H-atom.

WKB Approximation:
General formalism, Validity of WKB method, Connection Formulae, derivation of Bohr quantization rule, Application to Harmonic oscillator, Bound states for potential well with one rigid wall and two rigid walls, Tunnelling through potential Barrier, Cold emission, Alpha decay and Geiger - Nutal relation.

MODULE-III

(7 hours)

Time-dependent perturbation Theory:
Transition probability, constant and harmonic perturbation, Fermi Golden rule, electric dipole Radiation and Selection Rule, Spontaneous emission: Einstein's A and B - coefficients.

MODULE-IV

(10 hours)

Scattering Theory:

Scattering amplitude, and Cross section. Born approximation, Application to Coulomb and Screened Coulomb potential, Partial wave analysis for elastic and inelastic Scattering. Optical theorem, Black disc Scattering, Hard-sphere Scattering, Resonance Scattering from square well potential, Scattering of identical particles.

Text book:

- Quantum Mechanics: S. Gasiorowicz.
- Quantum Mechanics, Concept and Applications: N. Zettili.
- Quantum Mechanics: B.H. Bransden,C.J. Joachain.
- Quantum Mechanics : R. Shankar.
- Quantum Mechanics: A. Das.
- Quantum Mechanics: A. Ghatak and S. Lokanathan.

Reference Book:

- Advanced Quantum Mechanics: P. Roman.
- Quantum Mechanics (Non-Relativistic theory): L. D. Landau and E. M. Lifshitz.
- Elementary Theory of Angular Momentum: M. E. Rose.
- Principles of Quantum Mechanics: P. A. M. Dirac
- Introductory Quantum Mechanics: R.Liboff.
- Quantum Mechanics: E.Merzbacher .
- Quantum Mechanics: S. N.Biswas.
- Quantum Mechanics: L.I.Schiff.
- Quantum Mechanics vol I: A.Messiah.
- Modern Quantum Mechanics: J. J. Sakurai.

Experimental Techniques

Marks-100

Course Objective:

- Understand basic working principles to use various experimental techniques for studying structural, morphological, optical, and electrical properties of various types of materials.
- Familiar with the strengths and limitations of various experimental techniques used in condensed matter and materials physics.

Course Outcome:

Understand

1. X-ray and electron diffraction
2. Neutron diffraction
3. Electron microscopes (SEM, TEM)
4. Spectroscopic techniques (UV-visible, FTIR, RAMAN, XPS)
5. Scanning probe microscope (AFM and STM)

MODULE-I

(10 hours)

Crystallography:

Classification of Bravais lattices, Brillouin zone, X-ray diffraction (XRD), Bragg's law, Diffraction of x-rays in crystals via Laue, rotating crystal and powder method, miller indices, atomic form factor, geometric structure factor, systematic absences and analysis of simple patterns, intensity of diffraction lines in a powder pattern, peak widths, determination of lattice parameters, crystallite size and strain (device error, Williamson-Hall Method), diffraction of electrons and neutrons.

Crystal Binding:

Bond classifications – types of crystal binding, covalent, molecular and ionic crystals, London theory of van der Waals, hydrogen bonding, cohesive and Madelung energy, Vibrational Modes

MODULE-II

(10 hours)

Error Analysis:

Types of errors, Experimental uncertainty of single measurement and repeated measurements, Standard deviation, Propagation of error, Significant figures, Data Analysis

Imaging techniques:

Transmission electron microscope (TEM), scanning electron microscope (SEM), scanning Probe Microscope (SPM), Atomic Force Microscope (AFM), Scanning tunnelling Microscope (STM)

MODULE-III

(10 hours)

Spectroscopic techniques:

UV-Visible spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR) techniques, Raman, X-ray photoelectron spectroscopy, Energy Dispersive X-ray Fluorescence (EDXRF)

Text books:

- Materials Characterization: Introduction to Microscopic and Spectroscopic Methods: Y. Leng.
- Measurement, Instrumentation and Experiment Design in Physics and Engineering: M. Sayer and A. Mansingh (1999) Prentice Hall India Learning Private Limited 1st Edition.

Reference Books:

- Transmission Electron Microscopy: D. B. Williams, C. B. Carter.
- X-Ray diffraction: A practical approach: C. Suryanarayana, M. Grant Norton.

- Semiconductor material and device characterization: D. K. Schroder.
- Scanning Probe Microscopy: B. Voigtlände.
- An Introduction to Surface Analysis by XPS and AES: J. F. Watts, J. Wolstenholme.

Electronics

Marks-100

Course Objective:

- Understand operational principles, model and analysis of various operational amplifiers, Oscillators, digital circuits.
- Understand the model and analysis of radio communication and optical fibre.

Course Outcome:

1. Define the frequency response of linear amplifiers, and feedback amplifiers.
2. Explain and design differential amplifier, and integrator.
3. Describe feedback criteria for oscillation, crystal-controlled oscillator, Klystron oscillator, and the principle of multivibrator.
4. Analyze the basic logic operations of NOT, AND, OR, NAND, NOR, XOR and flip-flops.
5. Apply the basic principles of radio communications and antennas.
6. Explain the basic principles of optical fibres and electromagnetic wave propagation in optical fibre.

MODULE-I

(12 hours)

Amplifiers:

Frequency response of linear amplifiers, amplifier pass band, Direct, RC and Transformer coupled amplifiers, Frequency response, gain band-width product, Feedback amplifiers, effects of negative feedback, Boot-strapping the FET, Multistage feedback, stability in amplifiers, noise in amplifiers.

Oscillator Circuits:

Feedback criteria for oscillation, phase shift, Wien's bridge oscillator, crystal-controlled oscillator, Klystron oscillator, Principle of multivibrator.

MODULE-II

(12 hours)

Operational amplifiers:

The differential amplifiers, rejection of common mode signals. The operational amplifier input and output impedances, application of operational amplifiers, Unity-gain buffer, summing, integrating and differentiating amplifiers, comparators and logarithmic amplifiers.

Digital Circuits:

Logic fundamentals, Boolean theorem, Logic gates RTL, DTL and TTL gates, CMOS switch, RS flip- flop, JK flip-flop, Master-slave J-K flip-flop.

MODULE-III

(6 hours)

Radio Communication and Antenna:

Ionospheric propagation, Antennas of different types, superheterodyne, receiver (Block diagram). Various types of optical fibres and optical communications.

Text books:

- Electronic Fundamental and application: J . D. Ryder.
- Integrated Electronics: J. Millman, C. Halkias, C. D. Parika.
- Foundation of Electroni: D. Chattopadhyay, P.C. Rakshit, B. Saha, and N.N. Purkait.
- Optical Fibre Communication: G. Kaiser.

Reference Books:

- Int. Digital Electronics: N. W. Heap and G. W. Martin.
- Fundamentals of Optical Fibres: J. A. Buck.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: M.Sc., Programme: Physics, Duration: 2 years (Four Semesters)

Electromagnetic and Optics Laboratory

Marks-100

Course Objective:

- To analyze various situations or phenomena associated with electromagnetics and optics using basic principles.
- To introduce a broad range of physical phenomena involving optics, and electromagnetics.

Course Outcome:

1. Verify experimentally some of the laws and principles associated with electromagnetics and optics.

Experiments List:

1. Michelson's interferometer: determination of the wavelength of sodium lines.
2. Study of Fabry-Perot interferometer.
3. To study the Hall Effect in semiconductors and determine the Hall coefficient and Hall voltage.
4. To study the Hall Effect in semiconductors and determine the number density of charge carriers.
5. To study the Hall Effect in semiconductors and determine Hall mobility and Hall angle.
6. To determine the wavelength of (1) sodium and (2) Spectral lines of mercury light using plane diffraction Grating.
7. Calibration of magnetic field using Hall apparatus.
8. To study the interference using a laser and a double slit and find the wavelength of the He-Ne laser source.
9. Determination of thickness of air wedge and Newton's ring experiment.
10. Measurement of magneto-optic effect using Faraday effect.
11. Measurement of atomic spectra of discharge lamps (H_2, He, Ne).
12. Diffraction of light by straight edge using He-Ne laser.
13. Measurement of electro-optic coefficient using Kerr effect.
14. Diffraction of light by circular aperture (Pinhole).

Basic Electronics Laboratory

Marks-100

Course Objective:

- To examine the Frequency response of the operational amplifier
- To measure the frequency, amplitude and phase of signals using oscilloscopes.

Course Outcome:

1. Derive and determine various performances-based parameters and their significance for Op-Amp
2. Understand the characteristics of IC and Op-Amp and identify the internal structure
3. Analyze basic AC & DC circuits for voltage, current and power by using KVL, KCL, and network theorems
4. Use the basic logic gates and various reduction techniques of digital logic circuits in detail

Experiments List:

1. Frequency response of operational amplifier with and without feedback.
2. To study Astable multivibrator characteristics.
3. To study Bistable multivibrator characteristics.
4. To study Monostable multivibrator characteristics.
5. To design a phase shift oscillator using BJT.
6. To add two dc voltages using Op-amp in inverting and non-inverting mode.
7. To verify the superposition and maximum power transfer theorems.
8. To design a precision differential amplifier of given I/O specification using Op-amp.
9. To investigate the use of an op-amp as an Integrator.
10. To investigate the use of an op-amp as a Differentiator.
11. To study the characteristics of the Hartley oscillator.
12. To study the analog-to-digital converter (ADC) IC
13. To study the digital-to-analog converter (DAC) IC
14. To study the Sensitivity of the Wheatstone Bridge

THIRD Semester

Advanced Quantum Mechanics and Quantum Field Theory

Marks-100

Course Objective:

- To impart knowledge of advanced quantum mechanics for solving relevant physical problems.
- To deepen understanding of Quantum Mechanics.

Course Outcome:

1. A working knowledge of non-relativistic and relativistic quantum mechanics including time-dependent perturbation theory, relativistic wave equations, and second quantization.
2. Explain the relativistic quantum mechanical equations, namely, the Klein-Gordon equation and the Dirac Equation.
3. Describe the second quantization and relative concept
4. Explain the formalism of relative quantum field theory.
5. Derive a mathematical description of quantum motion in electromagnetic fields.
6. Apply the relativistic wave equations to simple single-particle problems.

MODULE-I

(10 hours)

Relativistic Quantum Mechanics:
Klein-Gordon equation, its solution and drawbacks, need for Dirac equation, Properties of Dirac matrices, Non-relativistic reduction of Dirac equation, magnetic moment, Darwin's term, Spin-Orbit coupling, Poincare transformation, Lorentz group, Covariant form of Dirac equation, Bilinear covariants, Gordon decomposition.

MODULE-II

(10 hours)

Dirac Equation for free particles and symmetry Properties:
Free particle solution of Dirac equation, Projection operators for energy and spin, Physical interpretation of free particle solution, Zitterbewegung, Hole theory, Charge conjugation, space reflection and time reversal symmetries of Dirac equation.

MODULE-III

(8 hours)

Continuous systems and fields. Transition from discrete to continuous systems, Lagrangian and Hamiltonian Formulations, Noether's theorem.

MODULE-IV

(12 hours)

Quantization of free fields:
Second quantization, Quantization of scalar and Dirac fields, Propagators for scalar, spinor and vector fields, Equal Time Commutators, Normal Ordering, covariant quantization of electromagnetic field, Gauge Invariance.

Text books:

- Advanced Quantum Mechanics: J. J. Sakurai.
- Relativistic Quantum Mechanics: J. D. Bjorken and S. D. Drell.
- Quantum Field Theory: F. Mandl and G. Shaw.

Reference Books:

- Quantum Field Theory: A Modern Introduction: Michio Kaku.
- Quantum Field Theory: C. Itzykson and J. Zuber.
- Quantum Field Theory: M. E. Peskin and D. V. Schroeder.
- Quantum Field Theory: L. H.Ryder.
- Quantum Field Theory: S. Weinberg.

Nuclear and Particle Physics

Marks-100

Course Objective:

- Introduce students to the fundamental principles and concepts governing nuclear and particle physics and have a working knowledge of their application to real-life problems.
- Provide students with opportunities to develop basic knowledge and understanding of scientific phenomena, facts, laws, definitions, concepts, theories, scientific vocabulary, terminology, conventions, scientific quantities and their determination, order-of-magnitude estimates, scientific and technological applications as well as their social, economic and environmental implications.

Course Outcome:

1. Explain the different forms of radioactivity and account for their occurrence
2. Master relativistic kinematics for computations of the outcome of various reactions and decay processes.
3. Account for the fission and fusion processes.
4. Explain the effects of radiation on biological matter.
5. Classify elementary particles according to their quantum numbers and draw simple reaction diagrams.

MODULE-I

(10 hours)

General nuclear properties:
Radius, mass, binding energy, nucleon separation energy, angular momentum, parity, electromagnetic moments, excited states.
Two Nucleon Problem:
Central and noncentral forces, deuteron and its magnetic moment and quadrupole moment; Force dependent on isospin, exchange forces, charge independence and charge symmetry of nuclear force, mirror nuclei.

MODULE-II

(10 hours)

Nuclear models & Structure:
Liquid drop model, fission, magic numbers, shell model, analysis of shell model predictions, beta stability line, collective rotations & vibrations, Form factor and charge distribution of the nucleus.

MODULE-III

(10 hours)

Nuclear reaction:
Energetics of nuclear reaction, conservation laws, classification of nuclear reaction, radioactive decay, radioactive decay law, production and decay of radioactivity, radioactive dating,
Alpha decay:
Gamow theory of alpha decay and branching ratios,
Beta decay:
Energetics, angular momentum and parity selection rules, compound nucleus theory, resonance scattering, Breit- Wigner formula, Fermi's theory of beta decay, Selection rules for allowed transition, parity violation.

MODULE-IV

(10 hours)

Particle Physics:
Particle classification, fermions and bosons, lepton favours, quark flavours, electromagnetic, weak and strong processes, Spin and parity determination, Isospin, strangeness, hypercharge, baryon number, lepton number, Gell-Mann-Nishijima Scheme,
Quarks in hadrons:
Meson and baryon octet, Elementary ideas of SU(3) symmetry, charmonium, charmed mesons and B mesons, Quark spin and need for colour degree.
Text books:
- Nuclear Physics, S. N. Ghosal.
- Nuclear Physics D C Tayal.

Reference Books:
- Nuclear physics, Satyaprakash.
- Nuclear and Particle Physics, Mital, Verma, Gupta.
- Atomic and Nuclear physics, Shatendra Sharma.

Basic Condensed Matter Physics

Marks-100

Course Objective:

- The objective of the course is to understand the crystal structure, crystal bonding types in solid and study the lattice dynamics as well as magnetic properties.
- In addition to this the student will be familiarized with the semiconductor materials, nanomaterials and superconducting materials.

Course Outcome:

1. Identify the difference between direct space and reciprocal lattice space
2. Describe the mode of vibrations and Dispersion relation
3. Apply specific heat equation for the metal and insulator
4. Analyze the properties of superconductor, cooper pair and energy gap in superconductor and high Tc superconductor

MODULE-I

(10 hours)

Diffraction by crystals:

X-rays, Electrons and Neutrons, Symmetry operations and classification of Bravais lattices, common crystal structures, reciprocal lattice, space groups, translational symmetry of crystals, symmetry operations in space groups, Brillouin zone, X-ray diffraction, Bragg's law, Von Laue's formulation, diffraction from non-crystalline systems, Geometrical factors of SC, FCC, BCC and diamond lattices; Basis of quasi-crystals.

Crystal Binding:

Bond classifications – types of crystal binding, covalent, molecular and ionic crystals, London theory of van der Waals, hydrogen bonding, cohesive and Madelung energy.

MODULE-II

(10 hours)

Lattice Dynamics:

Born-Oppenheimer Approximation, Hamiltonian for lattice vibrations in the harmonic approximation, Failure of the static lattice model, adiabatic and harmonic approximation, vibrations of linear monatomic lattice, one-dimensional lattice with basis, models of three-dimensional lattices, quantization of lattice vibrations, Einstein and Debye theories of specific heat, Specific heat of metal, phonon density of states, neutron scattering.

Magnetism and Ferro electricity:

Langevin's theory of dia- and para-magnetism, Landau diamagnetism and Pauli paramagnetism, Weiss theory of ferromagnetism, Curie Weiss law of susceptibility, Heisenberg model- condition for ferro and anti-ferromagnetic order, Anti ferro magnetic order, Neel temperature.

Ferroelectric crystals, classification of Ferroelectric crystals, Multiferroics-Elementary concept

MODULE-III

(10 hours)

Band theory of Solids:

Wave equation for an electron in a periodic potential, Bloch functions, Brillouin zones E-K diagram under free electron approximation, Density of state in one dimension, effect of temperature on Fermi-Dirac distribution, Free electron gas in three dimensions, heat capacity of electron gas, electrical and thermal conductivity of metals. Nearly free electron approximation-Diffraction of electrons by lattice planes and opening of a gap in E-K diagram. The effective mass of electrons in crystals, Holes, Kronig Penney model, Tight binding approximation.

MODULE-IV

(10 hours)

Nanomaterials:
Nano structured materials-Classification based on spatial extension (0-D, 1-D, 2-D). 0-D nanostructures-quantum dots, Widening of band gap in quantum dots, 1-D nano structures-Quantum wells-super-lattices.

Superconductivity:
Phenomenology, review of basic properties, Meissner effect, Type-I and Type-II superconductors, thermodynamics of superconductors, London's phenomenological theory, flux quantization, Cooper instability, BCS theory of superconductivity, Superconducting ground state and gap equation at T= 0K. Josephson effects, Ginzburg- Landau theory, SQUID, High Tc superconductors.

Text books:

- Introduction to Solid State Physics: C. Kittel, Wiley .
- Solid State Physics, Brooks/Cole: N. W. Ashcroft and N.D. Mermin.
- Principles of the Theory of Solids, Cambridge University Press: J. M. Ziman.
- Solid State Physics: J. Dekker, Macmillan.
- Superconductivity: V. L. Ginzburg and E. A. Andryushin (World Scientific, 1994)
- Introduction to Superconductivity and high: Tc materials by Michel Cyrot and Davor Pavuna, (World Scientific, 1992).
- Fundamentals of Crystallography: C. Giacovazzo, H. L. Monaco, D. Viterbo, F. scordari, G. Gilli, G. Zanotti, M. Cattl (Oxford University Press).

Reference Books:

- Solid State Physics: G. Burns, Academic Press.
- Condensed Matter Physics: M. P. Marder, Wiley.
- Principles of Condensed Matter Physics: P. M. Chaikin and T. C. Lubensky, Cambridge University Press.
- Introduction to Superconductivity: M. Tinkham, CBS.
- Group Theory and Its Applications in Physics: T. Inui, Y. Tanabe and Y. Onodera, (Springer Series in Solid-State Sciences).
- Introduction to Superconductors: K.H. Bennemann, J. B. Ketterson.
- The Physics of quasicrystals: P.J. Steinhardt and S. Ostulond.

Nano Science and Technology

Marks-100

Course Objective:

- Gain scientific knowledge regarding nanomaterials and the size-dependent properties of nanomaterials which form basic principles for new-generation advanced devices.
- Provide students with opportunities to develop an understanding of basic scientific phenomena, structural modifications and property variation at the nano level.

Course Outcome:

1. Understand the basic properties of nanostructured materials and their device applications.
2. Provide basic ideas regarding carbon nanostructures such as C_{60} molecule, carbon nanotubes, and their applications.
3. Learn various synthesis techniques for nanomaterial fabrication.
4. Study nanostructured crystals and their physical properties.

MODULE-I (10 hours)

Nanostructured Materials: Classification based on spatial extension (0-D, 1-D, 2-D), Surface to volume ratio and quantum confinement, Density of states, Preparation of quantum nanostructures (top-down and bottom-up approach), Size effects, Excitons, Single electron tunnelling, Applications: infrared detectors, Quantum Dot Lasers

Properties of individual Nanoparticles: Metal nanoclusters: Magic numbers, Theoretical modelling of nanoparticles, Geometric structure, electronic structures, reactivity, fluctuations, magic clusters, Bulk to nano striction, Semiconducting Nanoparticles: Optical properties, photo fragmentation, Coulombic explosion, Photoluminescence, thermo luminescence

MODULE-II (10 hours)

Carbon nanostructures: Carbon molecules: Nature of the carbon Bond, New carbon structures Small Carbon Clusters, Discovery of C60, Structure of C60 and its crystal, Alkali-doped C_{60}, Larger and Smaller Fullerenes, Other Bucky ball

Carbon nanotubes: Fabrication, Structure, Electrical properties, Vibrational properties, Mechanical properties

Applications of carbon nanotubes: Field emission and shielding, computers, Fuel cells, Chemical Sensors, Catalysis, Mechanical Reinforcement

MODULE-III (10 hours)

Bulk Nanostructured materials: Solid Disordered Nanostructures: Methods of synthesis, Failure mechanism of Conventional Grain- Sized Materials, Mechanical properties, Nanostructured Multilayers, Electrical properties, other properties, Metal Nanocluster Composite Glasses, Porous Silicon

Nanostructured Crystals: Natural Nanocrystals, Computational Prediction of Cluster Lattices, Arrays of nanoparticles in Zeolites, Crystals of Metal Nanoparticles, Nanoparticle Lattices in Colloidal suspensions, Photonic Crystals

Physical Properties of Nanostructured Materials: Effect of size reduction on magnetic and electric behaviour of materials, Dynamics of nanomagnets, Ferro fluids

Text books:

- Introduction to Nanotechnology: C. P. Poole, (Jr.), F. J. Owens.
- Nanocrystal Quantum dots: Victor I. Klimov (Second Edition).
- Solid State Physics: C. Kittel (Eighth Edition).

References Books:

- Solid State Physics: N. W. Ashcroft and N.D. Mermin.
- Principles of the Theory of Solids: J. M. Ziman, Cambridge University Press.
- Solid State Physics: A. J. Dekker, Macmillan.
- Superconductivity: V. L. Ginzburg and E. A. Andryushin (World Scientific, 1994).
- Introduction to Superconductivity and high-Tc materials: M.l Cyrot and D. Pavuna, (World Scientific, 1992).
- Fundamentals of Crystallography: C. Giacovazzo, H. L. Monaco, D. Viterbo, F. scordari, G. Gilli, G. Zanotti, M. Cattl (Oxford University Press).

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: M.Sc., Programme: Physics, Duration: 2 years (Four Semesters)

Advanced Electronics Laboratory

Marks-100

Course Objective:

- To give knowledge of some basic electronic components and circuits.
- To give handsome train or in electronic instruments and devices.

Course Outcome:

1. Study basic circuits using diodes and transistors.
2. Introduce the basics of diode and transistor circuits.
3. Understand the working of some IC-based circuits.
4. Study logic gates and their usage in digital circuits.
5. Analyse basic AC & DC circuits for voltage, current and power by using KVL, KCL, and network theorems.
6. Use the basic logic gates and various reduction techniques of digital logic circuits in detail.

Experiments List:

1. Study of a basic configuration of OP-AMP (IC-741), simple mathematical operations and its use as comparator and Schmidt trigger
2. Study and design of differentiator, integrator and active filter circuits using OP-AMP (IC-741)
3. Study and design of phase shift oscillator using OP-AMP (IC-741)
4. Study of various logic families (DRL, DTL and TTL)
5. Study of Boolean logic operations using ICs
6. Design and study of full adder and subtractor circuits
7. Study of various stages of digital voltmeter.
8. Design and study of various counter circuits (up, down, ring, mod-n)
9. Design and study of astable multivibrators using IC-555 Timer
10. To design and study a monostable multivibrator of given specifications using 555 Timer.
11. To design a digital-to-analogue converter (DAC) of given specifications
12. Design and performance study of a constant current source
13. Design and performance study of a voltage-controlled oscillator
14. To design a switch (NOT gate) using a transistor.
15. To design and study of Wien bridge oscillator for a given frequency using an op-amp.
16. Study of various stages of the digital frequency counter.

Basic Condensed Matter Physics Laboratory

Marks-100

Course Objective:

- To develop understanding on the properties of matter.
- To give hands-on training in studying different material characteristics.

Course Outcome:

1. Study electrical, and magnetic properties.
2. Analysis mechanical, Optical Properties.

Experiments List:

1. Study of energy gap and resistivity of Germanium by four-probe method.
2. To draw the B-H curve of Fe using Solenoid & determine energy loss from Hysteresis.
3. Verification of Richardson's T3/2 law.
4. Study of Platinum resistance thermometer using Calendar and Griffith's bridge.
5. Determination of Young's modulus of a given specimen by the Coronus method
6. To determine the Coupling Coefficient of Piezoelectric crystal.
7. Determination of Planck's constant by reverse photoelectric effect method.
8. To study the PE Hysteresis loop of a Ferroelectric Crystal.
9. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
10. Dielectric constant at microwave frequency
11. To study the reflection, and refraction of microwaves
12. To study the current vs voltage characteristics of CdS photo-resistor at constant irradiance
13. To measure the photocurrent as a function of the irradiance at constant voltage
14. Determination of reverse saturation current of P-N junction

---

Literature Review and Seminar

Marks-100

Course Objective:

- To learn, practice, and critique effective scientific seminar skills.
- These skills will improve as students respond to critical feedback, and seek to make scientific information. understandable to scientists, peers, and the general public.

Course Outcome:

1. Communicate scientific discoveries in materials/devices for 30–40-minute oral presentation.
2. Understand and critique scientific presentations.

General Aspects of Oral Presentation: Presented at the level that is appropriate to the audience; clear and informative visual aids (simple, sufficient time); evident that the presenter has practised.

Introduction: Overview of your problem area provided; unfamiliar terms introduced; appropriate literature abstracted and presented clearly; research hypothesis of the study identified.

Methods: Brief overview of the equipment and materials used, and how obtained; a brief overview of the experimental design used and any other parts of the methods employed; materials and/or equipment described; procedures followed to experiment presented

Results: Anticipated and actual results reported; statistics presented.

Discussion: Implications if the hypothesis is supported clearly stated; implications if the hypothesis is not supported clearly stated; limitations of your study discussed; future research addressed

Questions: Demonstrated knowledge of the material; poised and confident, but no bluffing; answered the question(s) asked (asked for clarification or restatement of the question)

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: M.Sc., Programme: Physics, Duration: 2 years (Four Semesters)

FOURTH Semester

Atomic and Molecular Physics

Marks-100

Course Objective:

- Describe the atomic emission/absorption spectrophotometry and molecular spectroscopy.
- Explain the rotational, vibrational, electronic and Raman spectra of molecules.

Course Outcome:

1. Describe the function of one electron atom.
2. Explain the Hyperfine structure and calculate the energy spectrum of many-electron atoms.
3. Describe the Molecular electronic state of diatomic molecules and discuss the electronic wave function.
4. The detailed studies of rotational and vibrational spectra of diatomic molecules distinguish between the different spectra of diatomic molecules.
5. Discuss the fine structure and solves the problems.
6. Explain the vibration of a polyatomic molecule using the group theory.

MODULE-I

(10 hours)

One Electron Atom:
Introduction: Quantum States; Atomic orbital; Parity of the wave function; Angular and radial distribution functions.

Hyperfine structure:
Review of Fine structure and relativistic correction, Lamb shift. Hyperfine interaction and isotope shift; Hyperfine splitting of spectral lines; selection rules.

Many electron atoms:
Independent particle model; He atom as an example of central field approximation; Central field approximation for many-electron atoms; Slatter determinant; L-S and j-j coupling; Equivalent and non-equivalent electrons; Energy levels and spectra; Spectroscopic terms; Hunds rule; Lande interval rule; Alkali spectra.

MODULE-II

(10 hours)

Molecular Electronic States:
Concept of molecular potential, Separation of electronic and nuclear wave functions, Born-Oppenheimer approximation, Electronic states of diatomic molecules, Electronic angular momenta, Approximation methods for the calculation of electronic Wave function, The LCAO approach, States for Hydrogen molecular ion, Coulomb, Exchange and Overlap integrals, Symmetries of electronic wave functions; Shapes of molecular orbital and bond; Term symbol for simple molecules.

Rotation and Vibration of Molecules:
Solution of nuclear equation; Molecular rotation: Non-rigid rotator, Centrifugal distortion, Symmetric top molecules, Molecular vibrations: Harmonic oscillator and the anharmonic oscillator approximation, Morse potential.

MODULE-III

(10 hours)

Spectra of Diatomic Molecules:
Transition matrix elements, Vibration-rotation spectra: Pure vibrational transitions, Pure rotational transitions, Vibration-rotation transitions, Electronic transitions: Structure, Franck-Condon principle, Rotational structure of electronic transitions, Fortrat diagram, Dissociation energy of molecules, Continuous spectra, Raman transitions and Raman spectra.

Vibration of Polyatomic Molecules:

Application of Group Theory, Molecular symmetry; Matrix representation of the symmetry elements of a point group; Reducible and irreducible representations; Character tables for C2v and C3v point groups; Normal coordinates and normal modes; Application of group theory to molecular vibration.

Text books:

- Physics of Atoms and Molecules: B. H. Bransden and C. J. Joachain.
- Fundamentals of Molecular Spectroscopy: C. B. Banwell.

Reference Books:

- Quantum Mechanics vol. 1 and 2: C. Cohen,Tannoudji, B. Dier, and F. Laloe.
- Spectra of Diatomic Molecules: H. Herzberg.
- Molecular Spectroscopy: J. D. Graybeal.
- Principles of Quantum Mechanics: R. Shankar.
- Molecular Spectroscopy: G. M. Barrow.
- Lasers, Theory and Applications: K. Thyagarajan and A. K. Ghatak.
- Principles of Lasers: O. Svelto.
- Quantum Chemistry: B. H. Eyring, J. Walter and G. E. Kimball.
- Molecular Physics: W. Demtroder.
- Atomic and Molecular Spectroscopy: M. C. Gupta.
- Lasers and Non-linear Optics: B. Laud.
- Spectrophysics Thorne: U. Litzen and J. Johnson.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: M.Sc., Programme: Physics, Duration: 2 years (Four Semesters)

Professional Elective

Advanced Condensed Matter Physics

Course Objective:

- The objective of the course is to discuss the basic principles responsible for several properties of solids. Different theories related to electron interaction and magnetism will be discussed in detail.
- In addition to this the students will be familiar with their optical properties and also have insights into the defects in solids.

Course Outcome:

Upon successful completion of this course, students will have/ be able:

1. Explain the basic principles underlying solids scientifically.
2. State and derive different types of magnetism in mathematical forms like the Curie –Weiss law for susceptibility
3. Understand the Landau theory of phase transition
4. Describe the Kramers-kronig relation for dielectric materials
5. Understand the Defects in solids
6. A broad understanding of the optical properties of solids.

Marks-100

MODULE-I

(12 hours)

Magnetism:

Classification of different types of magnetism: Diamagnetism, Paramagnetism, Ferromagnetism, Anti-ferromagnetism, Ferrimagnetism, Helical order. Ferromagnetic domains, Magnetic anisotropy energy, Hysteresis. Heisenberg and Ising Model, Excitations: magnon contribution to specific heat, Bloch's $T^{3/2}$ Law. Frustration, spin glasses, superparamagnetism, 1D and 2D magnets.

Transport Properties:

The Boltzmann equation electrical conductivity, general transport coefficients, thermal conductivity, thermoelectric effect, Magneto-resistance: Magneto-resistance of ferromagnets, anisotropic magnetoresistance, Giant magneto-resistance and Colossal magnetoresistance, Hall effect, Elementary ideas on Quantum Hall Effect.

MODULE-II

(10 hours)

Electron Interaction:

Perturbation formulation, Hartree Equation, Hartree-Fock Equation, Dielectric function of an interacting electron gas (Lindhard‟s expression), Static screening, Thomas-Fermi theory of Screening, Screened impurity, Kohn effect, Friedel Oscillations and sum rule, Dielectric constant of semiconductor, Plasma oscillations.

MODULE-III

(10 hours)

Optical properties of solids:

The dielectric function: the dielectric function for a harmonic oscillator, dielectric losses of electrons, Kramers-Kronig relations, Interaction of phonons and electrons with photons, Interband transition - direct and indirect transition; Absorption in insulators, Polaritons; One-phonon absorption; Optical properties of metals, skin effect and anomalous skin effect.

MODULE-IV

(08 hours)

Fermi Surface:

Experimental methods of study of Fermi surface, Cyclotron Resonance, de Hass van Alphen effect.

Defects in Crystals:

Lattice defects, Frenkel and Schottky defects. Line defects, edge and screw dislocations – Burger‟s vector, planner (stacking) faults-twin planes and grain boundaries, dislocation densities, dislocation multiplication and slip strength of crystal, color centers, polarons and excitons.

Text books:

- Magnetism in Condensed Matter: Stephen Blundell, Oxford University Press.
- Magnetism and Magnetic Materials: J. M. D. Coey, Cambridge University Press.
- Introduction to Magnetic Materials: B. D. Cullity, Wiley.
- Introduction to Solid State Physics: C. Kittel, Wiley.
- Solid State Physics: N. W. Ashcroft and N.D. Mermin, Brooks/Cole.
- Principles of the Theory of Solids: J.M. Ziman, Cambridge University Press.
- Advanced Solid-State Physics: P. Phillips, Overseas Press, India Pvt. Ltd.
- Solid State Physics: A. K. Saxena, Trinity Publication.

Reference Books:

- Introduction to Modern Solid-State Physics: Y. M. Galperin.
- Introduction to Solids: N.W. Ashcroft, N.D. Mermin.
- Elementary Solid-State Physics: A. Omar.
- Solid state physics: A.J. Dekkar Macmillan, London.
- Solid State Physics: H.E. Hall.
- Introduction to Modern Solid-State Physics: Y. M. Galperin.
- Principles of Condensed Matter Physics: P.M. Chaikin and T.C. Lubensky.
- Solid State Physics, Essential Concepts: D. W. Snoke, Pearson Education (2009).

Advanced Particle Physics

Mark-100

Course Objective:
- Understand the mathematical formalism of field theory and use them for elementary particles.
- Understand various phenomena discovered in particle physics in projection to discovery.

Course Outcome:
1. Explain the properties of various elementary particles.
2. Derivation of relevant mathematical formalism (group theoretical/ integral) for the different processes associated with elementary particles.

MODULE-I (10 hours)

Symmetry: Different types of symmetries and conservation laws. Noethers' theorem.
Symmetry groups and Quark model: SU(2) and SU(3): quark model, colour, heavy quarks and their hadrons.

MODULE-II (10 hours)

Lorentz Group: Continuous and discrete transformations, Group structure, Proper and improper Lorentz Transformations, SL(2, C) representations, Poincare group.
Interacting fields: Interaction picture, covariant perturbation theory, S-matrix, Wicks theorem, Feynman diagrams.

MODULE-III (10 hours)

QED: Feynman rules, Example of actual calculations: Rutherford, Bhabha, Moeller, Compton, $e^+ e^- \longrightarrow \mu^+ \mu^-$. Decay and scattering kinematics. Mandelstam variables and use of crossing symmetry.
Gauge theories: Gauge invariance in QED, non-abelian gauge theories, QCD (introduction), Spontaneous symmetry breaking, Higgs mechanism.

MODULE-IV (10 hours)

Weak Theory: Classification of weak interactions, Parity violation, Elementary notions of leptonic decay of strange particles. Cabibbo-angle and Cabibbo hypothesis.
Electroweak Theory: Weak Isospin and hypercharge. Basic electro-weak interaction. Spontaneous symmetry breaking. Standard Model, Gauge boson and fermion masses.

Text books:
- Introduction to elementary particles: David J Griffith.
- Quantum Field Theory: M. Peskin and F. Schroeder:

Reference Books:
- Quantum Field Theory: A Modern Introduction: M. Kaku.
- Relativistic Quantum Fields: J. D. Bjorken and S. D. Drell.
- Introduction to Gauge Field Theory: D. Bailin and A. Love.
- A First Book of Quantum Field Theory: A. Lahiri and P. B. Pal.
- A Modern Primer Quantum Field Theory: F. Mandl and G. Shaw.
- Field Theory: P. Ramond.
- Quantum Field Theory: C. Itzykson and J. B. Zuber.
- Quarks and Leptons: F. Halzen and A. D. Martin.
- Dynamics of the Standard Model: J. Donoghue, E. Golowich and B. Holstein.
- Gauge Theories in Particle Physics: T. -P. Cheng and L. -F. Li.
- An Introduction to Gauge Theories and Modern Particle Physics: E. Leader and E. Predazzi.
- An Introduction to Quarks and Partons: F. E. Close.

Vacuum Technology and Cryogenics

Marks-100

Course Objective:

- Understand the concepts of pressure and vacuum.
- Understand the need for a vacuum for certain applications.
- Understand the procedure for creating a vacuum with related instruments.

Course Outcome:

1. Application of vacuum at various instruments (specific pumps).
2. Use of vacuum pumps in sequences. (i.e. in sputtering, TEM, etc..).
3. Know the use of gas cylinders, gas flow, clamps and valves.

MODULE-I (10 hours)

Behaviour of gases; Gas Transport phenomenon, Viscous, molecular and transition flow regimes, measurement of pressure, Residual gas analyses.

MODULE-II (10 hours)

Production of vacuum-mechanical pumps, Diffusion pumps, Getter and ion pumps, cryopumps, the material used in a vacuum; high vacuum and ultra-high vacuum systems; Leak detection, Vacuum gauges

MODULE-III (10 hours)

Properties of engineering material at low temperature; cryogenic fluids-Hydrogen, Helium3, Helium4, superfluidity, experimental method at low temperature: closed cycle, Refrigerators, single and double cycle He 3 refrigerator, He4 refrigerator, He3-He4 dilution refrigerator, pomeranchuk cooling, pulsed refrigerator system, magnetic refrigerator, Thermoelectric coolers; Cryostat Design: Cryogenic level sensors, Handling of cryogenic liquids, Cryogenic thermometry**.**

Text book:

- Handbook of Vacuum Science and Technology Edited by: Dorothy M. Hoffman, Bawa Singh, John H. Thomas III and John H. Thomas III, ISBN: 978-0-12-352065-4.
- The Art of Cryogenics, 1st Edition, Low-Temperature Experimental Techniques, Guglielmo Ventura Lara Risegari.

Reference Book:

- Vacuum Science and Technology: V.V. Rao, T.B. Gosh, K.L. Chopra.
- Vacuum Science, Technology and Applications: Pramod K. Naik.

Material Science

Marks-100

Course Objective:

- Understand the mechanical, thermal, dielectric, magnetic and optical properties of various materials.
- Understand the broad classification of advanced materials.

Course Outcome:

1. Identify mechanical, thermal properties of materials and their optical phenomena.
2. Discuss various properties of dielectric materials, plasmons, polarons, polaritons .
3. Demonstrate fundamentals on magnetic materials properties and their application.
4. Classify advanced materials and their properties.

MODULE-I

(12 hours)

Mechanical Properties: Tensile Strength, stress-strain behavior, ductile and brittle material, toughness, hardness, fatigue, creep and fracture.

Thermal properties: Thermal conductivity, thermoelectric effects, heat capacity, thermal stress.

Application to optical phenomena: Luminescence, photoconductivity, LED materials, optical fibers in communication. Lasers: Basic elements of a laser, population inversion, optical resonators, Q-switching and mode locking, three and four-level laser system: Ruby, He- Ne and semiconductor diode laser.

MODULE-II

(12 hours)

Dielectrics, Plasmons, polarons, and Polaritons:

Fundamental of dielectrics: Dielectric constant and polarizability, mechanism of polarization, kinds of polarization, molecular field in a dielectric, Clausius-Mossotti equation, classical theory of electronic polarizability, frequency dependent polarization, dielectric loss, dielectric relaxation, dielectric breakdown. Ferroelectricity: Theory, types and properties of ferroelectrics, domains, imperfections and polarization reversals, Polarization catastrophe, Soft optical phonons, Landau theory of phase transition-second and first-order transition, antiferroelectricity, piezoelectricity and pyroelectricity. Metal plasma, plasmon excitation, electron-phonon interaction in ionic crystals (polarons). Ionic polarization: Application to long wavelength optical modes of ionic crystals, condition for transverse optical mode, the interaction of electromagnetic waves with optical modes (polaritons).

Magnetic properties: Exchange interactions: direct and indirect interactions, magnetic anisotropy, hard and soft magnetic materials, magnetic bubbles, spin waves (magnons), magnetoresistance, GMR materials, dilute magnetic semiconductor (DMS) materials, technological application in memory devices, sensors.

MODULE-III

(6 hours)

Soft condensed matter: Polymeric materials: Thermosetting and thermoplastics.

Composite materials: Fibre reinforced composites, Polymer matrix composites, Metal-matrix composites, Ceramic-matrix composite, Carbon-carbon composites.

Ceramic materials: Properties and applications of ceramic materials.

Advanced materials: Brief description of corrosion resistant materials, nanophase materials, metallic glasses**,** smart materials, piezoelectric, magnetostrictive, electrostrictive materials, shape memory alloys, rheological fluids, CCD device materials.

Text book:

- Material Science and Engineering: W. D. Callister, Jr. D. G. Rethwisch, Wiley.
- Materials Science: M Vijaya, Rangarajan G, McGraw Hill Education.

Reference Book:

- Materials Science of Thin Films, Deposition and Structure: M. Ohring.
- Elements of Material Science and Engineering: V. Vlack.

- Introduction to Polymer Science and Technology: N. B. Singh, S. S. Das.
- Polymer Science and Technology: J. R. Fried.
- Ceramic Materials: Synthesis, Performance and Applications: J. Perez.
- Advanced Structural Ceramics: B. Basu, K. Balani.
- Introduction to Laser Technology: C. B. Hitz, J. J. Ewing, J. Hecht.
- Laser System and Applications: V. Saluja,Satya Prakash.
- Lasers and Optoelectronics: Fundamentals, Devices and Applications: A. K. Maini.
- Materials Science and Engineering: V. Raghavan.

Modern Physics Laboratory

Marks-100

Course Objective:

- To introduce students to the principles and operations of modern physics experiments.

Course Outcome:

1. Express the energy and Balmar series of the Hydrogen spectrum.
2. Know about the Millikan oil drop experiments.
3. Demonstrate the energy spectrum of the Normal Zeman effect.
4. Explain the change in intensity as polarized light passes through a polarizing filter.
5. Explain the working principle of lasers
6. Calculate the Rydberg constant of the hydrogen spectrum.

Experiments List:

1. To study the different spectra (up to 3rd order of Balmer series of Hydrogen spectra and estimate the Rydberg constant.
2. To set up the Millikan oil drop apparatus and determine the charge of an electron.
3. To demonstrate the quantum nature of charge using the Millikan oil drop apparatus
4. Existence of discrete energy level by Frank Hertz experiment.
5. To study the effect of filament voltage and anode plate voltage on the Frank-Hertz characteristic curve for neon
6. Study of polarization using Malus Law.
7. Determination of Brewster's angle.
8. To analyze elliptically polarized Light by using a Babinets compensator.
9. To study damping oscillations in various mediums.
10. Rectification by junction Diode using various filters.
11. Study of junction capacitance of P-N junction
12. To study the Normal and Anomalous Zeeman effect
13. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece

----

Project

Marks-100

Course Objective:

- To carry out research on a certain topic given by the supervisor.
- To do literature survey

Course Outcome:

1. To present research outcome in the seminar.
2. Submit a project thesis
3. Able to answer the question of the examiner.

Project evaluation guidelines:

Every student will have to complete the project in the Semester with 100 marks. Students can take one long project (especially for SSP / SSE / Material Sc. / Nanotechnology / Nuclear /Particle physics etc). However, for the project students have to submit a dissertation consisting of the problem definition, literature survey and status, objectives, methodology, experimental work, results and analysis. The project can be theoretical or experimental, related to advanced topics, electronic circuits, models, industrial projects, training in a research institute, training in handling sophisticated equipment etc. A maximum of three students can do a joint project. Each one of them will submit a separate project report with details/parts only he/she has done. However, he/she can in brief (on page one or two) mention in the Introduction section what other group members have done. In the case of electronic projects, the use of readymade electronic kits available in the market should be avoided. The electronics project/models should be demonstrated during the presentation of the project. In case a student takes training in a research institute/training of handling sophisticated equipment, he/she should mention in a report what training he/she has got, which instruments he/she handled and their principle and operation etc.

Each project will be 100 marks by internal evaluation.

The project report should be le bound/spiral bound/hardbound and should have the following format

- Title Page/Cover page
- Certificate endorsed by Project Supervisor and Head of Department
- Declaration
- Abstract of the project
- Table of Contents
- List of Figures
- List of Table

Chapters of Content:

- Introduction and Objectives of the Project Experimental/Theoretical
- Methodology/Circuit/Model etc. details Results and Discussion if any
- Conclusions
- References

Evaluation by the Internal examiner will be based on the following criteria:

Criteria	Maximum Marks
Literature Survey	10
Objectives/Plan of the project	10
Experimental/Theoretical methodology/Working condition of project or model	20
Significance and originality of the study/Society application and Inclusion of recent References	10
Depth of knowledge in the subject / Results and Discussions	20
Presentation	30
Total marks	100

Professional Elective

Advanced Condensed Matter Physics Laboratory

Marks-100

Course Objective:

- To introduce students to advanced condensed matter physics experiments
- To get knowledge on the characteristics of different materials

Course Outcome:

1. Explain Lande's g factor using ESR
2. Analyze magnetic susceptibility by Gacoy-ballance
3. Study the characteristics of MOSFET, Thermo-EMF of a thermocouple
4. Study various techniques ; XRD, SEM, and UV visible spectroscopy.

Experiments List:

1. Determination of magnetic susceptibility by Guoy-balance.
2. Measurement of Lande's g factor of DPPII by ESR at Microwave frequency.
3. To observe the Meissner effect and determine the transition temperature of a given superconductor.
4. To study MOSFET characteristics.
5. Determination of Thermo-EMF of a thermocouple
6. Determination of Magnetoresistance of Bismuth.
7. To characterize Solar cells and find out their power conversion efficiency.
8. To determine the Dielectric constant of solid (wax) by Lecher Wire
9. To study lattice vibrations in mono- and di-atomic lattice using a lattice dynamics kit.
10. Preparation of thin film using spin coating techniques
11. Study of the lattice parameter of a given material using X-ray diffraction technique
12. To determine the magnetic moment of an electron using ESR equipment 1
13. To study the dielectric properties of a given substance using an Impedance analyzer
14. Characterization of a given nanomaterial by Scanning electron microscope
15. To verify the Beer-Lambert law using a UV-visible spectrometer.

Advanced Particle Physics Laboratory

Marks-100

Course Objective:

- To understand the detection principles and mechanism of various detectors.

Course Outcome:

1. Calibrate the detectors and obtain the data
2. Analyze the data obtained from various detectors.
3. Carry out error analysis and need for improvement.

Experiments List:

1. Calibration of the x-ray spectrometer and determination of x-ray energy of unknown sources.
2. Determination of resolving power of x-ray spectrometers.
3. Study of β spectrum.
4. Determination of absorption coefficient of Aluminum using G. M Counter.
5. X-test and operating point determination using G-N tube.
6. Characteristics of G. M. counter.
7. Study of surface barrier detector.
8. Study of counter technique.
9. Study of single channel analyzer.
10. Study of the photodetector and photomultiplier.
11. Study of wide-band amplifier.
12. Emulsion photograph studies

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: M.Sc., Programme: Physics, Duration: 2 years (Four Semesters)

Contents

FIRST Semester 3
Theory 3
Classical Mechanics 3
Mathematical Methods in Physics 4
Quantum Mechanics-I 5
Electrodynamics 7
Research Methodology 9
Fundamentals of Computer and Programming in C 10
Practical 11
General Physics Laboratory 11
Programming in C Laboratory 12
Advanced Computational Physics Laboratory 14
SECOND Semester 16
Theory 16
Statistical Mechanics 16
Physics of Semiconductor Devices 17
Quantum Mechanics-II 19
Experimental Techniques 21
Electronics 22
Practical 23
Electromagnetic and Optics Laboratory 23
Basic Electronics Laboratory 24
THIRD Semester 25
Theory 25
Advanced Quantum Mechanics and Quantum Field Theory 25
Nuclear and Particle Physics 26
Basic Condensed Matter Physics 27
Nano Science and Technology 29
Practical 31
Advanced Electronics Laboratory 31
Basic Condensed Matter Physics Laboratory 32
Literature Review and Seminar 32
FOURTH Semester 34
Theory 34
Atomic and Molecular Physics 34
Theory: Professional Elective 35
Advanced Condensed Matter Physics 35
Advanced Particle Physics 37
Vacuum Technology and Cryogenics 38
Material Science 39
Practical 41
Modern Physics Laboratory 41
Project 41
Practical: Professional Elective 43
Advanced Condensed Matter Physics Laboratory 43
Advanced Particle Physics Laboratory 43