**SYLLABUS**

**FOR**

**FIVE-YEAR INTEGRATED M.Sc. PROGRAMME**

**IN**

**APPLIED PHYSICS**



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| **NAAC – A Grade** |

**DEPARTMENT OF PHYSICS**

**COLLEGE OF ENGINEERING & TECHNOLOGY**

**(An Autonomous and Constituent College of BPUT, Odisha)**

**Techno Campus, Mahalaxmi Vihar, Ghatikia,**

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**Semester-1**

**Core-1: Classical Mechanics & Special Theory of Relativity (IPCPH101)**

**Course Objectives**

**This Course Enables the Student**

1. To know the importance of concepts such as generalized coordinates and constrained motion
2. How to represent the equations of motion for complicated mechanical systems using the Lagrangian and Hamiltonian formulations of classical mechanics.
3. To distinguish between ‘inertia frame of reference’ and ‘non-inertial frame of reference
4. Introduce students to the concept of special relativity and its applications to Physical Sciences, and provide students with knowledge and proof of the validity of Physical Laws and nonexistence of the hypothetical stationary ether.

**Module-I**

***Newtonian Mechanics***

Mechanics of a Particle: Conservation of linear momentum, Conservation of angular momentum, Conservation of energy.

Mechanics of a System of Particles: External and internal forces, Centre of mass, conservation of linear momentum, Centre of mass-frame of reference, Conservation of angular momentum, Conservation of energy.

**Module-II**

***Lagrangian Dynamics***

Constraints: Holonomic constraints, Nonholonomi constraints, Forces of constraints. Generalized coordinates, Principle of Virtual Work, D’ Alembert’s principle, Lagrangian’s equation from D’ Alembert’s principle, Procedure for formation of Lagrange’s equations, Lagrange’s equation in presence of Non-conservative forces, Generalized Potential-Lagrangian for a charged particle moving in an Electromagnetic field.

**Module-III**

***Hamiltonian Dynamics***

Generalized momentum and cyclic coordinates, Conservation theorems and Symmetry properties, Conservation of linear momentum, Conservation of angular momentum, Significance of translation and rotation cyclic coordinates, Hamiltonian function and conservation of energy: Jacobi’s Integral, Hamiltonian’s equations, Hamiltonian’s equations in different coordinate systems, Examples in Hamiltonian’s Dynamics: Harmonic oscillator, Motion of a particle in a central force field, Charged particle moving in an electromagnetic field, Compound pendulum, Two dimensional harmonic oscillator, Routhain.

**Module-IV**

***Special Theory of Relativity***

Galilean Transformations, Principle of relativity, Transformation of force from one Inertial system to another, the covariance of the physical laws, Principle of relativity and speed of light, The Michelson-Morley Experiments, Ether hypothesis, Postulates of special theory of relativity, Lorentz transformation, Consequence of Lorentz transformation, Velocity Addition and Thomas precession.

**Books:**

1. Introduction to Classical mechanics by David Morin, Cambridge
2. Classical Mechanics by R. Douglas Gregory, Cambridge
3. Classical Mechanics by J.C. Upadhyaya, Himalaya Publishing House

**Course Outcomes**

Students learn about the motion of a particle.

1. Establish the non-existence of the hypothesised stationary ether through the null result of Michelson-Morley Experiments with an interferometer.
2. Explain the true nature of Newtonian mechanics and Lorentz Transformation equations.
3. Understand the concept of constant relative motion of different bodies in different frames of references

**GE-1: Chemistry - I (IOECH101)**

**Course Objectives:**

1. **To make aware about comparison study of different properties of solid, liquid and gas.**
2. **Student can predict atomic structure, chemical bonding or molecular geometry based on accepted models.**
3. **To provide idea on properties of atoms in a systematic manner.**

**Module-I**

***States of Matter: Gaseous state****:*

Postulates of Kinetic theory of gases, derivation from ideal behavior, van der walls equation of state. Critical phenomena: PV isotherm of real gases, continuity of states, the isotherms of van der walls equation, relationship between vanderwals constant and critical constants, the law of corresponding states, reduced equation of state.

***Liquid state****:*

Intermolecular forces, structure of liquids (qualitative description), liquid crystals: difference between liquid crystal, solid and liquid.

***Solid state****:*

space lattice and unit cell. Qualitative description of X-ray diffraction in crystals. Derivation of Braggs equation.

**Module-II**

***Atomic structure****:*

de-Broglie matter waves, Uncertainty principle, Schrodinger wave equation, quantum numbers and its significance, shape of s, p, d orbitals, electronic configuration of elements.

***Periodic properties:***

Screening effect, effective nuclear charge, size of atoms and ions, ionization potential, electron affinity, electronegativity, variable valency and oxidation states, horizontal, vertical and diagonal relationship.

**Module-III**

***Chemical bonding:***

Ionic bond, polarizability, Fajan’s rule, lattice energy and Born- Haber cycle, solvation energy and solubility of ionic compounds, Covalent bond: Lewis theory, dipole moment and its application, percentage ionic character from dipole moment and electronegativity, VBT, hybridization, VSEPR theory, MOT (homo and heteronuclear diatomic molecule), Resonance Metallic bond (free electron and band theories) H-bond, Vanderwaals force.

**Books:**

1. Concise Inorganic Chemistry, J.D. Lee, Wiley India, 5thEdn., 2008.
2. Inorganic Chemistry Principle, Structure and Reactivity, Huheey, Keiter and Keiter, Harper Collins College, 4thEdn.,1997.
3. Inorganic Chemistry R.D.Madan, S.Chand, 4thEdn.,1987.
4. Principles of Physical Chemistry, Puri, Sharma & Pathania, Vishal Publishing Co, 47th Edn., 2017.

**Course Outcomes:** Students are able to

1. **Know the critical phenomenon**
2. **Analyse the packing of atoms in solids**
3. **Know about the behavior of subatomic particles**
4. **Know the types of attraction between the atoms in molecules**

**GE-2: Mathematics - I (IOEMH101)**

**Course Objectives:**

1. Identify essential characteristics of ordinary differential equations.
2. Develop essential methods of obtaining closed form solutions numerical solutions.
3. Explore the use of differential equations as models in various applications.
4. Explore the use of series methods to solve problems with variable coefficients.
5. Explore methods of solving initial value problems by transform methods.

**Module-I:**

Basic Concepts of Differential Equation: Origin and Classification of Differential equation, Solution of Differential Equation, Kinds of solution, Initial and Boundary value problem, Existence and uniqueness of solution, Formation of Differential equation. First Order First Degree Equation: Variable separable, Homogenous Equation, Exact Differential equation, Integrating Factors, Linear equations, Equation reducible to linear form. Equations of First order but of Higher Degree: Equations solvable for p, Equation solvable for y, Equation solvable for x,

**Module-II:**

Linear Equations with Constant coefficient: Linear differential equation of nth order, Homogenous Linear equation with constant coefficient, Non- Homogenous Linear equation with constant coefficient, Operators and its use to solve linear differential equations with constant coefficient, Method of Variation of Parameter, Linear Differential Equation with variable coefficient: Method of reduction of order, method based on the removal of the first derivatives. Existence and Uniqueness of solution: Picard’s method of successive Approximation, Existence and uniqueness Theorem.

**Module-III:**

Series Solution and special function: Power series, Radius of convergence of power series, Ordinary point, singular point and regular singular point (only definition), Series solution about an ordinary point, Legendre equation and Legendre polynomial, Orthogonality, Power series method about singular point, Bessel ‘s equation and Bessel’s function, Orthogonality in Bessel function. Boundary value problem for Ordinary Differential Equation; Sturm –Liouville Problems.

**Text Books:**

1. A Course on Ordinary and Partial Differential Equation by J. Sinha Roy, S Padhy, Kalyani Publisher. Chapters: 1(1.1-1.4), 2(2.1-2.7), 3(3.1-3.4), 4(4.1-4.6), 6(6.1,-6.3), 7(7.1,7.2,7.3.1,7.4.1)), 10 (10.1,10.2).

**Reference Books:**

1. Ordinary Differential Equation by P C Biswal (Pub- PHI).

**Course Outcomes:**

After the successful completion of this course the students will be able to

1. Identify and apply initial and boundary values to find solutions to first-order, second-order, and higher order homogeneous and non-homogeneous differential equations by manual and technology-based methods and analyze and interpret the results.
2. Select and apply series techniques to solve differential equations.
3. Select and apply appropriate methods to solve differential equations.

**AECC-1: English for Communication (IOEMH102)**

**Course Objectives:**

1. To introduce engineering students to the theory and practice of communication.
2. To equip them with both theoretical vocabulary and basic tools which will help them develop as better communicators.
3. To initiate them to select literary texts and establish how these texts contribute to the afore-mentioned objectives.

**Module-I**

***Introduction to Communication:***

1.1 Importance of Communication in English

1.2 The process of communication and factors that influence the process of communication:

Sender, receiver, channel, code, topic, message, context, feedback, ‘noise’.

1.3 Principles of Communication.

1.4 Barriers to Communication & Communication Apprehension

1.5 Verbal (Spoken and Written) and non-verbal communication, Body language and its importance in communication.

**Module-II**

***Phonetics and Functional Grammar***

2.1 Sounds of English: Vowels (Monopthongs and Diphthongs), Consonants

2.2 Syllable division, stress (word, contrastive stress) & intonation

2.3 MTI and problem sounds

2.4 Review of Parts of Speech

2.5 Subject and Predicate, Tense, Voice Change

2.6 Idioms and Phrasal Verbs

(**Note:** This unit should be taught in a simple, non-technical, application oriented manner, avoiding technical terms as far as possible.)

**Module-III**

***Reading Literature***

**Prose:**

1. Stephen Leacock: My Financial Career
2. Mahatma Gandhi: from My Experiments with Truth.
3. O’Henry: The Last Leaf

**Poetry:**

1. Nissim Ezekiel: Professor
2. Jack Prelutsky: Be glad your nose is on your face.
3. Maya Angelou: Still I rise (Abridged)

**BOOKS:**

1. Paul V. Anderson, Technical Communication, Cengage Learning, 2014.
2. Leech, Geoffrey and Ian Swartik., A Communicative Grammar of English, Longman, 2003.
3. O’Connor, J.D., Better English Pronunciation, Cambridge University Press, 1980.
4. Wren & Martin, English Grammar and Composition, S. Chand,1995.

**SEC-1: Fundamentals of Computers & Programming in C (IOECS101)**

**Course Objectives:**

1. Develop a greater understanding of the issues involved in programming language design and implementation
2. Develop an in-depth understanding of functional, logic, and object-oriented programming paradigms
3. Implement several programs in languages other than the one emphasized in the core curriculum
4. Understand design/implementation issues involved with variable allocation and binding, control flow, types, subroutines, parameter passing
5. Develop an understanding of the compilation process

**Module - I**

***Digital Logic Fundamentals:***

Logic Gates, Introduction to Multiplexer, Demultiplexer, Encoder, Decoder & Flip - Flops.

***Introduction to Computer Fundamentals:***

The basic architecture of computer, Functional Units, Operational concepts, Bus structures, Von Neumann Concept. Instruction code, Instruction set, Instruction sequencing, Instruction cycle, Instruction format, addressing modes, Micro instruction, Data path, Hardwired controlled Unit-, Micro programmed controlled Unit**-**. Generation of Programming languages, Compiler, Linker, Loader

**Module - II**

***C language fundamentals:***

Character set, Keywords, Identifiers, data types, constants and Variables, Statements, Expressions, Operators, Precedence and associativity of operators, Side effects, Type conversion, Managing input and output

***Control structures:***

Decision making, branching and looping.

***Arrays:***

One dimensional, multidimensional array and their applications, Declaration, storage and manipulation of arrays

***Strings:***

String variable, String handling functions, Array of strings

***Functions:***

Designing structured programs, Functions in C, Formal vs. actual arguments, Function category, Function prototype, Parameter passing, Recursive functions.

***Storage classes:***

Auto, Extern, register and static variables

**Module - III**

***Pointers:***

Pointer variable and its importance, pointer arithmetic and scale factor, Compatibility, Dereferencing, L - value and R-value, Pointers and arrays, Pointer and character strings, Pointers and functions, Array of pointers, pointers to pointers, Dynamic memory allocation

***Structure and union:***

Declaration and initialization of structures, Structure as function parameters, Structure pointers, Unions.

***File Management:***

Defining and opening a file, Closing a file, Input/output Operations in files, Random Access to files, Error handling

**Books:**

1. William Stalling, “Computer Organization and Architecture” Pearson Education
2. Balagurusamy: “C Programming” Tata McGraw - Hill

**Reference Books:**

1. J. P. Hayes “Computer Architecture and Organization" McGraw Hill Education India.
2. H. Schildt – “C the complete Reference” McGraw - Hill
3. K.R. Venugopal, S.R. Prasad, “Mastering C, McGraw - Hill Education India

**Lab 1 (Core Lab-1): Mechanics and Thermal Physics - I Laboratory (ILCPH101)**

**Course Objectives**

1. To introduce different Experiments to test the basic understanding of physics concepts.

***List of Experiment***

1. Determination of accurate weight of a body using balance by Gauss method.
2. Error analysis using Vernier caliper, screw gauge and spherometer.
3. Determination of velocity of sound by resonance column method.
4. To determine the acceleration due to gravity by bar pendulum and study of the effect of amplitude on time period.
5. To determine the acceleration due to gravity by Katter’s pendulum.
6. Verification of laws of vibration of string using sonometer.
7. Determination of Young’s modulus of wire by Searle’s method.
8. Determination of rigidity modulus of a rod by static method.
9. Determination of surface tension of water by using the capillary rise method.
10. Determination of viscosity of liquid by Poiseuille’s method.
11. Determination of specific heat of solid/liquid applying radiation correction.
12. To study the velocity of sound by Kundt’s tube.
13. Calculate surface tension of mercury by using capillary rise method.
14. To determine the moment of inertia of a flywheel about its axis of rotation.
15. To determine Young’s modulus of a wire using optical lever method.

**Course Outcomes**

1. The hands-on exercises undergone by the students will help them to apply physics principles.

**Lab 2 (GE Lab-1): Chemistry - I Laboratory (ILCCH102)**

**Course Objectives:**

1. The students will know the theoretical basis of qualitative inorganic analysis containing common and less common ions.
2. To carry out simple experiments to study the kinetics of reactions

**Syllabus**

Qualitative analysis of mixture of inorganic substances containing four ions (including anions like phosphate, fluoride and mixture of anions like carbonate, sulfite, sulfide, nitrate, chloride, bromide, phosphate, arsenate, nitrate, iodate and sulfate and cations of qualitative groups I, II, III, IV, V and VI)

***Kinetics Experiment:***

1. To determine the specific reaction rates of acid hydrolysis of the esters at room temp.
2. To study the effect of acid strength on hydrolysis of the esters
3. To study kinetically the reaction rate of iodide-H2O2 reaction

***Distributive Law Experiment:***

1. To study the distribution of iodine between water and CCl4
2. To study the distribution of benzoic acid between water and benzene.

**Course Outcomes**

**The student will gain the laboratory skills in qualitative analysis of different acid and basic radicals.**

**Lab 3 (AECC Lab-1): English for Communication Laboratory (ILCMH101)**

**Course Objectives:**

1. The laboratory experience for this course aims at acquainting the learners with their strength and weakness in expressing themselves, their interests and academic habits.
2. To improve their skills of LSRW (Listening, Speaking, Reading and Writing) through mutual conversation and activities related to these skills.
3. To promote the creative and imaginative faculty of the students through practice before the teacher-trainer.

There will be 10 sessions of 2 hours each. Lab sessions will give a platform for the students to indulge in activities based on the first two modules of theory taught in the class room. All the lab classes will be divided in such a manner that all the four aspects of language (LSRW) are covered.

**Ist session:**

Speaking: Ice-breaking and Introducing each other (1 hour), Writing: Happiest and saddest moment of my life (1 Hour)

**IInd session:**

Listening: Listening practice (ear-training): News clips, Movie clips, Presentation, Lecture or speech by a speaker (1 Hour), Speaking: Debate (1 Hour)

**IIIrd session:**

Reading: Reading comprehension (1 Hour), Writing: Creative writing (Short story: Hints to be given by the teacher) (1 Hour)

**IVth session:**

Reading: Topics of General awareness, Common errors in English usage (1 Hour), Writing: Construction of different types of sentences (1 Hour)

**Vth session:**

Speaking: Practice of vowel and consonant sounds (1 Hour), Writing: Practice of syllable division (1 Hour)

**VIth session:**

Speaking: My experience in the college/ or any other topic as per the convenience of the student (1 Hour), Writing: Phonemic transcription practice (1 Hour).

**VIIth session:**

Listening: Practice of phonetics through ISIL system and also with the help of a dictionary (1Hour), Speaking: Role-play in groups (1 Hour)

**VIIIth session:**

Speaking: Practice sessions on Stress and Intonation (1Hour), Writing: Practice sessions on Grammar (Tense and voice change) (1 Hour)

**IXth session:**

Speaking: Extempore, (1 Hour), Writing: Framing sentences using phrasal verbs and idioms (1 Hour).

**Xth session:**

Watching a short English movie (1 Hour), Writing: Critical analysis of the movie (1 Hour).

BOOKS:

Lab Manual Cum Workbook, *English Language Communication Skills*, Cengage Learning, 2014.

**Note: 70 marks will be devoted for sessions, 10 marks for record submission, 10 marks for viva-voce and 10 marks for project work.**

**End term assignment:** Students are required to make a project report of at least5 pages on a topic on the following broad streams: Technology, General awareness, Gender, Environment, Cinema, Books and the like. The assignment should involve data collection, analysis and reporting.

**Lab 4 (SEC Lab-1): Programming in C Laboratory (ILCCS102)**

**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:
2. Sum=1 - x2
3. /2! +x4
4. /4! - x6
5. /6! +x8
6. /8! - x10/10!
7. 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
   1. To find the factorial of a given integer.
   2. To find the GCD (greatest common divisor) of two given integers.
   3. To solve Towers of Hanoi problem.

**Experiment No. 4**

1. Write a C program to find both the largest and smallest number in a list of integers.
2. Write a C program that uses functions to perform the following:
   1. Addition of Two Matrices
   2. Multiplication of Two Matrices

**Experiment No. 5**

1. Write a C program that uses functions to perform the following operations:
   1. To insert a substring in to given main string from a given position.
   2. 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:
   1. Reading a complex number
   2. Writing a complex number
   3. Addition of two complex numbers
   4. Multiplication of two complex numbers

(Note: represent complex number using a structure.) 21

**Experiment No. 8**

* + 1. Write a C program which 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.)

**Book: -**

1. PVN. Varalakshmi, Project Using C Scitech Publish

**Semester-2**

**Core-2: Thermal Physics and Properties of matter (IPCPH201)**

**Course Objectives:**

This Course Enables the Student

1. Understand the nature and role of the following thermodynamic properties of matter: internal energy, enthalpy, entropy, temperature, pressure and specific volume;
2. Be able to represent a thermodynamic system by a control mass or control volume, distinguish the system from its surroundings, and identify work and/or heat interactions between the system and surroundings;
3. Recognize and understand the different forms of energy and restrictions imposed by the first law of thermodynamics on conversion from one form to another;
4. Understand the implications of the second law of thermodynamics and limitations placed by the second law on the performance of thermodynamic systems;
5. This course introduces properties of solids, liquids and gases. It deals with forces and energy between atoms and between molecules, and with mechanical and thermal properties.
6. Properties of fluids especially knowledge of viscosity and surface tension help the students in their daily life

**Module - I**

Thermodynamical system, Principles of thermodynamics, concept of thermodynamic state, Zeroth law of thermodynamics, work done in isothermal and isobaric processes, Heat and Work, Free energy and their application, internal energy function and the first law of thermodynamics, application to various processes, Heat capacity, CP -CV, Equation of state for adiabatic process, work done in adiabatic process, Equations of state. Ideal gases and their P-V-T relations

**Module - II**

The second law of thermodynamics, Carnot’s engine, Carnot theorem, the thermodynamic scale of temperature, Entropy, entropy change in reversible and irreversible processes, mathematical formulation of second law, Maxwell’s relations, first TdS equation, second TdS equation, Phase change, Clausius - Clapeyron equation

**Module - III**

Maxwell -Boltzmann formula for distribution of molecular speed (statement of formula and discussion), Average RMS and most probable speed, Mean free path, Degrees of freedom, The principle of equipartition of energy, The Vanderwaals equation of state, Evaluation of critical constants,

**Module - IV**

Properties of Matter: Stress and strain, Hook’s law, three types of elasticity, Poisson’s ratio, effect of a suddenly applied load, twisting couple on a cylinder, Torsional pendulum, bending of Beams, Bending moment, cantilever, transverse vibration of a loaded cantilever, Searle’s method for comparison of young’s modulus and coefficient of rigidity in a given material.

**Books:**

1. Heat and thermodynamics -Zemansky and Dittman (Mc Graw Hill)
2. Heat and thermodynamics -A. B Gupta, H. Ray (New Age)
3. Advance text Book of heat -P.K Chakraborty (Hindustan Publication)
4. A treatise on heat – Saha And Srivastava (The Indian Press)
5. Heat and thermodynamics -D. S Mathur.
6. Properties of matter - FH. Newman V.H.L. Searle (Edward Arnold publication)
7. Properties of matter – D.S. Mathura (S. Chand)

**Course Outcomes:**

1. A fundamental understanding of the first and second laws of thermodynamics and their application to a wide range of systems.
2. An ability to evaluate entropy changes in a wide range of processes and determine the reversibility or irreversibility of a process from such calculations.
3. Familiarity with calculations of the efficiencies of heat engines and other engineering devices.
4. Ability to determine the equilibrium states of a wide range of systems, ranging from mixtures of gases, mixtures of gases and pure condensed phases, and mixtures of gases, liquids, and solids that can each include multiple components.
5. Familiarity with basic concepts in solution thermodynamics, and an ability to relate the characteristics and relative energies of different liquid and solid solutions to the phase diagram of the system.
6. Explain the applications of the elastic properties of solids.
7. Explain thermal conduction in matter

**GE-3: Chemistry - II (IOECH201)**

**Course Objectives:**

1. To provide a bridge between basic and advanced organic chemistry knowledge. It also makes connection from chemical principles to the structures and functions of different organic molecules.
2. Apply principle and knowledge in stereo chemical aspects of different organic molecules and reactions.
3. To provide basic idea on the reactions and mechanisms involving aliphatic and aromatic hydrocarbons.
4. Students are required to apply mathematical skills (derivations and integrations) and basic physics to understand chemical reactions and related processes.
5. Students will gain a good foundation of knowledge and skills for further study in Physical Chemistry.

**Module-I**

***General Organic Chemistry:***

Nomenclature of Organic molecules: Brief revision, Nomenclature of polycyclic compounds including bridged, spiro and other special structures.

Structure and Bonding: Nature of bonding in aliphatic, aromatic compounds; Aromaticity in benzenoid and non-benzenoid compounds. Inductive and Field effects, Resonance; hyperconjugation, structural effects on acidity and basicity.

Types of reagents-Electrophiles, nucleophiles, Reactive Intermediates-Carbocations; carbanions; free radicals, radical anions and cations; (Introduction to structure, stability, and reactions).

**Module-II**

***Isomerism and Reaction Mechanism:***

Stereochemistry: Conformational analysis of acyclic systems and cyclohexane systems, axial and equatorial bonds, conformation of monosubstituted cyclohexane, Introduction of terminologies such as erythro, threo, exo, endo, epimers, etc. Optical isomerism (in compounds containing more than one chiral centre, in biphenyls, allenes and spiro compounds.), resolution of enantiomers, inversion, racemisation and retention

Relative and absolute configuration, sequence rule, D,L and R,S systems of nomenclature

Geometric isomerism: determination of configuration (cis, trans and E,Z),oximes and alicyclic compounds.

Reaction mechanism: Substitution reaction: Aliphatic substitutions: SN1, SN2, reactions; Free radical substitutions, electrophilic aromatic substitution (idea only); addition reaction (addition of H2, X2, HX type), markownikoff and anti-markownikoff addition, Eliminations: E1, E2,

**Module-III**

***Chemical Kinetics and catalysis:***

Rates of reactions, factors influencing rates of reaction- conc., temp, press, solvent, light, catalyst. (Arrehenius eqn. concept of activation energy), collision theory of reaction rates, Order and molecularity, mathematical characteristics of simple chemical reactions-zero order, first order, second order, pseudo order, half and mean life. Determination of the order of reaction (differential method, half-life period method, method of isolation and integration)

Catalysis: characteristic of catalysed reactions, classification of catalysis

**Essential Readings:**

1. Principles of Physical Chemistry, Puri, Sharma & Pathania, Vishal Publishing Co, 47th Edn., 2017.
2. Organic Chemistry, Jonathan Clayden, Nick Greeves, and Stuart Warren, Oxford press, 2nd Edn., 2012.
3. Organic Chemistry, P.Y. Bruice, Pearson, 8th Edn., 2017.

**Course Outcomes:**

1. Understand the formation, stability and structure of different reaction intermediate.
2. Able to identify the type of reaction and mechanism.
3. Knowledge of the basic mechanisms of elimination (E1, E2, E1cb, electron transfer)
4. Naming and identifying the structures including configurational isomers (stereo-isomers and geometric isomers) and conformational isomer.
5. Analyse the mechanism and kinetics of a chemical reaction

**GE-4: Mathematics - II (IOEMH201)**

**Course Objective:**

1. To understand concepts of real numbers, open sets and closed sets.
2. Demonstrate knowledge and understanding of sequences, their convergence conditions, limits of sequences
3. Demonstrate knowledge and understanding of groups, subgroups, cosets of a subgroup, normal subgroup, quotient groups.
4. To build concept of group homomorphism and isomorphism.
5. Demonstrate knowledge and understanding of permutation groups and their properties.

**Module I:**

Bounded and unbounded sets, Infimum and Supremum of a set and their properties, Order completeness property of R, Archimedian property of R, Density of rational and irrational numbers in R.

Neighbourhood, Open set, Interior of a set, Limit point of a set, Closed set, Countable and uncountable sets, Derived set, closure of a set, Bolzano- Weierstrass theorem for sets.

**Module II:**

Sequence of real numbers, Bounded sequence, limit points of a sequence, limit interior and limit superior convergent and non-convergent sequences, Cauchy’s sequence, Cauchy’s general principle of convergence.

Infinite series and its convergence, Test for convergence of positive term series, Comparison test, Ratio test, Cauchy’s root test**.**

**Module III:**

Preliminary Notations, Group Theory**:** Algebraic structures, Groups, Some Examples of Groups, Subgroups, A Counting Principle, Cosets, Normal Subgroups and Quotient Groups,

Group Homomorphisms, Isomorphisms, Automorphisms, Permutation Groups. Ring Theory : Definition & Example of Rings, Some Special Classes of Rings.

**Text Books**

1. Fundamentals of Mathematical Analysis, G. Das & S. Pattnaik, TMH
2. Topics in Algebra, by I. N. Herstein, Wiley Eastern.Ch. 1, Ch. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.10, Ch. 3.1, 3.2, 3.3, 3.4

**Reference Books**

1. Introduction to Real Analysis, R. G. Bartle and D.R. Sherbert, Wiley.4th Edition
2. Elementary Analysis: The Theory of Calculus, Under graduate Texts in Mathematics, K. A. Ross, Springer (SIE), Indian reprint, 2004.
3. A course in Calculus and Real Analysis, Limaye, Undergraduate Text in Mathematics, Sudhir R Ghorpade and Balmohan V.., Springer (SIE). Indian reprint, 2004.
4. Modern Algebra by A. R. Vasishtha,Krishna, PrakashanMandir, Meerut.
5. Topics in Algebra by P.N.Arora, Sultan Chand & Sons.

**Course outcomes:**

After the successful completion of this course the students will be able to

1. Determine if sets are open, closed. Recognize convergent, divergent, bounded, Cauchy and monotone sequences.
2. Recognize alternating, convergent, conditionally and absolutely convergent series.
3. Determine if a function is discontinuous, continuous, or uniformly continuous.
4. Use various canonical types of groups (including cyclic groups and groups of permutations) produce rigorous proofs of propositions arising in the context of abstract algebra

**AECC-2: Communication in Practice (IOEMH202)**

**Course Objectives**:

1. To introduce students to various building blocks of communication, both within and outside their formal articulations.
2. To train students in the basic science of writing and help them use the same in various sites such as report, paragraph etc.
3. To create conditions in the classroom that encourages students to engage in meaningful conversation.

**Module - I**

***Basics of Communication in Practice***

1.1 Types of Communication in an organization: Formal (internal and external) and Informal (grapevine)

1.2 Communication Channels: Upward, Downward, Diagonal and Horizontal

1.3 Introduction to cross-cultural communication.

1.4 Bias-free communication & use of politically correct language in communication

1.5 Importance of reading and ethics of writing

1.6 Negotiation Skills, Argumentation & Consensus building.

**Module-II**

***Business Writing***

2.1 Skills of Writing: Coherence, Cohesion, Sentence Linkers, Clarity of Language and stylistic variation, process of writing.

2.2 Paragraph writing: Topic Sentence, Supporting sentence & Concluding sentence,

Logical structuring (Inductive approach and deductive approach)

2.3 Letters, Applications

2.4 Reports and Proposals

2.5 Memos, Notices, Summaries, Abstracts& e-mails

2.6 Writing a CV/Resumeˈ: Types of CV

2.7 Writing a Cover letter

**Module -III**

***Speaking and Presentation***

3.1 Oral Presentation: 4 P’s of presentation, PPT

3.2 Group Discussion: Structured and Un-structured, Various types of topics (abstract, absurd, contemporary etc.)

3.3 Types of Interview: Preparing an Interview and techniques

3.4 Grooming and dress code, Personality development

**Books:**

1. Carol M Lehman, Debbie D Dufrene and Mala Sinha., Business Communication, Cengage Learning. 2nd Edition. 2016.
2. Anderson, Paul.V, Technical Communication, Cengage Learning, 2014.
3. Bovee, Courtland. L. et al., Business Communication Today, Pearson, 2011.
4. Jeff Butterfield, Soft Skills for Everyone, Cengage Learning, 2015

**SEC-2: OOPS Using C++ (IOECS202)**

**Module- I**

Introduction to object-oriented programming, user-defined types, structures, unions, polymorphism, encapsulation. Getting started with C++ syntax, data - type, variables, strings, functions, default values in functions, recursion, namespaces, operators, flow control, arrays and pointers.

**Module- II**

Abstraction mechanism: Classes, private, public, constructors, destructors, member data, member functions, inline function, friend functions, static members, and references.

Inheritance: Class hierarchy, derived classes, single inheritance, multiple, multilevel, hybrid inheritance, the role of virtual base class, constructor and destructor execution, base initialization using derived class constructors.

Polymorphism: Binding, Static binding, Dynamic binding, Static polymorphism: Function Overloading, Ambiguity in function overloading, Dynamic polymorphism: Base class pointer, object slicing, late binding, method overriding with virtual functions, pure virtual functions, abstract classes.

Operator Overloading: This pointer, applications of this pointer, Operator function, member and non-member operator function, operator overloading, I/O operators.

Exception handling: Try, throw, and catch, exceptions and derived classes, function exception declaration.

**Module- III**

Dynamic memory management, new and delete operators, object copying, copy constructor, assignment operator, virtual destructor. Template: template classes, template functions.

Namespaces: user defined namespaces, namespaces provided by library.

**Books:**

1. Object-Oriented Programming with C++-E. Balagurusamy, McGraw - Hill Education (India)
2. ANSI and Turbo C++-Ashoke N. Kamthane, Pearson Education
3. Big C++-Wiley India
4. C++: The Complete Reference -Schildt, McGraw - Hill Education (India)
5. C++ and Object-Oriented Programming – Jana, PHI Learning.
6. Object-Oriented Programming with C++-Rajiv Sahay, Oxford

**Lab 5 (Core Lab-2): Electrical Laboratory (ILCPH201)**

**Course Objectives**

1. To introduce different Experiments to test the basic understanding of physics concepts.

***Experiment Lists:***

1. Determination of reduction factor of tangent Galvanometer.
2. Determination of figure of merit of a moving coil Galvanometer.
3. Measurement of high resistance with a Galvanometer.
4. Study the charging and discharging process of a capacitor through a resistor.
5. Calibration of CRO.
6. Determination of the unknown resistance of a wire using Meter Bridge (applying end correction method).
7. Comparison of EMFs of cellsby stretched wire potentiometer.
8. LCR impedance apparatus.
9. Carry Foster’s bridge.
10. To determine the self-inductance of a coil by Rayleigh’s method.
11. To determine the mutual inductance of two coils by the absolute method.
12. To determine self-inductance of a coil by Anderson’s bridge.
13. Conversion of the voltmeter to ammeter and vice-versa.
14. To study the force experienced by a current-carrying conductor placed in a magnetic field (Lorentz’s force) using a mechanical balance.

**Course Outcomes**

1. The hands-on exercises undergone by the students will help them to apply physics principles.

**Lab 6 (GE Lab-2): Chemistry - II Laboratory (ILCCH202)**

**Course Objectives:**

1. To know the principle and procedure of determination of viscosity
2. Know the flash and fire point of Lubricating Oil
3. The use of spectrophotometer and its use

***Experiment List***

1. To determine the percentage composition of a given mixture (non-reacting system) by viscosity method.
2. To determine the viscosity of amyl alcohol in water at different concentrations and calculation of excess viscosity of these solutions
3. To determine the percentage composition of a given binary mixture (acetone and ethylmethyl ketone) by surface tension method.
4. Estimation of Ca2+ and Mg2+ by EDTA
5. Determination of pH of a buffer solution
6. Determination of viscosity of lubricating oil.
7. Determination of flash and fire point of an oil by Pensky-Marten apparatus.
8. Determination of concentration of a coloured solution by a spectrophotometer.

**Course Outcomes:** Students are able to

1. Set out the environmental condition to prevent any accident in industry
2. Find out the qualities of water used in various industries
3. Find out composition of components in a mixture

**Lab 7 (AECC Lab-2): Communication in Practice Laboratory (ILCMH201)**

**Course Objectives:**

1. To enable the students, engage in polite, negotiating and argumentative conversation.
2. To train the learners in writing CV, Report, Minutes, Business Letters etc.
3. To give students an opportunity of power point presentation relating to topical issues.

There will be 10 lab sessions of 2 hours each. Lab sessions will be used to give the students an in-hand experience of communication taking place in an organization. This will help the students to understand the requirement of communication in the workplace. Students will be encouraged to brush-up themselves in activities based on all the modules of theory taught in the class room. Special emphasis will be given to speaking and writing business correspondences.

**Ist session:** Speaking: Greeting an acquaintance/ friend, introducing oneself, introducing a third person to a friend, breaking off a conversation politely, leave-taking, describing people, objects, places, processes etc., Writing an application

**IInd session:** Speaking: making and responding to inquiries; expressing an opinion; expressing agreement/ disagreement, contradicting/ refuting an argument; expressing pleasure, sorrow, regret, anger, surprise, wonder, admiration, disappointment etc., Writing an informal letter/Business Letter

**IIIrd session:** Speaking: Narrating or reporting an event, Writing a Report

**IVth session:** Speaking: Ordering / directing someone to do something, Making requests; accepting / refusing a request, Expressing gratitude; responding to expressions of gratitude, Asking for or offering help; responding to a request for help, Asking for directions (e.g. how to reach a place, how to operate a device etc.) and giving directions, Speaking: asking for and granting/ refusing permission, prohibiting someone from doing something, suggesting, advising, persuading, dissuading, making a proposal, praising, complimenting, felicitating, expressing sympathy (e.g. condolence etc.), Complaining, criticizing, reprimanding etc., Writing a proposal

**Vth Session:** Speaking: Understanding and interpreting graphs, flowcharts, pictograms, pictures, curves etc., Writing: Describing, explaining and interpreting graphs, flowcharts, pictograms, pictures, curves etc.

**VIth session:** Speaking: Group discussion, Writing a memo, notice and circular

**VIIth session:** Speaking: In-house communication on work-related situations, Writing a CV

**VIIIth session:** Presentation 1 (Students will make and present a topic in power point on a pre-assigned topic), Writing an e-mail

**IXth session:** Presentation 2 (Students will make and present a topic in power point on a pre-assigned topic), Writing an abstract

**Xth session:** Presentation 3 (Students will make and present a topic in power point on a pre-assigned topic), Writing a summary

**Books:**

1. Kumar, Sanjay & Lata, Pushp, *Communication Skills A Workbook*, OUP,2018

**Lab 8 (SEC Lab-2): OOPS Using C++ Laboratory (ILCCS202)**

1. Programs on the concept of classes and objects
2. Programs using inheritance
3. Programs using static polymorphism
4. Programs on dynamic polymorphism
5. Programs on operator overloading
6. Programs on dynamic memory management using new, delete operators
7. Programs on copy constructor and usage of assignment operator
8. Programs on exception handling
9. Programs on generic programming using template function & template class
10. Programs on file handling

**Semester-3**

**Core 3: Analog Systems and Applications (IPCPH301)**

**Module-I**

***Semiconductor Diodes:*** P and N type semiconductors, energy level diagram, conductivity and Mobility, Concept of Drift velocity, PN junction fabrication (simple idea), Barrier formation in PN Junction Diode, Static and Dynamic Resistance, Current flow mechanism in Forward and Reverse Biased Diode, Drift velocity, derivation for Barrier Potential, Barrier Width and current Step Junction.

***Two terminal devices and their applications:*** (1) Rectifier Diode: Half-wave Rectifiers. centre-tapped and bridge type Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, L and C Filters (2) Zener Diode and Voltage Regulation, Principle and structure of LEDs, (2) Photodiode (3) Solar Cell.

**Module- II**

***Bipolar Junction Transistors:*** n-p-n and p-n-p transistors, Characteristics of CB, CE and CC Configurations, Current gains a and b, Relation between a and b, Load line analysis of Transistors, DC Load line and Q-point, Physical mechanism of current flow, Active, Cut-off and Saturation Regions.

***Transistors Biasing:*** Transistor Biasing and Stabilization circuits, Fixed Bias and Voltage Divider Bias.

***Amplifiers:*** Transistors as 2-port network h-parameter Equivalent Circuit, Analysis of a single-stage CE amplifier using Hybrid Model, Input and Output impedance, Current, Voltage and Power Gains, Classification of class A, B and C amplifiers, Push-pull amplifier (class B)

**Module-III**

***Coupled Amplifier:*** RC-coupled amplifier and its frequency response.

***Feedback in Amplifiers:*** Effect of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain Stability, Distortion and Noise. Sinusoidal Oscillations: Barkhausens Gaterian for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency, Hartley and Colpitts oscillators.

**Module-IV**

***Operational Amplifiers (Black Box approach):*** Characteristics of an Ideal and Practical OP-AMP (IC741). Open-loop and Closed-loop Gain. Frequency Response. CMRR, Slew Rate and concept of virtual ground.

**Text Books:**

1. Foundations of Electronics-Raskhit and Chattopadhyay (New age International Publication)
2. Concept of Electronics- D.C. Tayal (Himalay Publication)

**Reference Books:**

1. Electronic devices and circuits R.L. Boylstad (Pearson India)
2. Electronic Principles- A.P. Malvino (Tata McGraw-Hill)
3. Principles of Electronics- V. K. Mehta and Rohit Mehta (S. Chand Publication)
4. OP-Amps and Linear Integrated Circuit-R. A. Gayakwad (Prentice-Hall)
5. Physics of Semiconductor Devices, Donald A Neamen (Prentice Hall)

**Core 4: Elements of Modern Physics (IPCPH302)**

**Module- I**

***Atomic Spectra and Models:*** Inadequacy of classical physics, Brief Review of Black body Radiation, Photoelectric effect, Compton Effect, dual nature of radiation wave nature of particles, Atomic spectra, Line spectra of hydrogen atom, Ritz Rydberg combination principle, Alpha Particle Scattering, Rutherford Scattering Formula, Rutherford Model of atom and its limitations. X-ray Diffraction, Laser.

***Atomic Model:*** Bohrs Model of Hydrogen atom, explanation of atomic spectra, correction for the finite mass of the nucleus, Bohr correspondence principle, limitations of Bohr model, discrete energy exchange by atom, Frank Hertz Experiment, Sommerfield's modification of Bohrs Theory.

**Module- II**

***Wave Packet:*** superposition of two waves, phase velocity and group velocity, wave packets, Gaussian Wave Packet, the spatial distribution of wave packet, Wave-Particle Duality, Complementarity.

***Wave-Particle Duality:*** de Broglie hypothesis, Experimental confirmation of matter-wave, Davisson Germer Experiment, velocity of deBroglie wave, wave-particle duality, Complementarity.

**Module- III**

***Nuclear Physics- I:*** Size and structure of atomic nucleus and its relation with atomic weight, Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle, Nature of the nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers.

**Module-IV**

***Nuclear Physics- II:*** Radioactivity, stability of the nucleus, Law of radioactive decay, Mean life and Half-life Alpha decay, Beta decay-energy released, spectrum and Paulis prediction of neutrino, Gamma-ray emission energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus, Fission and fusion mass deficit, relativity and generation of energy, Fission-nature of fragments and emission of neutrons, Nuclear reactor: slow neutron interacting with Uranium 235, Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussion).

**Text Books:**

1. Concepts of Modern Physics Arthur Beiser (McGraw-Hill)
2. Modern Physics Murugeshan and Sivaprasad (S.Chand)

**Reference Books:**

1. Quantum Mechanics: Theory and Applications, A.K.Ghatak and S.Lokanathan, (Macmillan)
2. Introduction to Quantum Theory, David Park (DoverPublications)
3. Theory and Problems of Modern Physics, Schaum‘soutline, R.Gautreau and W.Savin- (Tata McGraw-Hill)
4. Modern Physics-Serway (CENGAGE Learnings)
5. Physics of Atoms and Molecules Bransden and Joachim (Pearson India)
6. Atomic and Nuclear Physics-A.B. Gupta (New Central)
7. Theoretical Nuclear Physics, J.M. Blatt and V.F. Weisskopf (Springer)

**Core 5: Waves and Optics (IPCPH303)**

**Module - I**

***Wave Motion:*** Plane and Spherical Waves, Longitudinal and Transverse Waves, Plane Progressive (Traveling) Waves, Wave Equation, Particle and Wave Velocities, Differential Equation, Pressure of a Longitudinal Wave, Energy Transport, Intensity of Wave. Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods, Lissajous Figures (1: 1 and 1: 2) and their uses, Superposition of N harmonic waves.

**Module - II**

***Geometrical optics:*** Fermat's principle, reflection and refraction at plane interface, Matrix formulation of geometrical Optics, Cardinal points and Cardinal planes of an optical system, Idea of dispersion, Application to thick Lens and thin Lens, Ramsden and Huygens eyepiece. Wave Optics: Electromagnetic nature of light. Definition and properties of wavefront Huygens Principle. Temporal and Spatial Coherence.

**Module - III**

***Interference:*** Division of amplitude and wavefront, Young’s double-slit Experiment, Lloyds Mirror and Fresnels Bi-prism, Phase change on reflection: Stokes treatment, Interference in Thin Films: parallel and wedge-shaped films, Fringes of equal inclination (Haidinger Fringes), Fringes of equal thickness (Fizeau Fringes), Newton’s Rings: Measurement of wavelength and refractive index. Interferometer: Michelson’s Interferometer- (1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes, Fabry-Perot interferometer.

**Module - IV**

***Fraunhofer diffraction:*** Single slit, Circular aperture, Resolving Power of a telescope, double slit, multiple slits, Diffraction grating, and Resolving power of grating. Fresnel Diffraction: Fresnels Assumptions, Fresnels Half-Period Zones for Plane Wave, Explanation of Rectilinear Propagation of Light, and Theory of a Zone Plate: Multiple Foci of a Zone Plate, Fresnels Integral, and Fresnel diffraction pattern of a straight edge, a slit and a wire.

**Text Books:**

1. A Text-Book of Optics N. Subrahmanyam and Brij Lal (S.Chand Publishing)
2. Optics - AjoyGhatak (McGraw Hill)

**Reference Books:**

1. Optics by E. Hecht (Pearson)
2. Fundamentals of Optics-F.A. Jenkins and H.E. White (McGraw-Hill)
3. Geometrical and Physical Optics R.S. Longhurst (Orient Blackswan)
4. The Physics of Vibrations and Waves-H.J. Pain (John Wiley)
5. Optics by P.K. Chakrabarty
6. Principles of Optics-Max Born and Emil Wolf (Pergamon Press)
7. The Physics of Waves and Oscillations-N.K. Bajaj (McGraw-Hill)

**GE 5: Chemistry- III (IOECH301)**

**Course Objectives:**

1. The proposed course aims to provide basic idea on electrochemistry, redox reactions thermodynamic quantities of cell reactions and theories of corrosions and methods to combat it.
2. To provide basic idea on aliphatic and aromatic hydrocarbons, preparation methods and properties.
3. To provide the knowledge on co-ordination compounds, idea about effective atomic number, isomerism and valency bond theory.

**Module-I**

***Electrochemistry:*** Types of reversible electrodes – gas-metal ion, metal-metal ion, metal-insoluble salt-anion and redox electrodes. Electrode reactions, Nernst equation, derivation of cell EMF and single electrode potential, standard hydrogen electrode- reference electrodes- standard electrode potential, sign conventions, electrochemical series and its significance. Electrolytic and Galvanic cells – reversible and irreversible cells, conventional representation of electrochemical cells. EMF of a cell and its measurements. Computation of cell EMF. Calculation of thermodynamic quantities of cell reactions (ΔG, ΔH and K), polarization, over potential and hydrogen overvoltage. Concentration cell with and without transport, liquid junction potential, application of concentration cells, valency of ions, solubility product and activity coefficient, potentiometric titrations.

Definition of pH and pKa, determination of pH using hydrogen, quinhydrone and glass electrodes by potentiometric methods. Buffers – mechanism of buffer action, Henderson – Hazel equation. Hydrolysis of salts. Corrosion types, theories and methods of combating it.

**Module-II**

***Chemistry of Aliphatic Hydrocarbons:*** Carbon-Carbon sigma bonds (Alkanes): Kolbe’s reaction. Free radical substitutions: Halogenation -relative reactivity and selectivity. Carbon-Carbon pi bonds (Alkenes & Alkynes): Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

***Chemistry of Aromatic Hydrocarbons:*** Aromaticity: Hückel’s rule, Armaticity in benzenoid and non-benzenoid compounds, annulenes, antiaromaticity, homo-aromaticity, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft’s alkylation/acylation. Directing effects of the groups.

**Module-III**

***Coordination compounds***

Warner’s coordination theory and its experimental verification, effective atomic number concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complexes.

**Books:**

1. Atkin’s Physical Chemistry, P. W. Atkins, J. D. Paula, 10th Edn., Oxford University Press, 2014.
2. A Textbook of Physical Chemistry- Vol. 1, Kapoor, K. L., Mc Graw Hill Education (India) 2019.
3. Organic reaction mechanism, V.K.Alluwalia, R.K.Parashar, Narosa Publising House, 3rd Edn,.
4. Organic Chemistry, V. Mehta, M. Mehta, PHI learning pvt ltd , Eastern Economy Edition. 2nd Edn.

**Course Outcomes:**

* Learn fundamental principles of electrochemistry, thermodynamic quantities of cell.
* Learn preparation and properties of aliphatic and aromatic compounds.
* Learn about co-ordination compound, Werner’s co-ordination theory and valency bond theory

**GE 6: Mathematics –III (IOEMH301)**

**Course Objectives:**

1. Understand how complex numbers provide a satisfying extension of the real numbers
2. Understand the concept of asymptotes. Explain concepts of curve tracing, curvature which forms the basis of many mathematical problems
3. Understanding the concept of partial derivatives and use it to compute the maxima and minima of functions of two variables
4. Demonstrate the knowledge of solving integrals using Green’s theorem, Gauss theorem and Stokes theorem
5. Demonstrate knowledge of geometrical figures such as sphere, cylinder, cone

**Module-I:**

The complex number system: The real numbers, The field of complex numbers, the complex plane, polar representation and roots of complex numbers, Line and half planes in the complex plane.

Asymptotes in Cartesian coordinates, intersection of curve and its asymptotes, asymptotes in polar coordinates, curvature, radius of curvature for Cartesian curves, polar curves, Newton’s method, centre of curvature, circle of curvature, chord of curvature. Cusp, Nodes & conjugate points, Types of cusps, Tracing of curves in Cartesian, Parametric, and Polar coordinates, Trace (Folium of Descartes, Strophoid, Astroid, Cycloid, Cardioids, Lemniscates of Bernoulli)

**Module-II:**

General equation of the Sphere, intersection of a sphere and a plane, intersection of two spheres, family of spheres, Intersection of a sphere and a line, Tangent plane, condition of tangency, equation of a cone, Enveloping cone of a sphere, cylinder, Enveloping cylinder of a sphere, Right circular cone & cylinder.

**Module-III:**

Functions of several variables, Limit and Continuity, Partial derivatives, Differentiability, Chain rule, Directional derivatives, Gradient vectors, tangent planes, Extreme values and saddle points, Lagrange multiplier,

Vector differential calculus: vector and scalar functions and fields, Derivatives, Curves, tangents and arc length, double integral, triple integral, gradient, divergence, curl

Vector integral calculus: Line Integrals, Green Theorem, Surface integrals, Gauss theorem and Stokes Theorem.

**Text Books:**

1. Differential Calculus by Shanti Narayan & P K Mittal, S. Chand Publication, Chapters 14 (14.1-14.6), 15, 16, 17
2. Calculus by M.J. Strauss, G.L. Bradley & K.J. Smith, 3rd edition, Pearson, Chapters 10 (10.1-10.2), 11 (11.1-11.8), 12, 13
3. Analytical Geometry of Quadratic Surfaces by B P Acharya & D C Sahu, Kalyani publisher Chapters: 2, 3
4. Functions of one Complex variable- J. B. Conway (springer Verlag, International student edition, Narosa Publishing house. Chapter-1 (1.1-1.5)

**Reference Books:**

1. Analytical Solid Geometry by Shanti Narayan
2. Calculus and Analytic Geometry by G.B. Thomas and R.L. Finney, 9th edition, Addison-Wesley Publishing Company.
3. Function of Several Variables by N C Bhattacharya
4. Complex Variable; Theory & Application: Kasana, PHI

**Course outcomes:**

1. Compute partial differentiation of various functions and determine their maximum and minimum values
2. Apply gradient to solve problems involving steepest ascent and normal vectors to level curves
3. Apply Fundamental Theorem of Line Integrals, Green’s Theorem, Stokes’ Theorem, or Divergence Theorem to evaluate integrals.
4. Write equation of conics and identify conics from a given equation. Give geometrical interpretation of many mathematical problems.
5. Explain the fundamental concepts of complex analysis and their role in modern mathematics and applied contexts.

**Lab 9 (Core Lab-3): Analog Systems and Applications Laboratory (ILCPH301)**

**(Minimum 5 Experiments are to be done)**

***List of Experiments:***

1. To study the V-I characteristics of a Zener diode and its use as a voltage regulator.
2. Study of V-I and power curves of solar cells, and find maximum power point and efficiency.
3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4. To study the various biasing configurations of BJT for normal class A operation.
5. To study the frequency response of voltage gain of an RC-coupled transistor amplifier.
6. To design a Wien bridge oscillator for given frequency using an op-amp.
7. To design a phase shift oscillator of given specifications using BJT.
8. To study the Colpitt’s oscillator.

**Reference Books:**

1. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
3. Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice-Hall.
4. Microprocessor 8085: Architecture, Programming and interfacing, A. Wadhwa, 2010, PHI Learning.

**Lab 10 (Core Lab-4): Elements of Modern Physics Laboratory (ILCPH302)**

**(Minimum of 4 experiments are to be done):**

***List of Experiments:***

1. To show the tunnelling effect in tunnel diode using I-V characteristics.
2. To determine the wavelength of the laser source using diffraction of single slit.
3. To determine the wavelength of the laser source using diffraction of double slits.
4. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating.
5. TodeterminethePlancksconstantusingLEDsofatleast4differentcolours.
6. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
7. To setup the Millikan oil-drop apparatus and determine the charge of an electron.

**Reference Books:**

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Books Book of Practical Physics, I. Prakashand Ramakrishna, 11th Edn, 2011, Kitab Mahal

**Lab 11 (Core Lab-5): Waves and Optics Laboratory (ILCPH303)**

**(Minimum of 5 Experiments are to be done)**

***List of Experiments:***

1. To determine the frequency of an electric tuning fork by Meldes Experiment and verify 2T law.
2. To plot the I-D curve of a prism using Spectrometer.
3. To determine the refractive index of the Material of a prism using sodium source.
4. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
5. To determine the wavelength of sodium light using Newtons Rings.
6. To determine the wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
7. To determine dispersive power and resolving power of a plane diffraction grating.
8. Determination of grating element of a diffraction grating.

**Reference Books:**

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text-Book of Practical Physics, I. Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani

**Lab 12 (GE Lab-3): Chemistry - III Laboratory (ILCCH351)**

**Course Objectives:**

1. To learn the techniques of acid-base titration using pH meter and conductivity meter
2. To learn the techniques of determination of conductivity cell.
3. To learn how to determine the critical micellar concentration (CMC) by conductivity meter.

***List of Experiments***

1. Acid-base titration using pH meter (only HCl)
2. Acid-base titration using pH meter (mixture, HCl and CH3COOH)
3. Acid-base titration using conductivity meter (only HCl)
4. Acid-base titration using conductivity meter (mixture, HCl and CH3COOH)
5. Determination of cell constant of a conductivity cell.
6. Determination of equivalent conductance at infinite dilution of a strong electrolyte.
7. Determination of critical micellar concentration (CMC) by using conductivity meter.
8. Mechanical equivalent of heat by Joule’s calorimeter.
9. Velocity of sound by resonance column method.
10. Thermal conductivity of a bad conductor by lee’s method.

**Essential readings:**

1. R.C. Das and B. Behera, Experimental Physical Chemistry, Tata McGraw Hill 2000
2. D. Alart, Practical Physical Chemistry, Longman, 1993.

**Course Outcomes:**

1. Learn the techniques of acid-base titration using pH meter and conductivity meter
2. Learn to determine the critical micelle concentration by conductivity meter

**Semester-4**

**Core-6: Digital Systems and Applications (IPCPH401)**

**Module-I**

***Integrated Circuits (Qualitative treatment only):*** Active and Passive Components, Discrete components, Wafer Chip, Advantages and Drawbacks of ICs, Scale of Integration: SSI, MSI, LSI and VLSI (basic idea and definitions only), Classification of ICs, Examples of Linear and Digital ICs.

***Digital Circuits:*** Difference between Analog and Digital Circuits, Binary Numbers, Decimal to Binary and Binary to Decimal Conversation, BCD, Octal and Hexadecimal numbers, AND, OR and NOT. Gates (realization using Diodes and Transistor), NAND and NOR Gates as Universal Gates, XOR and XNOR Gates and application as Parity Checkers.

**Module-II**

***Boolean algebra:*** De Morgans Theorems: Boolean Laws, Simplification of Logic Circuit using Boolean Algebra, Fundamental Products, Idea of Minterms and Max terms, Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

***Introduction to CRO:*** Block Diagram of CRO, Electron Gun, Deflection system and Time Base, Deflection Sensitivity,

***Applications of CRO:*** (1) Study of Wave Form, (2) Measurement of Voltage, Current, Frequency and Phase Difference.

**Module-III**

***Data Processing Circuits:*** Basic Idea of Multiplexers, De-multiplexers, Decoders, Encoders.

***Arithmetic Circuits:*** Binary Addition. Binary Subtraction using 2s complement. Half and Full Adders. Half and Full Subtractors, 4-bit binary Adder/Subtractor.

***Timers: IC 555:*** block diagram and application is Astable multivibrator and Monostable multivibrator.

**Module-IV**

***Introduction to Computer Organization:*** Input/output Devices, Data storage (the idea of RAM and ROM), Computer memory, Memory organization and addressing, Memory Interfacing, Memory Map.

**Text Books:**

1. Digital Circuits and Logic Design: Samuel C. Lee (Print ice Hall)
2. Digital Principles and Applications - A.P. Malvino, D.P. Leach and Saha (TataMcGraw)

**Reference Books:**

1. The Art of Electronics by Paul Horowitz and Winfield Hill, Cambridge University
2. Electronics by Allan R. Hambley, Prentice Hall 3. Principles of Electronics V.K.Mehta and Rohit Mehta (S.Chand Publishing)
3. Digital Logic and Computer Design M. Morris Mano (Pearson)
4. Concepts of Electronics D.C.Tayal (Himalaya Publishing house)

**Core-7: Electricity and Magnetism (IPCPH402)**

**Module – I**

***Electric field:*** Electric field lines, Electric flux, Gauss Law with applications to charge distributions with spherical, cylindrical and planar symmetry, Conservative nature of Electrostatic Field. Electrostatic Potential, Potential and Electric Field of a dipole, Force and Torque on a dipole, Potential calculation indifferent simple cases, Laplace’s and Poisson equations, The Uniqueness Theorem,

Method of images and its application to (1) Plane Infinite Sheet and (2) Sphere. Electrostatic energy of the system ofcharges, Electrostatic energy of a charged sphere, Conductors in an electrostatic Field, Surface charge and force on a conductor.

**Module – II**

***Magnetic Field:*** Magnetic Force, Lorentz Force, Biot Savarts Law, Current Loop as a Magnetic Dipole and its Dipole Moment (analogy with Electric Dipole), Amperes Circuital Law and its application to (1) Solenoid (2) Toroid (3) Helmhotz coil, Properties of B: curl and divergence, Vector Potential, Ballistic Galvanometer: Torque on a Current Loop, Current and Charge Sensitivity, Electromagnetic damping, Logarithmic damping, CDR.

**Module – III**

***Dielectric Properties of Matter:*** Electric Field in the matter, Polarization, Polarization Charges, Electrical Susceptibility and Dielectric Constant, Capacitor (parallel plate, spherical, cylindrical) filled with dielectric, Displacement vector D, Relations between E, P and D, Gauss Law in dielectrics. Magnetic Properties of Matter: Magnetization vector (M), Magnetic Intensity (H), Magnetic Susceptibility and permeability, Relation between B, H, M, Ferromagnetism, B-H curve and hysteresis.

***Electromagnetic Induction:*** Faradays Law, Lenz's Law, Self-Inductance and Mutual Inductance, Reciprocity Theorem, Energy stored in a Magnetic Field, Introduction to Maxwell’s Equations, Derivation of Maxwellequation in differential form, Displacement current, Modified Ampere circuital Law, equation of continuity, Poynting Theorem.

**Module- – IV**

***Electrical Circuits:*** AC Circuits: Kirchhoffs laws for AC circuits, Complex Reactance and Impedance, Series LCR Circuit: (1) Resonance (2) Power Dissipation (3) Quality Factor, (4) Band Width, Parallel LCR Circuit.

***Network theorems:*** Ideal Constant-voltage and Constant-current Sources, Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem, Applications to DC circuits. Transient Currents Growth and decay of current in RC and LR circuits.

**Books:**

1. Introduction to Electrodynamics – D.J. Griffiths (Pearson, 4th edition, 2015)
2. Foundations of Electromagnetic Theory-Ritz and Milford (Pearson)

**Reference Books:**

1. Classical Electrodynamics, J. D. Jackson (Wiley).
2. Electricity and Magnetism D. C. Tayal (Himalaya Publishing house)
3. Electricity, Magnetism and Electromagnetic Theory- S. Mahajan and Choudhury ( Tata McGraw Hill)
4. Feynman Lectures Vol.2, R. P. Feynman, R. B. Leighton, M. Sands (Pear- son)
5. Electricity and Magnetism, J. H. Fewkes and J. Yarwood. Vol. I (Oxford Univ. Press)

**Core-8: Mathematical Physics - I (IPCPH403)**

The emphasis, of course, is on applications in solving problems of interest to physicists. The students are to be examined entirely based on problems, seen and unseen.

**Module-I**

***Calculus -I:*** Plotting of functions, Intuitive ideas of continuous, differentiable functions and plotting of curves, Approximation: Taylor and binomial series (statements only), First Order Differential Equations and Integrating Factor, Second Order Differential equations: Homogeneous Equations with constant coefficients, Statement of existence and Uniqueness Theorem for Initial Value Problems, Particular Integral.

**Module-II**

***Calculus-II:*** Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with a simple illustration, Constrained Maximization using Lagrange Multipliers,

***Vector algebra:*** Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations, Vector product, Scalar triple product and their interpretation in terms of area and volume respectively, Scalar and Vector fields.

**Module-III**

***Orthogonal Curvilinear Coordinates:*** Orthogonal Curvilinear Coordinates, Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems, Comparison of velocity and acceleration in the cylindrical and spherical coordinate system

***Dirac Delta function and its properties:*** Definition of Dirac delta function. Representation as the limit of a Gaussian function and rectangular Function, Properties of Dirac delta function.

**Module-IV**

***Vector Differentiation:*** Directional derivatives and normal derivative, Gradient of a scalar field and its geometrical interpretation, Divergence and curlof a vector field, Del and Laplacian operators, Vector identities

***Vector Integration:*** Ordinary Integrals of Vectors, Multiple integrals, Jacobian, Notion of infinitesimal line, surface and volume elements, Line, surface and volume integrals of Vector fields, Flux of a vector field, Gauss’ divergence theorem, Green’s and Stokes Theorems and their applications (no rigorous proofs)

**Text Books:**

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris (2013, 7th Edn., Elsevier)
2. Advanced Engineering Mathematics, Erwin Kreyszig (Wiley India)

**Reference Books:**

1. Mathematical Physics C. Harper (Prentice Hall India)
2. Complex Variable: Schaum’s Outlines Series M. Spiegel (2nd Edition, Mc-Graw Hill Education)
3. Complex variables and applications, J. W. Brown and R.V. Churchill
4. Mathematical Physics, Satya Prakash (Sultan Chand)
5. Mathematical Physics, B. D. Gupta (4th edition, Vikas Publication)
6. Mathematical Physics and Special Relativity, M. Das, P.K. Jena and B.K. Dash (Srikrishna Prakashan)
7. Mathematical Physics–H.K. Dass, Dr. Rama Verma (S. Chand Publishing)

**DSE 1: Advanced Mathematical Physics (IPEPH401)**

**Objective**

1. Studying detailed about vector space.
2. State the definition of a linear transformation L from a vector space V to another vector space W. Give examples of linear transformations.
3. Study of Matrix algebra.
4. Understanding Tensor, tensor algebra and its application

**Learning Outcome**

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

1. Know how to manipulate with vectors in Euclidean space.
2. Explain tensor, different types of and its basic operations. Work with the transformation of coordinates.
3. Do Fourier expansion and use Fourier transforms to understand tensors.
4. Using tensor in different topics of Physics.

**Module- I**

***Linear Vector Spaces:*** Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations Representation of Linear Transformations by Matrices

***Matrices:*** Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit- Matrices. Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of a Matrix. Inner Product

**Module- II**

Eigen-values and Eigenvectors. Cayley- Hamilton Theorem. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary Differential Equations. Functions of a Matrix.

***Cartesian Tensors:*** Transformation of Co-ordinates. Einstein’s Summation Convention. The relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-Symmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors.

**Module- III**

Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities.

Tensorial Formulation of Analytical Solid Geometry: Equation of a Line. The angle between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. The foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor. Generalized Hooke’s Law.

**Module- IV**

***General Tensors:*** Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-Symmetric Tensors. Metric Tensor.

**Text Books:**

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier

**Reference Books:**

1. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
2. Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press
3. Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.
4. Linear Algebra, W. Cheney, E.W.Cheney & D.R.Kincaid, 2012, Jones & Bartlett Learning
5. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
6. Mathematical Methods for Physicis& Engineers, K.F.Riley, M.P.Hobson, S.J.Bence, 3rd Ed., 2006, Cambridge University Press

**DSE 1: Communication System (IPEPH402)**

**Objective**

1. Understanding the electronic communication system.
2. To learn about analogue modulation and its applications.
3. To learn digital pulse modulation in digital transmission.
4. Students will be exposed to the communication and navigation systems like satellite communication and mobile telephony system.

**Learning Outcome**

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

1. Overall idea about communication system, modulation, TRAI and concept of noise.
2. Understand the analog modulation system.
3. Understand the satellite communication system and navigation system.
4. Also, understand the architecture of mobile communication system which will enable them for further study in this growing area.

**Module- I**

***Electronic communication:*** Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. A brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio.

***Analog Modulation:*** Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single sideband generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Superheterodyne receiver

**Module- II**

***Analog Pulse Modulation:*** Channel capacity, sampling theorem, Basic Principles-PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing.

***Digital Pulse Modulation:*** Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK).

**Module-III**

***Introduction to Communication and Navigation systems:***

***Satellite Communication***– Introduction, need geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink.

***Mobile Telephony System*** – Basic concept of mobile communication, frequency bands used in mobile communication, the concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption,

**Module- IV**

Architecture (block diagram) of mobile communication network, the idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only)

GPS navigation system (qualitative idea only)

**Text Books:**

1. Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.

**Reference Books**

1. Advanced Electronics Communication Systems- Tomasi, 6th edition, Prentice-Hall.
2. Electronic Communication Systems, G. Kennedy, 3rdEdn., 1999, Tata McGraw Hill.
3. Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill
4. Communication Systems, S. Haykin, 2006, Wiley India
5. Electronic Communication system, Blake, Cengage, 5th edition.
6. Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press

**Lab 13 (Core Lab-6): Digital Systems and Applications Laboratory (ILCPH401)**

**(Minimum of 6 Experiments are to be done):**

***List of Experiments:***

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO and to test a Diode and Transistor using a Millimeter.
2. To design a switch (NOT gate) using a transistor.
3. To verify and design AND, OR, NOT and XOR gates using NAND gates.
4. Half Adder, Full Adder and 4-bit binary Adder.
5. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
6. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
7. To design an astable multivibrator of given specifications using 555Timer.
8. To design a monostable multivibrator of given specifications using 555 Timer.

**Reference Books:**

1. Basic Electronics: A Text Books lab manual, P.B. Zbar, A.P. Malvino,
2. M.A. Miller, 1994, Mc-McGraw-Hill.
3. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice-Hall.
4. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
5. Electronic Devices and Circuit Theory, R.L. Boylestad and L.D. Nashelsky, 20 09, Pearson

**Lab 14 (Core Lab-7): Electricity and Magnetism Laboratory (ILCPH402)**

**(Minimum of 6 Experiments are to be done)**

***List of Experiments:***

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Fosters
5. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
6. To verify the Thevenin and Norton theorems.
7. To determine self-inductance of a coil by Andersons bridge.
8. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Bandwidth.
9. To study the response curve of a parallel LCR circuit and determine its (a) Antiresonance frequency and (b) Quality factor Q.

**Reference Books:**

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text-Book of Practical Physics, I.Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

**Lab 15 (Core Lab-8): Mathematical Physics - I Laboratory (ILCPH403)**

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

Highlights the use of computational methods to solve physical problems

The course will consist of lectures (both theory and practical) in the Lab

The evaluation did not on the programming but on the basis of formulating the problem

Aim at teaching students to construct the computational problem to be solved

Students can use anyone operating system Linux or Microsoft Windows

1. **Introduction and Overview:** Computer architecture and organization, memory and Input/output devices.
2. **Basics of scientific computing:** Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow and overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods. Algorithm **Errors and error Analysis:** Truncation and round off errors, Absolute and relative errors, Floating-point computations. Systematic and Random Errors, Propagation of Errors, Normal Law of Errors, Standard and Probable Error.
3. **Review of C and C++ Programming:** Introduction to Programming, constants, variables and Fundamentals data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (If Statement, If else Statement, Nested If structure, Else If Statement, Ternary operator, Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops), Arrays (1D and 2D) and strings, user-defined functions, Structures and Unions, Idea of classes and objects
4. **Programs:** Sum and average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
5. **Random number generation:** Area of circle, area of the square, volume of sphere, value of *π*.

**Reference Books:**

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
2. Schaum’s Outline of Programming with C++.J. Hubbard, 2000, McGraw– Hill Pub.
3. Numerical Recipesin C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn. 2007, Cambridge University Press.
4. The first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning.
5. Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn. , 2007, Wiley India Edition.
6. Numerical Methods for Scientists and Engineers, R.W. Hamming, 1973, Courier Dover Pub.
7. An Introduction to computational Physics, T. Pang, 2nd Edn., 2006, Cambridge Univ. Press.

**Lab 16 (DSE Lab-1): Advanced Mathematical Physics Laboratory (ILCPH404)**

***Scilab/ C++ based simulations Experiments based on Mathematical Physics problems like***

Linear algebra:

1. Multiplication of two 3 x 3 matrices
2. Eigenvalue and eigenvectors of

1. Orthogonal polynomials as Eigen functions of Hermitian differential operators.
2. Determination of the principal axes of the moment of inertia through diagonalization.
3. Vector space of wave functions in Quantum Mechanics: Position and momentum differential operators and their commutator, wave functions for stationary states as Eigen functions of Hermitian differential operator.
4. The Lagrangian formulation in Classical Mechanics with constraints.
5. Study of geodesics in Euclidean and other spaces (surface of a sphere, etc).
6. Estimation of ground state energy and wave function of a quantum system.

**Text Books:**

1. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896

**Reference Books:**

1. Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444
2. Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

**Lab 16 (DSE Lab-1): Communication System Laboratory (ILCPH405)**

***List of Experiments:***

1. To design an Amplitude Modulator using Transistor
2. To study envelope detector for demodulation of AM signal
3. To study FM - Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
6. To study Time Division Multiplexing (TDM)
7. To study Pulse Amplitude Modulation (PAM)
8. To study Pulse Width Modulation (PWM)
9. To study Pulse Position Modulation (PPM)
10. To study ASK, PSK and FSK modulators

**Text Books:**

1. Electronic Communication Systems, G. Kennedy, 1999, Tata McGraw Hill.

**Reference Books**

1. Electronic Communication system, Blake, Cengage, 5th edition.

**Semester-5**

**Core-9: Mathematical Physics - II (IPCPH501)**

The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

**Module-I**

***Fourier Series-I:*** Periodic functions, Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only), Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients, Complex representation of Fourier series, Expansion of functions with arbitrary period, Expansion of non-periodic functions over an interval, Even and odd functions and their Fourier expansions and Application, Summing of Infinite Series, Term-by-Term differentiation and integration of Fourier Series, Parseval Identity.

**Module-II**

***Frobenius Method and Special Functions:*** Singular Points of Second Order Linear Differential Equations and their importance, Singularities of Bessels and Laguerre Equations, Frobenius method and its applications to differential equations: Legendre and Hermite Differential Equations, Legendre and Hermite Polynomials: Rodrigues Formula, Generating Function, Orthogonality.

**Module-III**

***Polynomials:*** Simple recurrence relations of Legendre and Hermite Polynomials, Expansion of function in a series of Legendre Polynomials, Associated Legendre Differential Equation, Associated Legendre polynomials, Spherical Harmonics

**Some Special Integrals:** Beta and Gamma Functions and relation between them, Expression of Integrals in terms of Gamma Functions, Error Function (Probability Integral).

**Module-IV**

***Partial Differential Equations:*** Solutions to partial differential equations using separation of variables: Laplace’s Equation in problems of rectangular, cylindrical and spherical symmetry. Conducting and dielectric sphere in an external uniform electric field. Wave equation and its solution for vibrational modes of a stretched string

**Text Books:**

1. Mathematical Methods for Physicists, G.B.Arfken, H.J.Weber, F.E.Harris (2013, 7th Edn., Elsevier)
2. Advanced Engineering Mathematics, Erwin Kreyszig (Wiley India)

**Reference Books:**

1. Mathematical Physics and Special Relativity, M. Das, P.K. Jena and B.K. Dash (Srikrishna Prakashan)
2. Mathematical Physics–H. K. Dass, Dr. Rama Verma (S. Chand Publishing)
3. Mathematical Physics C. Harper (Prentice Hall India) Complex Variable:
4. Schaum’s Outlines Series M. Spiegel (2nd Edition, McGraw Hill Education)
5. Complex variables and applications J.W. Brown and R.V. Churchill
6. Mathematical Physics, Satya Prakash (Sultan Chand)
7. Mathematical Physics B.D. Gupta (4th edition, Vikas Publication)

**Core-10: Quantum Mechanics and Applications (IPCPH502)**

**Module- I**

***Schrodinger equation:*** Time-dependent Schrodinger equation, Properties of Wave Function, Interpretation of wave function, Probability and probability current densities in three dimensions, Conditions for Physical Acceptability of Wave Function, Normalization, Linearity and Superposition Principles. Wave function of a free particle, Wave Packet, Fourier Transform and momentum space Wave function, Spread of Gaussian Wave packet, Evolution with time, Position and Momentum Uncertainty.

**Module-II**

***Operators:*** Operators, Commutator Algebra, Position, Momentum Angular Momentum and Energy operators, Hermitian Operators, Expectation values of position and momentum, Ehrenfest Theorem, Eigenvalues and Eigenfunctions of Hermitian Operator, Energy Eigen Spectrum, Degeneracy, Orthonormality of Eigenfunctions, Linear Dependence. Orthogonalisation.

**Module-III**

Time Independent Schrodinger equation in one dimension (1d), 2d and 3d, Hamiltonian, stationary states and energy Eigenvalues, expansion of an arbitrary wave function as a linear combination of energy Eigenfunctions, General solution of the time-dependent Schrodinger equation in terms of linear combinations of stationary states. General Discussion of Bound states in an arbitrary potential: Continuity of wave function, Boundary condition and emergence of discrete energy levels, Application to one dimensional problem-Square well potential, Quantum mechanics of simple Harmonic Oscillator-Energy Levels and energy Eigenfunctions, ground state, zero-point energy and uncertainty principle, One dimensional infinitely rigid box energy Eigenvalues and Eigenfunctions, normalization, quantum dot as example, Quantum mechanical scattering and tunneling in one dimension across a step potential and rectangular potential barrier.

**Module-IV**

***Atoms in Electric and Magnetic Fields:*** Electron angular momentum. Space quantization, Electron Spin and Spin Angular Momentum, Larmors Theorem, Spin Magnetic Moment, Stern Gerlach Experiment, Vector Atom Model, L-S and J-J coupling, Zeeman Effect, Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Atoms in External Magnetic Fields: Normal and Anomalous Zeeman Effect, Paschen back and Stark Effect (qualitative Discussion only)

**Text Books:**

1. Introduction to Quantum Theory David Park (Dover Publications)
2. Introduction to Quantum Theory, D. J. Griffiths (Pearson)

**Reference Books:**

1. Quantum Mechanics, Theory and applications A.Ghatak and S.Lokanathan (McMillan India)
2. Quantum Mechanics - G.Aruldhas (PrinticeHallofIndia)
3. Quantum Physics – S. Gasiorowicz (Wiley)
4. Quantum Mechanics - G.R.Chatwal and S.K.AnandQuantum Mechanics -.L. Powell and B. Craseman (Narosa)
5. Introduction to Quantum Mechanics M.Das and P.K.Jena (Shri Krishna Publication)

**Core-11: Solid State Physics (IPCPH503)**

**Module-I**

***Crystal Structure:*** Solids, Amorphous and Crystalline Materials, Lattice translation Vectors, Lattice with a Basis. Central and Non-Central Elements. Module- Cell, Miller Indices, Types of Lattices, Reciprocal Lattice, Brillouin zones, Diffraction of X-rays by crystals, Bragg Law, Atomic and Geometrical Factor

**Module-II**

***Elementary Lattice Dynamics:*** Lattice Vibrations and Phonons: Linear, Monatomic and Diatomic Chains, Acoustical and Optical Phonons, Qualitative Description of the phonon spectrum in solids, Dulong and Petits Law, Einstein and Debye theories of specific heat of solids, *T*3 Law

***Magnetic Properties of Matter:*** Dia-, Para-, Ferri- and Ferromagnetic Materials, Classical Langevin's theory of dia and Paramagnetic Domains, Curie's law, Weiss Theory of Ferromagnetismand Ferromagnetic Domains, Discussion of B-H Curve, Hysteresis and energy loss.

**Module-III**

***Dielectric Properties of Materials:*** Polarization Local Electrical Field at an Atom, Depolarization Field, Electric Susceptibility, Polarizability, Clausius Mosotti Equation, Classical theory of Electronic Polarizability.

***Lasers:*** Einstein’s A and B coefficients, Metastable States, Spontaneous and Stimulated emissions, Optical Pumping and population Inversion, Three Level and Four-Level Lasers, Ruby Laser and He-Ne Laser.

**Module-IV**

***Elementary band theory:*** Kronig-Penny model of band Gap, Conductor, Semiconductor (P and N-type) and insulator, Conductivity of Semiconductor, mobility, Hall Effect, Measurement of conductivity (04probe method) and Hall Co-efficient.

***Superconductivity:*** Experimental Results, Critical Temperature, Critical magnetic field, Meissner effect, Type-I and type-II Superconductors, Londons Equation and Penetration Depth, Isotope effect, Idea of BCS theory (No derivation)

**Text Books:**

1. Introduction to Solid State Physics- Charles Kittel (Wiley India)
2. LASERS: Fundamentals and Applications – Thyagarajan and Ghatak (McMillan India)

**Reference Books:**

1. Solid State Physics-N.W. Ashcroft and N.D. Mermin (Cengage)
2. Solid State Physics- R.K. Puri and V.K. Babbar (S. Chand Publication)
3. Solid State Physics S. O. Pillai (New Age Publication)
4. Lasers and Nonlinear Optics B.B. Laud (Wiley Eastern)
5. Elements of Solid-State Physics-J.P. Srivastava (Prentice Hall of India)
6. Elementary Solid-State Physics-Ali Omar (Addison Wiley)

**DSE-2: Fluid mechanics (IPEPH501)**

**Module - I**

***Hydrostatics:*** Fluids, hydrostatic pressure, Pascal’s law, the principle of Archimedes, equilibrium of floating bodies, stability of equilibrium, determination of metacentric height, pressure due to a compressible fluid or gas, measurement of atmospheric pressure, correction of Barometer reading.

**Module - II**

***Flow of liquid and viscosity:*** Rate of flow of a liquid, energy of the liquid, Bernoulli’s theorem and its applications, critical velocity, Poiseuille’s equation for flow of liquid through a tube, Motion in a viscous medium, determination of coefficient of liquid, Stoke’s method, variation of viscosity of a liquid with temperature.

**Module - III**

***Surface tension:*** Molecular range, Sphere of influence, surface tension, surface film and surface energy, the free energy of a surface, pressure difference across a liquid surface, Drops and Bubbles: excess pressure inside a liquid drop, excess pressure inside a soap bubble, determination of the surface tension of a bubble.

**Module - IV**

***Capillarity:*** Layer of liquid between two plates, Shape of the liquid meniscus in a capillary tube, Angle of contact, measurement of angle of contact, rise of liquid in a capillary tube, energy required to raise a liquid in a capillary tube, raise of liquid between two parallel plates.

**Books:**

1. Properties of matter- FH. Newman V.H.L. Searle (Edward Arnold publication)
2. Properties of matter –D.S. Mathura (S.chand)
3. Mechanics –K.R. Symon (Addison Wesley)

**DSE-2: Applied Dynamics (IPEPH502)**

**Objective**

1. To initiate the students to the concepts, techniques and applications of non-linear dynamics and deterministic chaos in continuous and discrete systems
2. To expose the students to various examples taken from Physical, Chemical and Biological Sciences and to train them how to apply the techniques taught to analyse such systems
3. To initiate the students to elementary concepts of Fluid Dynamics and various types of fluid flows

**Learning Outcome**

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

1. Develop a heuristic and wholistic understanding of dynamics occurring in Physical, Chemical and Biological systems
2. Apply tools of phase space dynamics to analyse system dynamics and chaos develop
3. Have a basic understanding of Fluid Dynamics and apply the laws to elementary problems of fluid dynamics

**Module- I**

***Introduction to Dynamical systems:*** Definition of a continuous first-order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as first-order dynamical systems: the free particle, particle under uniform gravity, simple and damped harmonic oscillator. Sketching flows and trajectories in phase space; sketching variables as functions of time, relating the equations and pictures to the underlying physical intuition.

Other examples of dynamical systems –

In Biology: Population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, simple genetic circuits

**Module- II**

In Chemistry: Rate equations for chemical reactions e.g. autocatalysis, bistability In Economics: Examples from game theory.

Illustrative examples from other disciplines.

Fixed points, attractors, the stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems, with applications to the above examples.

Computing and visualizing trajectories on the computer using software packages. Discrete dynamical systems. The logistic map as an example.

**Module- III**

***Introduction to Chaos and Fractals:*** Examples of 2-dimensional billiard, Projection of the trajectory on momentum space. Sinai Billiard and its variants. Computational visualization of trajectories in the Sinai Billiard. Randomization and ergodicity in the divergence of nearby phase space trajectories, and dependence of time scale of divergence on the size of the obstacle. Electron motion in mesoscopic conductors as a chaotic billiard problem. Other examples of chaotic systems; visualization of their trajectories on the computer.

Self-similarity and fractal geometry: Fractals in nature – trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure. Fractals in dynamics – Sierpinski gasket and DLA.

Chaos in nonlinear finite-difference equations- Logistic map: Dynamics from time series. Parameter dependence- steady, periodic and chaos states. Cobweb iteration. Fixed points. Defining chaos- aperiodic, bounded, deterministic and sensitive dependence on initial conditions. Period- Doubling route to chaos.

**Module- IV**

***Elementary Fluid Dynamics:*** Importance of fluids: Fluids in the pure sciences, fluids in technology. Study of fluids: Theoretical approach, Experimental fluid dynamics, computational fluid dynamics. Basic physics of fluids: The continuum hypothesis-concept of the fluid element or fluid parcel;

Definition of a fluid- shear stress; Fluid properties- viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow phenomena- flow dimensionality, steady and unsteady flows, uniform & non-uniform flows, viscous & inviscid flows, incompressible & compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated & unseparated flows. Flow visualization - streamlines, pathlines, Streaklines.

**Text Books**

1. Nonlinear Dynamics and Chaos, S.H. Strogatz, Levant Books, Kolkata, 2007

**Reference Books**:

1. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
2. An Introduction to Fluid Dynamics, G.K. Batchelor, Cambridge Univ. Press, 2002
3. Fluid Mechanics, 2nd Edition, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1987.

**AECC-3: Environmental science (IMCCH501)**

**Module - I**

***Ecological Concepts and Natural Resources:*** Ecological perspective and value of the environment. Environmental auditing, Biotic components, Ecosystem Process: Energy, Food Chain, Water cycle, Air cycle etc., Environmental gradients, Tolerance levels of environment factor, EU, US and Indian Environmental Law, Global Perspective. Chemistry and Microbiology in Environmental Engineering: Physical and chemical properties of water, Atmospheric chemistry, Soil chemistry, Microbiology, Chemical and biochemical reactions, Material balances and Reactor configurations. The concept in Hydrology: Hydrological cycle, Water balance, Energy budget, Precipitation, Infiltration, evaporation and evapotranspiration, Rainfall-runoff relationships, Urban hydrology, Groundwater, Groundwater chemistry, Water contamination and pollution prevention.

**Module – II**

***Water Pollution:*** water quality standards and parameters, Assessment of water quality, Aquatic pollution, Freshwater pollution, Estuarine water quality, Marine pollution, Organic content parameters, DO and BOD demand in streams, Transformation process in water bodies, Oxygen transfer by water bodies, Turbulent mixing, Water quality in lakes and preservers, Groundwater quality. Air Pollution: Air pollution and pollutants, criteria pollutants, Acid deposition, Global climate change –greenhouse gases, non-criteria pollutants, emission standard form industrial sources, air pollution meteorology, Atmospheric dispersion. Noise Pollution: Physical Properties of sound, Noise criteria, Noise Standards, Noise measurement, Noise control.

**Module – III**

***Water Treatment:*** Water quality standards, Water sources and their quality, Water treatment processes, Pre-treatment of water, Conventional process, Advanced water treatment process. Waste Water Treatment: Water flow rate and characteristics, Design of wastewater network, Wastewater treatment process, pre-treatment, primary and secondary treatment of wastewater, Activated sludge treatment: Anaerobic digestion and its microbiology, Reactor configurations and methane production. Application of anaerobic digestion. Biosolids regulations, Characteristics and processing of biosolids, first and second stage processing of sludge. Sludge disposal, Integrated sewage and sludge management. Solid Waste Management: Source classification and composition of MSW: properties and separation, storage and transportation, MSW Management, Waste minimization of MSW, Reuse and recycling, Biological treatment, Thermal treatment, Landfill, Integrated waste management. Hazardous Waste Management, Hazardous waste and their generation, Medical hazardous waste, Household waste, Transportation and treatment of hazardous waste: Incinerators, Inorganic waste treatment, Treatment systems for hazardous waste, handling of treatment plant residue. 38 Industrial Air Emission Control: Characterization of air stream, Equipment selection, Equipment design, Special Methods: Flue gas desulphurization, NOx removal, Fugitive emissions.

**Module - IV**

***Waste Minimization:*** Concept, Life Cycle Assessment, Elements of waste minimization strategy, Benefits of waste minimization, Elements of waste minimization programme, Waste reduction techniques. Environment Impact Assessment, Origin and procedure of EIA, Project Screening for EIA, Scope studies, Preparation and review of EIS.

**Books:**

1. G. Kiely – Environmental Engineering Irwin/ McGraw Hill International Edition, 1997
2. M. L. Davis and S. J. Masen, Principles of Environmental Engineering and Science, McGraw Hill International Edition, 2004.

**Lab 17 (Core Lab-9): Mathematical Physics - II Laboratory (ILCPH501)**

The aim of this Lab is to use computational methods to solve physical problems. The course will consist of lectures (both theory and practical) in the Lab. The evaluation did not on the programming but based on formulating the problem.

**Topics**

**Introduction to Numerical computation software Scilab:** Introduction to Scilab, Advantages and disadvantages, Scilab computation software Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built-in Scilab functions, Introduction to plotting, 2D and 3D plotting (2),

Branching Statements and program design, Relational and logical operators, the while loop, for loop, details of loop operations, break and continue statements, nested loops, logical arrays and vectorization (2) User-defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays (2) an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program (2).

**Curve fitting, least square fit Goodness of fit, standard constant Deviation:** Ohms law to calculate R, Hookes law to calculate spring constant

**The solution of Linear system of equations by Gauss elimination Solution method and Gauss-Seidel method. Diagonalization matrices, Inverse of a matrix, Eigenvectors, problems:** Solution of mesh equations of electric circuits (3meshes), Solution ofcoupled spring-mass systems (3masses)

**The solution of ODE First-order Differential equation Euler modified Euler Runge-Kutta second methods Second order differential equation. Fixed difference method: First order differential equation**

1. Radioactive decay
2. Current in RC, LC circuits with DC source
3. Newtons law of cooling
4. Classical equations of motion

**Second-order Differential Equation**

1. Harmonic oscillator (no friction)
2. Damped Harmonic oscillator
3. Over damped
4. Critical damped
5. Oscillatory
6. Forced Harmonic oscillator
7. Transient and Steady statesolution
8. Apply above to LCR circuits also

**Reference Books:**

1. Mathematical Methods for Physics and Engineers, K.FRiley, M.P.Hobson and S. J.20 Bence, 3rd ed., 2006, Cambridge University Press
2. Complex Variables, A.S. Fokas and M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
3. The first course in complex analysis with applications, D.G.Zill and P.D.Shanahan, 1940, Jones and Bartlett
4. Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernndez. 2014 Springer
5. Scilab by example: M. Affouf 2012, ISBN: 978-1479203444
6. Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair.2011S.Chand and Company
7. Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing

**Lab 18 (Core Lab-10): Quantum Mechanics Laboratory (ILCPH502)**

*Use C/C++/Scilab for solving the following problems based on Quantum Mechanics like (Use finite difference method, matrix method, ODE Solver method in all cases)*

1. Solve the s-wave Schrödinger equation for the ground state and the first excited state of the hydrogen atom:

where m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wave functions. Remember that the ground state energy of the hydrogen atom is ~ -13.6 eV. Take , and

1. Solve the s-wave radial Schrödinger equation for an atom:

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened Coulomb potential:

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wave function. Take , and and . The ground state energy is expected to be above -12eV in all three cases.

1. Solve the s-wave radial Schrödinger equation for a particle of mass m:

for the anharmonic oscillator potential: .

Find the ground state energy (in MeV) of the particle to an accuracy of three significant digits. Also plot the corresponding wave function. Choose . In these Units, . [The ground state energy is expected to lie between 90 and 110 MeV for all the three cases.]

1. Solve the s-wave radial Schrödinger equation for the vibrations of hydrogen molecule: where m is the reduced mass of the two-atom system for the Morse potential: , where . Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave functions for the choices given below:

***Laboratory-based Experiments:***

1. Study of Electron spin resonance- determine the magnetic field as a function of the resonance frequency
2. Study of Zeeman effect: with the external magnetic field; Hyperfine splitting
3. To show the tunneling effect in tunnel diode using I-V characteristics.
4. Quantum efficiency of CCDs

**Reference Books:**

1. Schaum’s Outline of Programming with C++. J.Hubbard, 2000, McGraw– Hill Publication
2. Numerical Recipes in C: The Art of Scientific Computing, W.H. Press et al., 3rd Edn., 2007, Cambridge University Press.
3. An introduction to computational Physics, T.Pang, 2nd Edn., 2006, Cam- bridge Univ. Press
4. Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C.V. Fernndez.2014 Springer.
5. Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011S. Chand andCo.
6. Scilab Image Processing: L.M. Surhone.2010 Betascript Publishing ISBN: 9786133459274

**Lab 19 (Core Lab-11): Solid State Physics Laboratory (ILCPH503)**

**(Minimum 4 Experiments are to be done)**

***List of Experiments:***

1. Measurement of the susceptibility of paramagnetic solution (Quincks Tube-Method)
2. To measure the Magnetic susceptibility of Solids.
3. To measure the Dielectric Constant of a dielectric Materials with frequency
4. To determine the Hall coefficient of a semiconductor sample.
5. To draw the BH curve of Fe using a solenoid and to determine the energy loss from Hysteresis
6. To measure the bandgap of a given semiconductor by the four-probe method.

**Reference Books:**

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Books Book of Practical Physics, I. Prakash and Ramakrishna, 11 Ed., 2011, Kitab Mahal
4. Elements of Solid-State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice- Hall of India.

**Lab 20 (DSE Lab 2): Fluid Mechanics Laboratory (ILCPH504)**

***List of Experiments:***

1. To determine the surface tension of a liquid by capillary rise method.
2. To determine the coefficient of viscosity of a known fluid using Stokes' method.
3. To determine the Surface Tension of Liquid by Jaeger's Method.
4. To find Reynolds number for a pipe flow.
5. To determine coefficient of viscosity of water by Poiseuille’s Method
6. Measurement of density and specific gravity
7. Study of the effect of capillary elevation between flat sheets
8. Study of Archimedes’ principle
9. Measurement of the viscosity of a fluid using a sphere viscometer
10. Determination of co-efficient of friction of flow in a pipe
11. To verify the Bernoulli’s Theorem.
12. To show the velocity and pressure variation with radius in a forced vortex flow.

**Lab 20 (DSE Lab 2): Applied Dynamics Laboratory (ILCPH505)**

***Laboratory/Computing and visualizing trajectories using software such as Scilab, Maple, Octave, XPPAUT based on Applied Dynamics problems like***

1. To determine the coupling coefficient of coupled pendulums.
2. To determine the coupling coefficient of coupled oscillators.
3. To determine the coupling and damping coefficient of a damped coupled oscillator.
4. To study population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, simple genetic circuits.
5. To study rate equations for chemical reactions e.g. autocatalysis, bistability.
6. To study examples from game theory.
7. Computational visualization of trajectories in the Sinai Billiard.
8. Computational visualization of trajectories Electron motion in mesoscopic conductors as a chaotic billiard problem.
9. Computational visualization of fractal formations of Deterministic fractal.
10. Computational visualization of fractal formations of the self-similar fractal.
11. Computational visualization of fractal formations of Fractals in nature – trees, coastlines, earthquakes.
12. Computational Flow visualization - streamlines, pathlines, Streaklines.

**Text Books**

1. Nonlinear Dynamics and Chaos, Steven H. Strogatz, Levant Books, Kolkata, 2007

**Reference Books**:

1. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
2. An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
3. Fluid Mechanics, 2ndEdn, L.D.Landau& E.M. Lifshitz, Pergamon Press, Oxford, 1987
4. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
5. Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444
6. Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

**Semester-6**

**Core-12: Electro - Magnetic Theory (IPCPH601)**

**Module-I**

***Maxwell Equations:*** Maxwell's equations, Displacement Current, Vector and Scalar Potentials, Gauge Transformations: Lorentz and Coulomb Gauge, Boundary Conditions at Interface between Different Media, Wave Equations, Plane Waves in Dielectric Media, Poynting Theorem and Poynting Vector, Electro-magnetic (EM) Energy Density, Physical Concept of Electromagnetic Field Energy Density

**Module-II**

***EM Wave Propagation in Unbounded Media:*** Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance, Propagation through conducting media, relaxation time, skin depth, Electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.

**Module-III**

***EM Wave in Bounded Media:*** Boundary conditions at a plane interface between two media, Reflection and Refraction of plane waves at plane interface between two dielectric media, Laws of Reflection and Refraction, Fresnel’s Formulae for perpendicular and parallel polarization cases, Brewster’s law, Reflection and Transmission coefficients, Total internal reflection, evanescent waves, Metallic reflection (normal Incidence)

**Module-IV**

***Polarization of Electromagnetic Waves:*** Description of Linear, Circular and Elliptical Polarization, Uniaxial and Biaxial Crystals, Light Propagation in Uniaxial Crystal, Double Refraction, Polarization by Double Refraction, Nicol Prism, Ordinary and extraordinary refractive indices, Production and detection of Plane, Circularly and Elliptically Polarized Light,

***Phase Retardation Plates:*** Quarter-Wave and Half-Wave Plates. Babinets Compensator and its Uses, Analysis of Polarized Light.

***Rotatory Polarization:*** Optical Rotation, Biots Laws for Rotatory Polarization, Fresnels Theory of optical rotation, Calculation of angle of rotation, Experimental verification of Fresnel's theory, Specific rotation, Laurents half- shade polarimeter.

**Text Books:**

1. Introduction to Electrodynamics, D.J. Griffiths (Pearson)
2. Principles of Optics - MaxBorn and E.Wolf

**Reference Books:**

1. Classical Electrodynamics by J.D.Jackson
2. Foundation of electromagnetic theory: Ritzand Milford (Pearson)
3. Electricity and Magnetism: DC Tayal (Himalaya Publication)
4. Optics: A.K.Ghatak
5. Electricity and Magnetism: Chattopadhyaya, Rakhit (New Central)

**Core-13: Mathematical Physics - III (IPCPH602)**

The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

**Module-I**

***Complex Analysis:*** Brief Revision of Complex Numbers and their Graphical Representation Eulers formula, De Moivres theorem, Roots of Complex Numbers, Functions of Complex Variables, Analyticity and Cauchy-Riemann Conditions, Examples of analytic functions, Singular functions: poles and branch points, order of singularity, branch cuts, Integration of a function of a complex variable, Cauchy's Inequality, Cauchy's Integral Formula, Simply and multiply connected region, Laurent and Taylors expansion, Residues and Residue Theorem, Application in solving Definite Integrals.

**Module-II**

***Integral Transforms-I:*** Fourier Transforms: Fourier Integral theorem, Fourier Transform, Examples, Fourier Transform of trigonometric, Gaussian, finite wave train and other functions, Representation of Dirac delta function as a Fourier Integral, Fourier transform of derivatives, Inverse Fourier Transform.

**Module-III**

***Integral Transforms-II:*** Convolution theorem, Properties of Fourier Transforms (translation, change of scale, complex conjugation), Three dimensional Fourier transforms with examples, Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat flow Equations.

**Module-IV**

***Laplace Transforms*** Laplace Transforms (LT) of Elementary functions,

***Properties of Laplace Transforms:*** Change of Scale Theorem, Shifting Theorem, LTs of Derivatives and Integrals of Functions, Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of **Unit-** Step function, Dirac Delta function, Periodic Functions, Inverse LT, Application of Laplace Transforms to Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits.

**Text Books:**

1. Mathematical Methods for Physicists, G.B. Arfken, H.J.Weber, F.E.Harris (2013, 7th Edn., Elsevier)
2. Advanced Engineering Mathematics, Erwin Kreyszig (Wiley India)

**Reference Books:**

1. Mathematical Physics and Special Relativity – M. Das, P.K. Jena and B.K. Dash (Srikrishna Prakashan)
2. Mathematical Physics – H. K. Das, Dr. Rama Verma (S. Chand Publishing)
3. Mathematical Physics C. Harper (Prentice Hall India)
4. Complex Variable: Schaum’s Outlines Series M. Spiegel (2nd Edition, Mc- Graw Hill Education)
5. Complex variables and applications J.W. Brown and R.V. Churchill
6. Mathematical Physics, Satya Prakash (Sultan Chand)
7. Mathematical Physics by B.D. Gupta (4thedition, Vikas Publication)

**Core-14: Statistical Mechanics (IPCPH603)**

**Module- I**

***Classical Statistics-I:*** Macrostate and Microstate, Elementary Concept of Ensemble, Microcanonical, Canonical and Grand Canonical ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function.

**Module- II**

***Classical Statistics-II:*** Thermodynamic Functions of an Ideal Gas, classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of equipartition of Energy (with proof)- Applications to Specific Heat and its Limitations, Thermodynamic Functions of a two energy levels system, Negative Temperature.

**Module-III**

***Quantum Statistics:*** Identical particles, macrostates and microstates, Fermions and Bosons, Bose-Einstein distribution function and Fermi- Dirac distribution function. Bose-Einstein Condensation, Bose deviation from Planck's law, Effect of temperature on Fermi-Dirac distribution function, degenerate Fermi gas, Density of States Fermi energy.

**Module-IV**

***Radiation:*** Properties of Thermal Radiation, Blackbody Radiation, Pure Temperature dependence, Kirchhoff's law, Stefan Boltzmann law: Thermodynamic proof, Radiation Pressure, Wein’s Displacement law, Wiens distribution Law, Saha’s Ionization Formula, Rayleigh-Jeans Law, Ultra Violet catastrophe.

***Planck’s Law of Black body Radiation:***

Experimental verification, Deduction of (1) Wiens Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan Boltzmann Law, (4) Wein’s Displacement Law from Planck’s Law.

**Text Books:**

1. Introduction to Statistical Physics by Kerson Huang (Wiley).
2. Statistical Physics, Berkeley Physics Course, F. Reif (Tata McGraw-Hill)

**Reference Books:**

1. Statistical Mechanics, B.K. Agarwal and Melvin Eisner (New Age International)
2. Thermodynamics, Kinetic Theory and Statistical Thermodynamics: Francis W. Sears and Gerhard L. Salinger (Narosa)
3. Statistical Mechanics: R.K. Pathria and Paul D. Beale (Academic Press)

**DSE-3: Introduction to Nuclear and Particle Physics (IPEPH601)**

**Module-I**

***General properties of Nuclei:*** Constituents of nucleus and their intrinsic properties, Quantitative facts about mass, radius, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment electric moments, nuclear excites states.

***Radioactivity decays:*** (a) Alpha decay: basics of alpha- decay processes, the theory of alpha-emission, Gamow factor, Geiger Nuttall law (b) beta-decay: energy kinematics for beta-decay, positron emission, electron capture, neutrino hypothesis. (c) Elementary idea of Gamma decay.

**Module-II**

***Nuclear Models:*** Liquid drop model approach, semi-empirical mass formula and significance of its various terms, conditions of nuclear stability, two nucleon separation energies, evidence for nuclear shell structure, nuclear magic number, basic assumption of shell models.

**Module-III**

***Detector for nuclear radiations:*** Detector for nuclear radiations: Gas detectors: estimation of the electric field, mobility of particle, for ionization chamber and GM Counter. Basic Principle of Scintillation Detectors and Construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge Particle and photon detection (Concept of charge carrier and mobility), neutron detector.

***Particle Accelerators:*** Van-de Graff generator (Tandem Accelerator), Linear accelerator, Cyclotron, Synchrotrons

**Module-IV**

***Particle Physics:*** Particle interactions, basic features, types of particles and its families, Symmetries and conservation laws: Energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, strangeness and charm, Elementary ideas of quarks and gluons.

**Text Books:**

1. Introduction to Nuclear Physics By Roy and Nigam
2. Atomic and Nuclear Physics - N.Subramanyam, Brij Lal and JivanSeshan (S. Chand Publishing)

**Reference Books:**

1. Introduction to Modern Physics - H.S.Mani and G.K.Mehta (Affiliated east and west)
2. Introductory nuclear Physics-Kenneth S. Krane (Wiley India Pvt. Ltd)
3. Introduction to Elementary Particles-D. Griffith (John Wiley and sons)
4. Concepts of Nuclear Physics - Bernard L. Cohen. (Tata Mcgraw Hill).
5. Concepts of Modern Physics-Arthur Beiser (Mc GrawHill)

**DSE 3: Physics of Devices and Communication (IPEPH602)**

**Objective**

1. Learning about UJT, JEFT, MOS, MOSFET and CMOS.
2. Learning about different types of filters.
3. Learn about different techniques for the processing of devices
4. Learning about the digital data communication system, including both serial and parallel communication. Also the detailed communication system.

**Learning Outcome**

1. Upon successful completion of this course, students will be able to:
2. Understands the characteristics of JFET, MOSFET UJT etc.
3. Design filters and rectifiers.
4. Verify theorems and analyse several circuits by simulation.
5. Take an analytical approach to problems in their future endeavours.

**Module- I**

***Devices:*** Characteristic and small-signal equivalent circuits of UJT and JFET. Metal-semiconductor Junction. Metal oxide semiconductor (MOS) device. Ideal MOS and Flat Band voltage. SiO2-Si-based MOS. MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge-coupled devices. Tunnel diode.

Power supply and Filters: Block Diagram of a Power Supply, Qualitative idea of C and L Filters. IC Regulators, Line and load regulation, Short circuit protection.

**Module- II**

Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters.

***Multivibrators:*** Astable and Monostable Multivibrators using transistors.

***Phase-Locked Loop (PLL):*** Basic Principles, Phase detector (XOR & edge triggered), Voltage Controlled Oscillator (Basics, varactor). Loop Filter– Function, Loop Filter Circuits, transient response, lock and capture. The basic idea of the PLL IC (565 or 4046).

**Module- III**

***Processing of Devices:*** Basic process flow for IC fabrication, Electronic grade silicon. Crystal plane and orientation. Defects in the lattice. Oxide layer. Oxidation Technique for Si. Metallization technique. Positive and Negative Masks. Optical lithography. Electron lithography. Feature size control and wet anisotropic etching. Liftoff Technique. Diffusion and implantation.

**Module- IV**

***Digital Data Communication Standards:***

Serial Communications: RS232, Handshaking, Implementation of RS232 on PC.

Universal Serial Bus (USB): USB standards, Types and elements of USB transfers. Devices (the Basic idea of UART).

Parallel Communications: General Purpose Interface Bus (GPIB), GPIB signals and lines, Handshaking and interface management, Implementation of a GPIB on a PC. The basic idea of sending data through a COM port.

***Introduction to communication systems****:* Block diagram of the electronic communication system, Need for modulation. Amplitude modulation. Modulation Index. Analysis of Amplitude Modulated wave. Sideband frequencies in AM wave. CE Amplitude Modulator. Demodulation of AM wave using Diode Detector. The basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK.

**Text Books:**

1. Electronic devices and integrated circuits, A.K. Singh, 2011, PHI Learning Pvt. Ltd.

**Reference Books**

1. Physics of Semiconductor Devices, S.M. Sze & K.K. Ng, 3rd Ed.2008, John Wiley & Sons
2. Op-Amps & Linear Integrated Circuits, R.A. Gayakwad, 4 Ed. 2000, PHI Learning Pvt. Ltd
3. Electronic Devices and Circuits, A. Mottershead, 1998, PHI Learning Pvt. Ltd.
4. Electronic Communication Systems, G. Kennedy, 1999, Tata McGraw Hill.
5. Introduction to Measurements & Instrumentation, A.K. Ghosh, 3rd Ed., 2009, PHI Learning Pvt. Ltd.
6. Semiconductor Physics and Devices, D.A. Neamen, 2011, 4th Edition, McGraw Hill
7. PC based instrumentation; Concepts & Practice, N. Mathivanan, 2007, Prentice-Hall of India

**DSE 3: Embedded systems - Introduction to Microcontroller (IPEPH603)**

**Objective**

1. To make the student learn about the embedded system, its applications and challenges.
2. To learn about microprocessor and microcontroller.
3. To learn microprocessor programing.
4. To learn about embedded system design and development.
5. Practice mode learning for these topics.

**Learning Outcome**

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

1. Understand the embedded system and its application.
2. Understands microprocessor-based systems in detail.
3. Gains knowledge about the design and development of an embedded system.

**Module - I**

***Embedded system introduction:*** Introduction to embedded systems and general-purpose computer systems, the architecture of embedded system, classifications, applications and purpose of embedded systems, challenges & design issues in embedded systems, operational and non-operational quality attributes of embedded systems, elemental description of embedded processors and microcontrollers.

***Review of microprocessors:*** Organization of Microprocessor-based system, 8085μp pin diagram and architecture, the concept of data bus and address bus, 8085 programming model, instruction classification, subroutines, stacks and its implementation, delay subroutines, hardware and software interrupts.

**Module - II**

***8051 microcontrollers:*** Introduction and block diagram of 8051 microcontrollers, the architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions.

***8051 I/O port programming:*** Introduction of I/O port programming, pinout diagram of8051 microcontroller, I/O port pins description & their functions, I/O port programming in 8051 (using assembly language), I/O programming: Bit manipulation.

***Programming:*** 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic and logic instructions, 8051 programmings in C: for time delay & I/O operations and manipulation, for arithmetic and logic operations, for ASCII and BCD conversions.

**Module - III**

***Serial port programming with and without interrupt:*** Introduction to 8051 interrupts, programming timer interrupts, programming external hardware interrupts and serial communication interrupt, interrupt priority in the 8051.

***Interfacing 8051 microcontrollers to peripherals:*** Parallel and serial ADC, DAC interfacing, LCD interfacing.

**Module- IV**

***Programming Embedded Systems:*** Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging.

***Embedded system design and development:*** Embedded system development environment, file types generated after cross-compilation, disassembler/ decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry.

**Text Books:**

1. Embedded Systems: Architecture, Programming & Design, R.Kamal, 2008, Tata McGraw Hill

**Reference Books:**

1. The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education India.
2. Embedded microcomputer system: Real-time interfacing, J.W. Valvano, 2000, Brooks/Cole
3. Microcontrollers in practice, I. Susnea and M. Mitescu, 2005, Springer.
4. Embedded Systems: Design & applications, S.F. Barrett, 2008, Pearson Education India
5. Embedded Microcomputer Systems: Real-time interfacing, J.W. Valvano 2011, Cengage Learning

**DSE-4: Measurement Techniques (IPEPH604)**

**Objective**

1. To understand how to take measurements with accuracy and efficiency.
2. To develop a greater understanding of the issues involved different types of measurements.
3. To learn about transducers, impedance bridges and multimeter.

**Learning Outcome**

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

1. Understand the importance of accuracy in measurement.
2. Understand the working and application of transducers.
3. Learn about all these and LCR circuits by practice mode.

**Module-I**

***Measurements:*** Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from the mean, average deviation, standard deviation, chi-square) and curve fitting. Gaussian distribution.

***Signals and Systems:*** Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first and second-order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, shot noise, 1/f noise

**Module-II**

***Transducers & industrial instrumentation (working principle, efficiency, applications):*** Static and dynamic characteristics of Measurement Systems. Generalized performance of systems, Zero order first order, second-order and higher-order systems. Electrical, Thermal and Mechanical systems. Calibration.

Transducers and sensors. Characteristics of Transducers. Transducers as the electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning.

***Transducers continued***

Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers.

**Module-III**

***Digital Multimeter:*** Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement.

**Module-IV**

***Impedance Bridges and Q-meter:*** Block diagram and working principles of RLC Bridge. Q-meter and it’s working operation. Digital LCR Bridge.

***Sensors:*** Radiation Sensors: Principle of Gas-filled detector, ionization chamber, scintillation detector

**Text Books:**

1. Measurement, Instrumentation and Experiment Design in Physics and Engineering, M. Sayer and A. Mansingh, PHI Learning Pvt. Ltd.

**Reference Books:**

1. Experimental Methods for Engineers, J.P. Holman, McGraw Hill
2. Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Edition, PHI Learning Pvt. Ltd.
3. Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
4. Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill
5. Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd.
6. Electronic circuits: HandBook of design & applications, U.Tietze, Ch.Schenk, Springer

**Lab 21 (Core Lab-12): Electro - Magnetic Theory Laboratory (ILCPH601)**

**(Minimum of 4 Experiments are to be done):**

***List of Experiments:***

1. To verify the law of Malus for plane-polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinets compensator.
4. To determine the refractive index of a liquid by total internal reflection using Wollastons air-film.
5. To determine the refractive index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
6. To study the polarization of light by reflection and determine the polarizing angle for the air-glass interface.
7. To verify Stefan‘s law of radiation and to determine Stefan's constant.
8. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

**Reference Books:**

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. An advanced level Physics Practical’s, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Books Book of Practical Physics, I.Prakash and Ramakrishna, 11 Ed., 2011, Kitab Mahal Electromagnetic Field Theory for Engineers and Physicists, G. Lehner, 2010, Springer

**Lab 22 (Core Lab-13): Mathematical Physics - III Laboratory (ILCPH602)**

Scilab based simulation (XCos) experiments based on Mathematical Physics problems like

* Solve simple differential equations like:

with

with

with

with

* Direct Delta Function

Evaluate , for and show that it tends to 5

* Fourier Series:
* Program to sum
* Evaluate the Fourier coefficients of a given periodic function (square wave)
* Frobenius method and Special functions:

Plot , Legendre polynomial of degree n, and , Bessel function of first kind.

Show recursion relation

* Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
* Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.
* Evaluation of trigonometric functions e.g., sin θ. Given Bessel’s function at N points find its value at an intermediate point.

Complex analysis: Calculate and check it with computer integration.

* Integral transform: FFT of .

**Reference Books:**

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J.
2. Bence, 3rd ed., 2006, Cambridge University Press
3. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
4. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB:
5. Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V.
6. Fernández. 2014 Springer ISBN: 978-3319067896
7. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn.,
8. Cambridge University Press
9. Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
10. Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company
11. Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
12. https: //web.stanford.edu/~boyd/ee102/laplace\_ckts.pdf
13. ocw.nthu.edu.tw/ocw/upload/12/244/12handout.pdf

**Lab 23 (Core Lab-14): Statistical Mechanics Laboratory (ILCPH603)**

*Use C/C++/Scilab for solving the problems based on Statistical Mechanics like*

1. Plot Planck’s law for Black Body radiation and compare it with Weins
2. Law and Raleigh-Jeans Law at high temperature (room temperature) and low temperature.
3. Plot Specific Heat of Solids by comparing (a) Dulong-Petit law, (b) Einstein distribution function, (c)Debye distribution function for high temperature (room temperature) and low temperature and compare them for these two cases
4. Plot Maxwell-Boltzmann distribution function versus temperature.
5. Plot Fermi-Dirac distribution function versus temperature.
6. Plot Bose-Einstein distribution function versus temperature.

**Reference Books:**

1. Elementary Numerical Analysis, K.E. Atkinson, 3rdEdn. 2007, Wiley India Edition
2. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
3. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
5. Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C.V. Fernndez. 2014 Springer ISBN: 978-3319067896
6. Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
7. Scilab Image Processing: L.M. Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

**Lab 24 (DSE-3 Lab): Introduction to Nuclear and Particle Physics Laboratory (ILCPH604)**

1. G.M. Counter I
2. G.M. Counter II
3. Rutherford Scattering
4. Gamma ray spectrometer
5. Compton scattering

**Lab 24 (DSE-3 Lab): Physics of Devices and Communication Laboratory (ILCPH605)**

**At least any 8 of the followings to be done.**

***List of Experiments from both Section A and Section B:***

***Section-A***

1. To design a power supply using bridge rectifier and study effect of C-filter.
2. To design the active Low pass and High pass filters of a given specification.
3. To design the active filter (wide bandpass and band-reject) of given specification.
4. To study the output and transfer characteristics of a JFET.
5. To design a common source JFET Amplifier and study its frequency response.
6. To study the output characteristics of a MOSFET.
7. To study the characteristics of a UJT and design a simple Relaxation Oscillator.
8. To design an Amplitude Modulator using Transistor.
9. To design PWM, PPM, PAM and Pulse code modulation using ICs.
10. To design an Astable multivibrator of given specifications using transistor.
11. To study a PLL IC (Lock and capture range).
12. To study envelope detector for demodulation of AM signal.
13. Study of ASK and FSK modulator.
14. Glow an LED via the USB port of PC.
15. Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of the USB port.

***Section-B:***

***SPICE/MULTISIM simulations for electrical networks and electronic circuits***

1. To verify the Thevenin and Norton Theorems.
2. Design and analyze the series and parallel LCR circuits
3. Design the inverting and non-inverting amplifier using an Op-Amp of given gain
4. Design and Verification of op-amp as integrator and differentiator
5. Design the 1st order active low pass and high pass filters of a given cutoff frequency
6. Design a Wein`s Bridge oscillator of a given frequency.
7. Design clocked SR and JK Flip-Flop`s using NAND Gates
8. Design 4-bit asynchronous counter using Flip-Flop ICs
9. Design the CE amplifier of a given gain and its frequency response.

**Text Books:**

1. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A.Miller, 1994, Mc-Graw Hill

**Reference Books**

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice-Hall.
3. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4thedn., 2000, Prentice-Hall.
4. Introduction to PSPICE using ORCAD for circuits & Electronics, M.H. Rashid, 2003, PHI Learning.
5. PC based instrumentation; Concepts & Practice, N.Mathivanan, 2007, Prentice-Hall of India

**Lab 24 (DSE-3 Lab): Embedded systems - Introduction to Microcontroller Laboratory (ILCPH606)**

**(At least any 8 of the followings to be done.)**

***8051 microcontroller-based Programs and Experiments***

1. To find that the given numbers are prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED. Simulate binary counter (8 bit) on the LED.
5. Program to glow the first four LEDs then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segments LED display.
8. To interface the seven segments LED display with 8051 microcontrollers and display ‘HELP’ in the seven segments LED display.
9. To toggle ‘1234’ as ‘1324’ in the seven segments LED display.
10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in the clockwise or counterclockwise direction.
11. Application of embedded systems: Temperature measurement, some information on the LCD display, interfacing a keyboard.

***Arduino based programs and Experiments:***

1. Make a LED flash at different time intervals.
2. To vary the intensity of LED connected to Arduino
3. To control the speed of a stepper motor using a potential meter connected to Arduino
4. To display “PHYSICS” on LCD/CRO.

**Text Books:**

1. Embedded Systems: Architecture, Programming& Design, R. Kamal, ]2008, Tata McGraw Hill

**Reference Books:**

1. The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education India.
2. Embedded Microcomputer System: Real-Time Interfacing, J.W.Valvano, 2000, Brooks/Cole
3. Embedded System, B.K. Rao, 2011, PHI Learning Pvt. Ltd.
4. Embedded Microcomputer Systems: Real-time interfacing, J.W. Valvano 2011, Cengage Learning

**Lab 25 (DSE-4 Lab): Measurement Techniques Laboratory (ILCPH607)**

**(At least any 8 of the followings to be done.)**

***List of Experiments:***

1. Determine output characteristics of an LVDT & measure displacement using LVDT
2. Measurement of Strain using Strain Gauge.
3. Measurement of the level using the capacitive transducer.
4. To study the characteristics of a Thermostat and determine its parameters.
5. Study of distance measurement using ultrasonic transducer.
6. Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75) To measure the change in temperature of ambient using Resistance Temperature Device (RTD).
7. Create a vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.
8. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of the importance of grounding using function generator of mV level & an oscilloscope.
9. To design and study the Sample and Hold Circuit.
10. Design and analyze the Clippers and Clampers circuits using junction diode
11. To plot the frequency response of a microphone.
12. To measure Q of a coil and influence of frequency, using a Q-meter.

**Text Books:**

1. Electronic circuits: Hand Book of design and applications, U. Tietze and C. Schenk, 2008, Springer

**Reference Books:**

1. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1990, Mc-Graw Hill
2. Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer and A. Mansingh, 2005, PHI Learning.

**Lab 25 (DSE-4 Lab): Dissertation / Project (IPRPH601)**

[As per the department]

**Semester-7**

**Core-15: Classical Mechanics (IPCPH701)**

**Course Objectives:**

**Students will be able to:**

1. Develop familiarity with the physical concepts and facility with the mathematical methods of classical mechanics.
2. Develop skills in formulating and solving physics problems.
3. To demonstrate knowledge and understanding of the following fundamental concepts in:
   1. the dynamics of system of particles,
   2. motion of rigid body,
   3. Lagrangian and Hamiltonian formulation of mechanics
   4. Small oscillation problems
4. To represent the equations of motion for complicated mechanical systems using the Lagrangian and Hamiltonian formulation of classical mechanics.

**Module-I**

***Mechanics of a system of particles:***

Inertial and non-inertial frames of reference. 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-Lagranges equation, Brachistochrone problem, Hamiltons principle, extension of Hamiltons principle to nonholonomic systems, Legendre transformation and the Hamilton equations of motion, physical significance of Hamiltonian, Derivation of Hamiltons equations of motion from a variational principle, Rouths procedure, Principle of least action.

**Module-II**

***Canonical transformations:***

Canonical Transformation, types of generating function, conditions for Canonical Transformation, integral invariance of Poincare, Poissons theorem, Poisson and Lagrange bracket, Poisson and Lagrange Brackets as canonical invariant, Infinitesimal canonical Transformation and conservation theorems, Liouvilles theorem.

***Hamilton -Jacobi Theory:***

Hamilton - Jacobi equation for Hamiltons’ principal function, Harmonic oscillator and Kepler problem by Hamilton - Jacobi method, Action angle variables for completely separable system, Kepler problem in Action angle variables, Geometrical optics and wave mechanics.

**Module-III**

***Small oscillation:***

Problem of small oscillations, Example of two coupled oscillator, General theory of small oscillations, Normal coordinates and Normal modes of vibration, Free vibrations of a linear Triatomic molecule.

***Rigid body motion:***

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

***Rigid body dynamics:***

Angular Momentum and kinetic energy of motion about a point. The Inertia Tensor and momentum of Inertia, Eigenvalues 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.

**BOOKS:**

1. Classical Mechanics -H. Goldstein
2. Classical Mechanics - Landau and Liftshitz
3. Classical Mechanics Corben&Stehle
4. Classical Dynamics Marion & Thornton
5. Analytical Mechanics L. Hand and J. Finch
6. Classical Mechanics J. C. Upadhyaya

**Course Outcomes:**

Students will be able to:

1. Define and understand basic mechanical concepts related to discrete and continuous mechanical systems,
2. Describe and understand the vibrations of discrete and continuous mechanical systems,
3. Describe and understand planar and spatial motion of a rigid body and understand the motion of a mechanical system using Lagrange-Hamilton formalism.
4. Demonstrate a working knowledge of classical mechanics and its application to standard problems such as central forces.

**Core-16: Mathematical Methods in Physics-I (IPCPH702)**

**Course Objective:**

The objectives of this course are to:

1. Provide students with basic skills necessary for the application of mathematical methods in physics.
2. Introduction of various existing mathematical methods in order to analyse theories, methods and interpretations.
3. Develop understanding among the students how to use methods within his/her field of study of research and in the field of scientific knowledge to work independently.

**Module-I**

***Complex Analysis:***

Brief revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy’s Integral formula. Simply and multiply connected region. Laurent and Taylor’s expansion. Residues and Residue Theorem. Application in solving definite Integrals.

**Module-II**

***Integral Transforms:***

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three-dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One-dimensional Wave and Diffusion/Heat Flow Equations.

**Module-III**

***Laplace Transforms:***

Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits.

***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). Beta and Gamma functions.

**BOOKS:**

1. Mathematical methods of physics J. Mathews & R. L. Walker.
2. Mathematical methods of physics Arfken and Weber.
3. Mathematical methods for physicists Dennery & Krzywicki.
4. Mathematical methods of physics H. K. Das
5. Mathematical methods of physics Dr. Rama verma (S. Chand)
6. Mathematical methods of physics Satyaprakash (S. Chand)
7. Mathematical methods of physics Binoy Bhattacharya. (NCBA Publication)
8. Introduction to Tensor calculus - Goreux S. J.
9. Mathematical methods of physics Dettman J. W.
10. Advanced Engineering Mathematics, E. Kreyszig (New Age Publication) 2011.
11. Complex Variables, A. S. Fokas& M. J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
12. Complex Variables and Applications, J. W. Brown & R. V. Churchill, 7th Ed. 2003, Tata McGraw•
13. First course in complex analysis with applications, D. G. Zill and P. D. Shanahan, 1940, Jones & Bartlett.
14. Mathematical Physics –C. Harper, (Prentice Hall India) 2006.
15. Mathematical Physics-Goswami (Cengage Learning) 2014

**Course Outcomes:**

Upon completion of this course, students should be able to:

1. Demonstrate the utility and limitations of a variety of powerful calculation techniques and to provide a deeper understanding of the mathematics underpinning theoretical physics.
2. Understand elementary ideas in linear algebra, special functions and complex analysis.
3. Will be able to apply these to solve problems in classical, statistical and quantum mechanics, electromagnetism as well as solid state physics.
4. Use integral transform methods (Fourier Transform and Laplace Transform) to solve elementary differential equations in physics and engineering.

**Core-17: Quantum Mechanics-I (IPCPH703)**

**Course Objectives:**

Students will be able to:

1. Study postulates and formalism of quantum mechanics
2. Study operator formulation of quantum mechanics
3. Study time evolution of a state and operator and apply Schrodinger equation to 1D harmonic oscillator
4. Study operator algebra of orbital angular momentum and spin angular momentum operator
5. Study motion in spherical symmetric potential and apply Schrodinger equation to solve hydrogen atom

**Module-I**

***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, completeness and orthogonal relation, Schmidt’s orthonormalization procedure, Dual space, Bra and Ket vectors, Hilbert space formalism for quantum mechanics.

***Operator:***

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**

***Quantum Dynamics:***

Time evolution of quantum states, time evolution of operators and its 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, Density matrix.

***Rotation and orbital angular momentum:***

Rotation matrix, Angular momentum operators as the generation of rotation, components of angular momentum Lx, Ly, Lz and L2 and their commutator relations, Raising and lowering operators L+ and L\_; Lx, , Ly , Lz and L2 in spherical polar co-ordinates, Eigenvalue and eigenfunction of Lz and L2 (operator method), Spherical harmonics, matrix representation of Lz, L+, L\_ and L2, .

***Spin angular momentum:***

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

**Module-III**

***Addition of angular momentum:***

Total angular momentum J. Eigenvalue problem of Jz and J2, Angular momentum matrices, Addition of angular momenta and C. G. Coefficients, Angular momentum states for composite system in the angular momenta (1/2, 1/2) and (1, 1/2).

***Motion in Spherical symmetric Field:***

Hydrogen atom, Reduction to one dimensional one body problem, radial equation, Energy eigenvalue and Eigen function, degeneracy, radial probability distribution, evaluation of <r>, <1/r>, <r2> for H-atom.

***Free particle problem:***

Incoming and outgoing spherical waves, expansion of plane waves in terms of partial waves. Bound states in a 3-D square well potential, particle in a sphere.

**Books:**

1. Quantum Mechanics S. Gasiorowicz
2. Quantum Mechanics J. Sukurai
3. Quantum Mechanics R. Shankar
4. Quantum Mechanics S. N. Biswas
5. Quantum Mechanics A. Das
6. Quantum Mechanics A. Ghatak and S. Lokanathan
7. Advanced Quantum Mechanics P. Roman
8. Quantum Mechanics (Non Relativistic theory) L. D. Landau and E. M. Lifshitz
9. Elementary Theory of Angular Momentum M. E. Rose
10. Principles of Quantum Mechanics P. A. M. Dirac
11. Quantum Mechanics, concepts and application, N Zettili

**Course Outcomes:**

Students will be able to:

1. State basic postulates of quantum mechanics
2. Understand properties of different operators such ashermitean operators, projection operators, unitary operators etc.
3. Solve Schrodinger equation of harmonic oscillator problem completely by operator method
4. State addition of angular momentum theorems and spin angular momentum statistics
5. Solve the Schrodinger equation for the hydrogen atom

**Core-18: Electrodynamics (IPCPH704)**

**Course Objectives:**

Students will be able to:

1. Study Maxwell’s wave equation in different dielectric media and free space
2. Understand vector and scalar potential and their importance in electromagnetics
3. Study electromagnetic energy transport and Poynting vector
4. Understand Lorentz and Coulomb gauge conditions, covariant form of Maxwell’s equation.
5. Study laws of geometrical optics using Maxwell’s equation
6. Study Kramer Kronig relation on reflection and absorption of electromagnetic wave
7. Study and understand propagation of electromagnetic waves in different types of waveguides.
8. Study of retarded potential and solving it by Green’s Function techniques for different types of charge distributions
9. Study electric, magnetic dipole and quadrupole radiation
10. Study electromagnetic radiation due to moving point charge and accelerated charge

**Module-I**

***Electrostatics:***

Method of Images, Point Charge in the Presence of a Grounded Conducting Sphere, Point Charge in the Presence of a Charged, Insulated, Conducting Sphere, Point Charge Near a Conducting Sphere at Fixed Potential, Conducting Sphere in a Uniform Electric Field by Method  of Images, Green Function for the Sphere; Orthogonal Functions and Expansions, Separation of Variables; Laplace Equation in Rectangular, Coordinates, A Two-Dimensional Potential Problem; Summation of Fourier Series, Fields and Charge Densities in Two-Dimensional Corners and Along Edges. Solving potential problem using conformal transformation.

***Dielectrics polarisation:***

Multipole Expansion, Multipole Expansion of the Energy of a Charge Distribution in an External Field, Elementary Treatment of Electrostatics with Ponderable Media, Boundary-Value Problems with Dielectrics, Molecular Polarizability and Electric Susceptibility, Models for Electric Polarizability, Electrostatic Energy in Dielectric Media.

**Module-II**

***Magnetostatics:***

Introduction and Definitions, Biot and Savart Law, Differential Equations of Magnetostatics and Ampere's Law, Vector Potential, Vector Potential and Magnetic Induction for a Circular Current, Loop, Magnetic Fields of a Localized Current Distribution, Magnetic Moment, Force and Torque on and Energy of a Localized Current Distribution in an External Magnetic Induction, Macroscopic Equations, Boundary Conditions on B and H, Methods of Solving Boundary-Value Problems in Magnetostatics, Uniformly Magnetized Sphere, Magnetized Sphere in an External Field.

***Time varying field, Faraday’s law and Displacement current:***

Faraday's Law of Induction, Energy in magnetic field, Energy of self and mutual induction; Maxwells equations in free space; Magnetic charge; Maxwells equations inside matter; Displacement current; Vector and scalars potentials; Wave equation for potentials; Lorentz and Coulomb gauge conditions; Wave equation for Electric and Magentic fields in absence of sources. Derivation of the Equations of Macroscopic Electromagnetism.

**Module - III**

***Covariant Formulation of Maxwell’s Equation:***

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

***Plane Waves in Non-Conducting Media:***

Plane waves in non-conducting media; velocity of wave propagation and energy flow; linear, circular and elliptic polarization; Reflection and refraction of electromagnetic waves at a plane inter-face between dielectrics; normal and oblique incidence; total internal reflection and polarization 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. Diffraction:  Kirchhoff 's formulation of diffraction by a circular aperture. Electromagnetic fields of moving point charge using Lorentz transformation.

**Books:**

1. Classical Electrodynamics - J. D. Jackson
2. Classical Theory of Fields - L. Landau and Lifshitz
3. Introduction to Electrodynamics - D. J. Griffiths.
4. Classical Electricity and Magnetism – Panofsky and Phillips

**Course Outcomes:**

Students will be able to:

1. Write down and analyze Maxwell’s wave equation in different media
2. Derive scalar and vector potential in presence of different sources
3. Derive the Poynting theorem
4. Apply Gauge invariance condition to Maxwell’s equation
5. Derive Maxwell’s equation in co-variant form
6. Derive covariant form of Maxwell’s equations
7. Derive relation between reflection coefficient and absorption coefficient
8. Calculate different modes of electromagnetic waves in waveguides
9. Calculate angular distribution of radiation and power emitted by dipole
10. Show that accelerating charge produce electromagnetic radiation

**SEC-3: Research Methodology (IOEPH705)**

**Course Objectives:**

Students will be able to:

1. Understand how to do literature survey to start any scientific research
2. Learn digital platforms available for survey of scientific research articles
3. Learn how to write scientific articles and ethics involved in that.
4. Learn how to do scientific data analysis.

**Module-I**

***Literature Survey:***

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-Books, current contents Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

***Digital:***

Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citationindex, Impact factor, H-index, E-consortium, UGC infonet, E-Books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, Wiki- Databases, Science Direct, Sci Finder, Scopus. Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for Physics. Finding and citing published information.

**Module-II**

***Methods of Scientific Research and Writing Scientific Papers:***

Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation. Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism.

**Module-III**

***Data Analysis***

The Investigative Approach: Making and Recording Measurements. SI Units and theiruse. Scientific method and design of experiments. Analysis and Presentation of Data: Descriptive statistics. Choosing and using statistical tests. Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, r and its abuse. Basic aspects of multiple linear regression analysis.

**Books**

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A.(2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
3. Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.
4. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.

**Course Outcomes:**

Students will be able to:

1. Do literature survey for scientific research
2. Tell citation notation and index values of scientific research article.
3. Write project report and scientific research article.
4. Do scientific data analysis such as plotting, error analysis, curve fitting etc.

**Lab 26 (Core Lab-15): General Physics Laboratory (ILCPH701)**

***List of Experiments:***

1. To calculate the velocity of ultrasonic sound through solid medium using ultrasonic interferometer.
2. To calculate the adiabatic compressibility of the given solid using 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 colors.
7. To study different Flip-flop
8. Measurement of very small resistance using Precision Kelvin double bridge (Maxwell double bridge).
9. To determine wavelength of 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
13. To study of Resonance absorption of a passive RF oscillator circuit
14. Determining the refractive index and dispersion of liquids using 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 electron (e/m)
17. Determination of electrical permittivity of free space and dielectric constant of various materials.

**Lab 27 (SEC Lab-3): Advanced Computational Physics Laboratory (ILCCS704)**

Introduction to computer hardware and software, introduction to storage in computer memory, stored program concepts, storage media computer operating system, LINUX, Commands;

***JAVA programs on:***

1. Introduction, Compiling & executing a java program.
2. Data types & variables, decision control structures: if, nested if etc.
3. Loop control structures: do, while, for etc.
4. Classes and objects.
5. Data abstraction & data hiding, inheritance, polymorphism.
6. Threads, exception handlings and applet programs
7. Interfaces and inner classes, wrapper classes, generics

***Programming with FORTRAN:***

1. Programme solving on computers-algorithm and flow charts in FORTRAN 77 data types, Exercises for acquaintance:
2. Find the largest or smallest of a given set of numbers
3. To generate and print rst hundred prime numbers
4. Sum of an AP series, GP series, Sine series, Cosine series
5. Factorial of a number
6. Transpose of a square matrix
7. Matrix multiplication and addition
8. Evaluation of log and exponentials
9. Solution of quadratic equation
10. Division of two complex numbers
11. To find the sum of the digits of a number
12. Basic introduction to parallel programming, open MP & MPI

***Numerical Methods:***

1. Interpolation by Lagrange methods
2. Numerical solution of simple algebraic equation by Newton-Ralphson Methods
3. Least square fit using rational functions
4. Numerical integration: Trapezoidal methods, Simsons method, Romberg method, Gauss quadrature method.
5. Eigenvalues and Eigenvectors of a matrix
6. Solution of linear homogenous equations
7. Trace of a matrix
8. Matrix inversion
9. Solution of ordinary differential equation by Runge-Kutta Method
10. Introduction to Monte Carlo techniques

**Semester-8**

**Core-19: Statistical Mechanics (IPCPH801)**

**Course Objectives:**

Students will be able to:

1. Understand postulates of classical and quantum statistical mechanics
2. Study different formalism of statistical physics such as microstate, macrostate and ensembles
3. Understand the Boltzmann and Gibb’s interpretation of entropy.
4. Study Fermi-Dirac statistics and Bose-Einstein statistics
5. Understand phase transitions and Ising model to study ferromagnetism

**Module-I**

***Classical Statistical Mechanics:***

Review of Thermodynamics

***Classical probabilities:***

Binomial distribution of probability, variance, mean value; Poisson’s distribution, fluctuation, variance, mean value; Gaussian distribution, variance, mean value and applications.

***Classical statistical Mechanics:***

Basic principles and application of classical statistical mechanics, Liouville’s theorem, micro canonical ensemble, density functions, review of thermodynamics, equipartition theorem, classical ideal gas, Gibb’s paradox, Canonical ensemble, density functions and energy fluctuation, grand canonical ensemble, density function and density fluctuation, Equivalence of Canonical and grand canonical ensemble.

**Module-II**

***Quantum Statistical Mechanics:***

The density matrix, ensembles in quantum statistical mechanics, third law of thermodynamics, Ideal gas in micro, canonical and grand canonical ensembles, Distribution functions for Maxwell- Boltzman, Fermi-Dirac and Bose- Einstein systems

***Ideal Fermi Gas:***

Equation of states for ideal Fermi gas, thermodynamics, behaviour of ideal Fermi gas in low density and high temperature, and in high density and low temperature, Specific heat, Zero- point Pressure. Theory of white dwarf stars.

***Ideal Bose gas:***

Equation of state of an ideal Bose gas in grand canonical ensemble, internal energy, Photons and Planck’s radiation law, Stefan’s law, Bose-Einstein condensation and thermodynamics in condensed state. Phonons and behavior of specific heat of solids at different temperatures.

**Module-III**

***Ising model:***

Definition of Ising model, One-dimensional Ising model and its application to Ferromagnetism.

***Phase Transition:***

Thermodynamics description of Phase Transitions, Phase Transitions of first and second kind, order parameter, Landau theory of phase transition and its application to magnetic systems, critical indices, scale transformation and dimensional analysis,

***Fluctuations:***

Correlation of space-time dependant fluctuation, fluctuations and transport phenomena, Brownian motion.

**Books:**

1. Statistical physics - K. Huang
2. Statistical Physics- B B Laud
3. Statistical physics - R. K. Pathria
4. Statistical physics - F. Mohling
5. Elementary Statistical physics - C. Kittel
6. Statistical physics - Landau and Lifsitz
7. Physics Transitions & Critical Phonomena – H. E. Stanly
8. Fundamental of statistical & Thermal physics- F. Reif

**Course Outcomes:**

Students will be able to:

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

**Core-20: Mathematical Methods in Physics-II (IPCPH802)**

**Course Objectives:**

Students will be able to:

1. Familiar with advanced mathematical methods of physics
2. Develop required mathematical skills to solve various problems in classical mechanics, quantum mechanics and electrodynamics.

**Module-I**

***Tensor analysis:***

Cartesian tensor in three space, Curves in three space and Frenet Formula, General Tensor analysis, geodesics.

**Module-II**

***Special functions:***

**Elementary functions** in terms of Hypergeometric function, its intgral representation, confluent Hypergeometric function and its derivatives, integral representation.

**Bessel’s differential equation**, its solution, Bessel function in terms of Hypergeometric function, recurrence relation, its generating function, orthogonality relation, Bessel function of second kind, Neumann’s function, Hankel function, Spherical Bessel function.

**Laguerre’s differential equation** and its solution, generating function, recurrence relation, Laguerre’s function, Associated Laguerre’s differential equation and Lagurre Function.

**Module-III**

Ordinary differential equations, differential operations and Sturm- Liouville theory, Partial differential equations, Greens function in one, two and in three dimension, Solution of inhomogeneous partial differential equation by Green function method.

**BOOKS:**

1. Mathematical methods of physics, J. Mathews & R. L. Walker.
2. Mathematical methods of physics, Arfken and Weber.
3. Mathematical methods for physicists Denner and Krzywicki.
4. Mathematical methods of physics, H. K. Das
5. Mathematical methods of physics, Dr. Rama verma (S. Chand)
6. Mathematical methods of physics Satyaprakash (S. Chand)
7. Mathematical methods of physics Binoy Bhattacharya. (NCBA Publication)
8. Introduction to Tensor calculus - Goreux S. J.
9. Mathematical methods of physics Dettman J. W.
10. Gravitation and Cosmology, S Weinberg

**Course Outcomes:**

Students will be able to:

1. Understand basic theory of
   1. Tensors
   2. Special functions
   3. Partial differential equations
   4. Green’s function
2. Work with
   1. Tensors in various fields of physics
   2. Bessel functions
   3. Green’s function to solve differential equations

**Core-21: Quantum Mechanics-II (IPCPH803)**

**Course Objectives:**

Students will be able to:

1. Understand the importance of perturbation theory in quantum mechanics
2. Study time independent and time dependent perturbation theory and apply those to various physical problem
3. Understand fine structure of hydrogen atom, Stark effect, Zeeman effect,
4. Understand interaction of radiation with matter, selection rules
5. Understand quantum mechanical description of scattering
6. Understand variational principle and its application

**Module-I**

***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 Hydrogen atom, Degenerate perturbation theory, Removal of Degeneracy, parity selection rule, 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. Elementary ideas about field quantization and particle processes.

**Module-II**

***Variational Methods:***

Rayleigh-Ritz variational technique and its application to He-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.

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, Basic principle of laser and Maser.

**Module-III**

***Scattering Theory:***

Scattering amplitude and Cross section. Born approximation, Application to Coulomb and Screened Coulomb potential, Partial wave analysis for elastic and inelastic Scattering. Effective range and Scattering length. Optical theorem, Black Disc Scattering, Hard-sphere Scattering, Resonance Scattering from square well potential. Complex potential and absorption.

Identical Particles:

Symmetric and antisymmetric wave function, collisions of identical particles, spin angular momentum, spin functions of many electron atoms.

**BOOKS:**

1. Quantum Mechanics -S. Gasiorowicz
2. Quantum Mechanics -J. Sukurai
3. Quantum Mechanics -R. Shankar
4. Quantum Mechanics -S. N. Biswas
5. Quantum Mechanics -A. Das
6. Quantum Mechanics -A. Ghatak and S. Lokanathan
7. Advanced Quantum Mechanics- P. Roman
8. Quantum Mechanics (Non-Relativistic theory) -L. D. Landau and E. M. Lifshitz
9. Elementary Theory of Angular Momentum -M. E. Rose
10. Principles of Quantum Mechanic -P. A. M. Dirac
11. Quantum Mechanics, Concept and Applications-N Zettili

**Course Outcomes:**

Students will be able to:

1. Derive energy and wavefunction for physical system using time independent perturbation theory
2. Derive transition probability under time dependent perturbation theory
3. Explain Stark effect, origin of polarizability and dipole moment, fine structure of hydrogen atom and Zeeman effect
4. Tell dipole selections rules in various atomic transitions
5. Find out scattering cross-section for various scattering process such as black sphere scattering, hard sphere scattering and inelastic scattering
6. Apply variational principle to find out the ground state energy of the various physical system

**Core-22: Experimental Techniques (IPCPH804)**

**Course Objectives:**

Students will be able to:

1. Understand basic working principle to use various experimental techniques for studying structural, morphological, optical, electrical properties various types of materials
2. Familiar with strength and limitations of various experimental techniques used in condensed matter and materials physics

**Module-I**

***Structure and microstructure characterizations:***

X Ray Diffraction (XRD), Electron diffraction, Neutron diffraction, Synchrotron

**Module-II**

***Imaging techniques:***

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

**Module-III**

***Spectroscopic techniques:***

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

**BOOKS**

1. Semiconductor material and device characterization by Dieter K. Schroder

**Course Outcomes:**

Students will be able to:

1. Understand basic theory of
   1. X-ray and electron diffraction
   2. Neutron diffraction
   3. Electron microscope
   4. Atomic force microscope
   5. Scanning Tunneling microscope
   6. Spectroscopic techniques
2. Know strength and limitations of
   1. X - ray diffraction
   2. Neutron diffraction
   3. Scanning electron microscope (SEM)
   4. Transmission electron microscope (TEM)
   5. Scanning probe microscope (AFM and STM)
   6. UV-visible and FTIR spectroscopy
   7. Raman spectroscopy
   8. X-ray photoelectron spectroscopy (XPS)

**Core-23: Electronics (IPCPH805)**

**Course Objectives:**

Students will be able to:

1. Understand operational principle, model and analysis of various amplifiers
2. Understand operational principle, model and analysis of various operational amplifiers
3. Understand operational principle, model and analysis of various oscillators
4. Understand operational principle, model and analysis of various digital circuits
5. Understand model and analysis of radio communication and antenna
6. Understand working principles of fiber optics

**Module-I**

***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.

***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.

**Module-II**

***Oscillator Circuits:***

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

**Module-III**

***Digital Circuits:***

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

***Radio Communication and Antenna:***

Ionospheric propagation, Antennas of different types,

***Fibre Optics:***

Optical fibre, various types of optical fibres, Principle of propagation of light through Optical fibre, classification, optical

Acceptance angle and optical cone of the fibre, numerical aperture, fractional index change, skip distance and number of total internal reflection, light sources, attenuation and application of optical fibre in communication.

**Books:**

1. Electronic Fundamental and application, J. D. Ryder
2. Int. Digital Electronics, Heap and Martin
3. Integrated Electronics, Millman and Halkias
4. Optical Fibres; J A Buck
5. Foundation of Electronics Chattopadhyay; Rakshit, Saha and Purkait
6. Optical Fibre Communication; G Kaiser

**Course Outcomes:**

Students will be able to:

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

**Lab 28 (Core Lab-16): Electromagnetic and Optics Laboratory (ILCPH801)**

***List of Experiments:***

1. Michelson’s interferometer: determination of wavelength of sodium lines.
2. Study of Fabry-perot interferometer.
3. To study the Hall Effect in semiconductors and determine Hall coefficient and Hall voltage.
4. To study the Hall Effect in semiconductors and determine 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 determine angular spread of He-Ne laser using plane diffraction grating
9. To study the interference using laser and a double slit and find the wavelength of He-Ne laser source
10. Determination of thickness of air wedge and Newton’s ring experiment
11. Measurement of magneto-optic effect using Faraday effect
12. Measurement of atomic spectra of discharge lamps (H2, He, Ne)
13. Diffraction of light by straight edge using He-Ne laser
14. Measurement of electro-optic coefficient using Kerr effect
15. Diffraction of light by circular aperture (Pinhole)

**Lab 29 (Core Lab-17): Basic Electronics Laboratory (ILCPH802)**

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. Verification of Thevnin and Norton theorems
8. To verify the superposition and maximum power transfer theorems
9. To design a precision Differential amplifier of given I/O specification using Op-amp.
10. To investigate the use of an op-amp as an Integrator.
11. To investigate the use of an op-amp as a Differentiator.
12. To study the V-I characteristics of a LED.
13. To study the analog to digital converter (ADC) IC
14. To study the digital to analog converter (DAC) IC
15. To study Sensitivity of Wheatstone bridge

**Semester-9**

**Core-24: Adv. Quantum Mechanics & Quantum Field Theory (IPCPH901)**

**Course Objectives:**

1. To impact knowledge of advanced quantum mechanics for solving relevant physical problems.
2. To deepen understanding of Quantum Mechanics.

**Module-I**

***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, Darwins term, Spin-Orbit coupling, Poincare transformation, Lorentz group, Covariant form of Dirac equation, Bilinear covariants, Gordon decomposition.

**Module-II**

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

**Module-III**

***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.

**Books:**

1. Advanced Quantum Mechanics - J. J. Sakurai
2. Relativistic Quantum Mechanics - J. D. Bjorken and S. D. Drell
3. Relativistic Quantum Fields - J. D. Bjorken and S. D. Drell
4. Quantum Field Theory - F. Mandl and G. Shaw
5. Quantum Field Theory - C. Itzykson and J. Zuber
6. Quantum Field Theory - M. E. Peskin and D. V. Schroeder
7. Quantum Field Theory - L. H.Ryder
8. Quantum Field Theory - S. Weinberg

**Course Outcomes:**

The aim of the course is to advance the students' understanding of non-relativistic and relativistic quantum mechanics. Students will have achieved the ability to:

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, Klein-Gordon equation and Dirac Equation.
3. Describe 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.

**Core-25: Nuclear and Particle Physics (IPCPH902)**

**Course Objectives:**

Students will be able to:

1. 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.
2. 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.

**Module-I**

***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 force, charge independence and charge symmetry of nuclear force, mirror nuclei.

***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-II**

***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-III**

***Particle Physics:***

Particle classification, fermions and bosons, lepton favors, quark flavors, 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.

**BOOKS:**

1. Nuclear physics, Satyaprakash.
2. Nuclear and Particle Physics, Mital, Verma, Gupta.
3. Nuclear Physics, Dr. S. N. Ghosal.
4. Atomic and Nuclear physics, Shatendra Sharma.

**Course Outcomes:**

The student should be able to

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 effects of radiation in biological matter.
5. Classify elementary particles according to their quantum numbers and draw simple reaction diagrams.

**Core-26: Basic Condensed Matter Physics (IPCPH903)**

**Module-I**

***Crystallography:***

Crystal lattice, crystal structure, symmetry elements in crystal, proper rotation axis, plane of symmetry, inversion center, screw axis, glide plane, types of bravais lattices, crystal structure: simple cubic, body centre cubic face centred cubic, HCP structure, Diamond structure, Zinc blende structure, Fluorite structure, perovskite structure, , Weigner –Seitz cell, Miller indices.

***Lattice Vibration:***

Born Oppenheimer Approximation, Hamiltonian for lattice vibration in the harmonic Approximation, Normal modes of system. Phonons and lattice vibrations Vibrations of monoatomic and diatomic lattices, dispersion, optics& acoustic modes, quantum of lattice vibrations and phonon momentum.

**Module-II:**

***Free electron Fermi gas:***

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 gap in E-K diagram. Effective mass of electrons in crystals, Holes, Kronig Penney model, Tight binding approximation,

**Module-III:**

***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

***Transport Properties:***

The Boltzmann equation, Electrical conductivity, General transport coefficients, Thermal conductivity, thermoelectric effect, Hall Effect.

***Nanomaterials:***

Nano structured materials-Classification based on spatial extention (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:***

Experimental survey,Meisners effect, Type-I & Type-II superconductors, Thermodynamics of superconductors, Londons theory,

**BOOKS:**

1. Introduction to solid state physics by C. Kittel
2. Solid state physics by Ashcroft and Mermin
3. Principles of Condensed Matter physics by P. M. Chaikin and T. C. Lubensky
4. Solid state physics by A. J. Dekker
5. Solid state physics by O. E. Animaler
6. Quantum Theory Solid State by J. Callaway
7. Solid state physics by C. G. Kuper
8. Solid state physics David by W. Snoke (LPE Publication)
9. Solid state physics Dan Wei (Cengauge Learning)

**Core-27: Physics of Semiconductor Devices (IPCPH904)**

**Course Objectives:**

Students will be able to:

1. Understand basic semiconductor device physics.
2. Analyse the charge conduction across p-n junctions and devices.
3. Understand the application of Field-Effect Transistors and Bipolar Junction Transistors.
4. Design experiments for measuring semiconductor parameters and properties.
5. Know the physics of semiconductor junctions, metal-semiconductor junctions and metal-insulator-semiconductor junctions.

**Module-I:**

***Introduction to the quantum theory of solids:***

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, 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 EF with doping concentration and temperature. 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 relationship between diffusion coefficient and mobility. Electron- hole recombination, Thermal generation.

**Module-II**

***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.

**Module-III**

***The Bipolar Transistor:***

Introduction, Modes of operation, Minority Carrier distribution, Collector current, Base cur-rent, current gain, Base width Modulation by collector current, Breakdown mechanism, EquivalentCircuit Models - Ebers-Moll Model.

***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.

***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, MOSFETVt, Body effect and steep retrograde doping, pinch-o voltage.

**BOOKS:**

1. Physics of Semiconductor Devices - Donald A. Neamann
2. Physics of Semiconductor Devices - B. B. Swain
3. Physics of Semiconductor Devices – AnjanaAcharya
4. Physics of Semiconductor Devices - Calvin Hu.
5. Physics of Semiconductor Devices - Dilip K Roy
6. Fundamentals of Semiconductor Devices- M. K. Achthanand K. N. Bhatt
7. Solid state Electronics Devices Bhattacharya, Rajnish Sharma
8. Semiconductor Materials and Devices J. B. Gupta
9. Physics of Semiconductor Devices – Jivan Jyoti Mohanty.

**Course Outcome**

Students will be able to:

1. Understand the basic materials and properties of semiconductors with application to the pn junction and diode circuits.
2. Understand the application of Field-Effect Transistors with the application of the design of amplifiers.
3. Understand the application of Bipolar Junction Transistors with the application of the design of amplifiers.
4. Know the physics of semiconductor junctions, metal-semiconductor junctions and metal-insulator-semiconductor junctions.
5. Students will acquire a thorough understanding on the devices and be able to apply the knowledge to the development of new and novel devices for different applications.

**Major Project: Project (IPRPH901)**

**Project evaluation guidelines:**

Every student will have to complete project in 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 dissertation consisting of the problem definition, literature survey and status, objectives, methodology, experimental work, results and analysis. The project can be a theoretical or experimental project, related to advanced topic, electronic circuits, models, industrial project, training in a research institute, training of handling a sophisticated equipment etc. Maximum three students can do a joint project. Each one of them will submit a separate project report with details/part only he/she has done. However, he/she can in brief (in a page one or two) mention in Introduction section what other group members have done. In case of electronic projects, use of readymade electronic kits available in the market should be avoided. The electronics project / models should be demonstrated during presentation of the project. In case a student takes training in a research institute/training of handling sophisticate 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 of 100 marks by internal evaluation.

The project report should be le bound/spiral bound/hard bound and should have 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 Internal examiner will be based on 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 |

**Lab 30 (Core Lab-18): Advanced Electronics Laboratory (ILCPH901)**

***List of Experiments:***

1. Study of 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. Design and study of various flip flop circuits (RS, D, JK, T)
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 a monostable multivibrator of given specifications using 555 Timer.
11. To design a digital to analog 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 a Wien bridge oscillator for given frequency using an op-amp

**Lab 31 (Core Lab-19): Basic Condensed Matter Physics Laboratory (ILCPH902)**

***List of Experiments:***

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

**Semester-10**

**Core-28: Nano Science & Technology (IPCPH001)**

**Module-I**

***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 tunneling, 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 nanostriction

Semiconducting Nanoparticles: Optical properties, photofragmentation, Coulombic explosion, Photoluminescence, thermo luminescence

**Module-II**

***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 C60 , 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**

***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 behavior of materials, Dynamics of nanomagnets, Ferro fluids

**BOOK:**

1. Introduction to Nanotechnology: Charles P. Poole, Jr., Frank J. Owens
2. Nanocrystal Quantum dots by Victor I. Klimov (Second Edition)
3. Solid State Physics by C. Kittel (Eigth Edition)

**Core-29: Atomic and Molecular Physics (IPCPH002)**

**Module-I**

***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**

***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**

***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.

**BOOKS:**

1. B. H. Bransden and C. J. Joachain: Physics of Atoms and Molecules
2. C. Cohen-Tannoudji, B. Dier, and F. Laloe: Quantum Mechanics vol. 1 and 2
3. R. Shankar: Principles of Quantum Mechanics
4. C. B. Banwell: Fundamentals of Molecular Spectroscopy
5. G. M. Barrow: Molecular Spectroscopy
6. K. Thyagarajan and A. K. Ghatak: Lasers, Theory and Applications
7. O. Svelto: Principles of Lasers
8. B. H. Eyring, J. Walter and G. E. Kimball: Quantum Chemistry
9. W. Demtroder: Molecular Physics
10. H. Herzberg: Spectra of Diatomic Molecules
11. J. D. Graybeal: Molecular Spectroscopy
12. M. C. Gupta: Atomic and Molecular Spectroscopy
13. B. Laud: Lasers and Non-linear Optics
14. A. Thorne, U. Litzen and J. Johnson: Spectrophysics

**PE: Advanced Condensed Matter Physics (IPEPH001)**

**Module –I**

***Fermi surface:***

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

***Electron Interaction:***

Perturbation formulation, Dielectric function of an interacting electron Gas (Lindhard’s expression), static screening, screened impurity, Kohn effect, Friedel oscillations and sum rule, dielectric constant of semiconductor, plasma oscillation.

***Transport properties:***

Elementary ideas about Quantum Hall effect, magneto resistance, giant magneto resistance and colossal magneto resistance,

**Module-II**

***Electronic and lattice defects:***

Lattice defects, Frenkel and schottky defects, Line defects, Edge and screw dislocations-Burger’s Vector, planner (stacking) Faults- twin planes and grain boundaries Color centers-mechanism of coloration of a solid, F-center, other color centers.

***Excitons:***

Loosely bound, tightly bound, Excitonic Waves, Electron –hole droplets. Exotic Solids

**Module-III**

***Superconductivity:***

Electron-phonon interaction, Second quantized form of Hamiltonian for electrons and phonons interaction, electron-electron attractive interaction due to virtual phonon exchange, Cooper pairs and BCS Hamiltonian, Solution of BCS Hamiltonian- spin analog method. Elementary ideas on High Tc Superconductors.

***Josephson Effect:***

Microscopic quantum mechanical effect, Dc Josephson effect, Effect of electric field Ac/Inverse Ac Josephson effect, Effect of magnetic field, SQUID and other applications of superconductors.

**Books:**

1. D. Pines: Elementary Excitations in Solids S. Raimes: Many Electron Theory
2. O. Madelung: Introduction to Solid State Theory
3. N. H. March and M. Parrinello: Collective Effects in Solids and Liquids
4. H. Ibach and H. Luth: Solid State Physics: An Introduction to Theory and Experiments J. M. Ziman: Principles of the Theory of Solids
5. C. Kittel: Quantum Theory of Solids
6. M. Tinkham: Group Theory and Quantum Mechanics
7. M. Sachs: Solid State Theory
8. A. O. E. Animalu: Intermediate Quantum Theory of Crystalline Solids
9. N. W. Ashcroft and N. D. Mermin: Solid State Physics
10. J. M. Ziman: Principles of the Theory of Solids
11. C. Kittel: Introduction to Solid State Physics

**PE: Advanced Particle Physics (IPEPH002)**

**Module-I**

***Symmetry:***

Different types of symmetries and conservation laws. Noethers theorem.

***Symmetry groups and Quark model:***

SU(2) and SU(3): root and weight diagrams, Composite representation, Youngs tableaux, quark model, colour, heavy quarks and their hadrons.

**Module-II**

***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.

***QED:***

Feynman rules, Example of actual calculations: Rutherford, Bhabha, Moeller, Compton, e+ e-→ µ+ µ -. Decay and scattering kinematics. Mandelstam variables and use of crossing symmetry.

**Module-III**

***Gauge theories:***

Gauge invariance in QED, non-abelian gauge theories, QCD (introduction), Spontaneous symmetry breaking, Higgs mechanism.

***Electroweak Theory:***

Standard Model, Gauge boson and fermion masses, Neutral current, Experimental tests. Calculation of FB asymmetry in e+e-→ µ+ µ - and decay widths of W and Z (only at tree-level), Higgs physics. (13)

**BOOKS:**

1. Introduction to elementary particles By David J Griffith
2. M. Peskin and F. Schroeder: Quantum Field Theory
3. J. D. Bjorken and S. D. Drell: Relativistic Quantum Fields
4. D. Bailin and A. Love: Introduction to Gauge Field Theory
5. Lahiri and P. B. Pal: A First Book of Quantum Field Theory
6. F. Mandl and G. Shaw: Quantum Field Theory
7. P. Ramond: Field Theory: A Modern Primer
8. C. Itzykson and J. B. Zuber: Quantum Field Theory
9. F. Halzen and A. D. Martin: Quarks and Leptons
10. J. Donoghue, E. Golowich and B. Holstein: Dynamics of the Standard Model
11. T. -P. Cheng and L. -F. Li: Gauge Theories in Particle Physics
12. E. Leader and E. Predazzi: An Introduction to Gauge Theories and Modern Particle Physics
13. F. E. Close: An Introduction to Quarks and Partons

**OE: Advanced characterization Techniques (IOEPH001)**

**Module-I**

***X-ray diffraction and reciprocal lattices***

Choice of x-ray, electron and Neutron for crystal structure determination, Bragg diffraction, Reciprocal lattices, The Bragg‘s condition and Ewald construction, Brillouin zones, Brillouin zones of SC, BCC, FCC lattices, Atomic scattering factor, Geometrical Structure factor, Laue method, Rotating crystal method, powder method, Electron diffraction, Geometrical nature of electron diffraction patterns, Indexing of electron diffraction spot pattern, electron microscope, transmission electron microscopy, Debye Scherrer Technique, Analysis of the powder photograph, The determination of lattice type and space group, crystal structure determination.

**Module-II**

***Microscope techniques:***

Electron Microscope: SEM, TEM, FESEM, HRTEM

Scanning probe microscopy: Atomic Force microscopy, Scanning-tunnelling microscopy.

**Module-III**

***Spectroscopic Techniques:***

UV-visible Spectroscopy, Raman spectroscopy, Neutron scattering, X-ray scattering, x-ray photoelectron spectroscopy.

**BOOKS:**

1. Advanced Techniques for Materials Characterization, A. K. Tyagi, Mainak Roy, S. K. Kulshreshtha and S. Banerjee Vol 49-51

**OE: Vacuum science and Technology (IOEPH002)**

**Module-I**

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

**Module-II**

Production of vacuum-mechanical pumps, Diffusion pump, Getter and ion pumps, cryopumps, material in vacuum;high Vacuum and ultra-high vacuum systems; Leak detection.

**Module-III**

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

**BOOKS:**

1. 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
2. The Art of Cryogenics, 1st Edition, Low-Temperature Experimental Techniques, Guglielmo Ventura Lara Risegari

**OE: Material Science (IOEPH003)**

**Module-I**

***Mechanical Properties***

Mechanical, Thermal and electrical properties of materials, Tensile Strength, stress-strain behavior, Ductile and brittle material, Toughness, hardness, fatigue, creep and fracture.

***Thermal properties:***

Thermal conductivity, thermoelectric effects, Electrical properties: electrical conductivity, energy band structure of conductors, semiconductors and insulators, type-I and Type-II superconductors and their application, dielectric, ferroelectric and piezoelectric material and their application.

**Module-II**

***Laser Physics:***

Basic elements of a laser; Threshold condition; Four-level laser system, CW operation of laser; Critical pumping rate; Population inversion and photon number in the cavity around threshold; Output coupling of laser power.

Optical resonators; Cavity modes; Mode selection; Pulsed operation of laser: Q-switching and Mode locking; Experimental technique of Q-switching and mode locking Different aser systems: Ruby, CO2, Dye and Semiconductor diode laser;

***Optical materials:***

Optical properties scattering, refraction, reflection, transmission and absorption, optical fibres-principle and application.

**Module-III**

***Soft condensed matter:***

Polymeric materials: Types of polymers, Mechanism of polymerization, Mechanical behaviour of polymers, Fracture in polymers, Rubber types and applications, Thermosetting and thermoplastics, conducting polymers:

***Composite Materials:***

Micro composites & Macro composites; fibre reinforced composites; Continuous fibre composites; Short fibre composites, Polymer matrix composites, Metal-matrix composites: Ceramic-matrix composites; Carbon-carbon Composites; Hybrid composites.

***Ceramics:***

Types, structure, properties and application of ceramic materials

***Other materials:***

Brief description of other materials such as Corrosion resistant materials, Nano phase materials, Shape memory alloy, SMART materials.

**BOOKS:**

1. Material Science and engineering: An Introduction, by William D. Callister, Jr. David G. Rethwisch, Wiley
2. Materials Science by M Vijaya, Rangarajan G, McGraw Hill Education
3. Materials Science and Engineering, V. Raghavan, Phi Learning

**Seminar: Seminar (ISEPH001)**

**Course Objectives:**

To learn, practice, and critique effective scientific seminar skills. Students develop presentation skills that will be essential during their entire professional careers. These skills will improve as students respond to critical feedback, and seek to make scientific information understandable to scientists, peers, and the general public.

**Learning Outcomes:**

Students will be able to:

1. Communicate science in a 30-40-minute oral scientific presentation
2. Understand and critique scientific presentations

***General Aspects of Oral Presentation:***

Presented at level that is appropriate to the audience; clear and informative visual aids (simple, sufficient time); evident that presenter has practiced.

***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; brief overview of the experimental design used and any other parts of the methods employed; materials and/or equipment described; procedures followed to conduct the experiment presented

***Results:***

Anticipated and actual results reported; statistics clearly 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)

**Lab 32 (Core Lab-20): Modern Physics Laboratory (ILCPH001)**

***List of Experiments:***

1. To determine Rydberg constant from the Balmer series of Hydrogen emission.
2. To determine the wavelengths of Balmer series in the visible region from Hydrogen emission.
3. To setup the Millikan oil drop apparatus and determine the charge of an electron.
4. To demonstrate quantum nature of charge using Millikan oil drop apparatus
5. Existence of discrete energy level by Frank Hertz experiment.
6. To study the effect of filament voltage and anode plate voltage on the Frank-Hertz characteristic curve for neon
7. Study of polarization using Malus Law.
8. Determination of Brewster’s angle.
9. To analyze elliptically polarized Light by using a Babinets compensator.
10. To study damping oscillations in various medium.
11. Determination of temperature co-efficient of current for LED by Planck’s constant method
12. Rectification by junction Diode using various filters.
13. Study of junction capacitance of P-N junction
14. To study Normal and Anomalous Zeeman effect
15. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece

**Lab 33 (PE Lab): Advanced Condensed Matter Physics Laboratory (ILCPH002)**

***List of Experiments:***

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 Meissner effect and determine 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 cell and find out its power conversion efficiency.
8. To determine Dielectric constant of solid (wax) by Lecher Wire
9. To study lattice vibrations in mono- and di-atomic lattice using lattice dynamics kit.
10. Preparation of thin film using spin coating techniques
11. Study of lattice parameter of agiven material using X-ray diffraction technique
12. Measurement of resistivity of semiconductor by four probe method
13. To determine magnetic moment of an electron using ESR equipment
14. To study dielectric properties of a given substance using Impedance analyzer
15. Characterization of a given nanomaterial by Scanning electron microscope

**Lab 33 (PE Lab): Advanced Particle Physics Laboratory (ILCPH003)**

***List of Experiments:***

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 co-efficient 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 photo detector and photo multiplier.
11. Study of wide-band amplifier.
12. Emulsion photograph studies.