St. Xavier's College (Autonomous), Ahmedabad-380009

M.Sc. Physics Syllabus

Semester-4

CORE Paper. Instrumentation and Microcontroller
Course Code: PPH-4801
No. of credits: 4
Learning Hours: 60

Course Objectives

At the end of the course student will be able to

1. Study the drawbacks of two wire transmission lines at high frequency and the application of waveguides
2. Study the microwave junction and microwave sources including the klystron family.
3. Study and work with the microcontroller 8051, and will be designing the program including data transfer operation, arithmetic, logical, Boolean, and branching programs.
4. Design the Schmitt trigger, Astable Multivibrator and triangular wave generator using comparator circuits.
5. Know the importance of PLL IC, demonstrate the working of phase detector, comparator and *VCO.*
6. Design frequency multiplication using PLL.
7. Explain FM demodulation, FSK demodulator and AM detection.
8. Understand different concepts of Transducers, including those for measurement of temperature, strain, motion, position and light.
9. Choose proper transducer to make sensitive measurements of physical parameters like pressure, flow, displacement, velocity, temperature etc.
10. Locate different types of transducers and sensors used in real life applications.
11. Solve numerical based on above concepts and topics

Course Structure

Unit-1

Microwaves Transmission lines and waveguides: - line equations, impedance, reflections and voltage standing wave ratio, rectangular waveguides. Scattering(S) Parameters. Microwave T-Junctions: - H-plane Tee junction, E-plane Tee- junction, E-H (Hybrid or Magic) Tee. Directional couplers, isolator, Circulator. Microwave Sources and Devices - Two cavity Klystron amplifier, Multicavity Klystron, Reflex Klystron, Travelling wave tube (TWT), Magnetron, Gunn diode, lMPATT diode, Crystal Detector and PIN diode.

Unit-2

Microcontroller 8051 Microcontrollers-Introduction, MCS-51 Architecture, Registers in MCS- 51. A: 8051 Pin Description, Connections, I/O Ports and Memory Organization- 8051 Pin Description, 8051 Connections, 8051 Parallel I/O Ports, Memory Operations. B: Addressing Modes supported by 8051, Know the instruction set of MCS-51 microcontrollers, Data transfer instructions, Arithmetic instructions, Logical Instructions, Boolean variable manipulation instructions, program branching instructions.

Unit-3

OPAMP Applications Schmitt trigger, square wave generator, triangle wave generator Phase Locked Loop Introduction, Basic principles, Phase Detector and comparator, voltage-controlled oscillator (VCO), low pass filter, monolithic phase locked loop, PLL applications, frequency Multiplication/division, frequency translation, AM detection, FM demodulation, FSK demodulator.

Unit-4

Primary Sensing Elements and Transducers Mechanical Devices as Primary Detectors, Pressure Sensitive Primary Devices, Flow Rate Sensing Elements, Transducers, Characteristics Choice of Transducers, Resistive Transducers, Potentiometers, Strain Gauges, Resistance Thermometers, Thermistors, Thermocouples, Variable inductance Transducers, Capacitive Transducers, Piezoelectric Transducers, Hall Effect Transducers, Photo voltaic cell, Semiconductor Photo Diode, Photo Transistor.

Reference Books

1. Microwave Devices Circuits, Samuel Y Liao, Pearson
2. Microwave Radar Engineering, M Kulkarni, Umesh Publications
3. Microcontrollers (Theory and Applications) By Ajay V Deshmukh.
4. Linear Integrated circuit 4th edition, By Roy Choudhury and Jain, New Age International
5. Electronic Instrumentation by H S Kalsi, TMH Edition

6. A course in Electrical Electronic Measurements Instrumentation, AK Sawhney, Dhanpat Rai Co.

7. Electronic Instrumentation and Measurement Techniques, Cooper Helfric, Prentice Hall

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M.Sc. Physics Syllabus

Semester-4

CORE Paper: Adv. Theoretical Physics & Cosmology
Course Code: PPH-4802
No. of credits: 4
Learning Hours: 60

Course Objectives

At the end of the course student will be able to

1. Understand the Basic Fundamental of Statistical Mechanics.
2. To explain the Dirac equation and its free-particle solutions, to explain the existence of antiparticles
3. Describe the classical and quantum mechanical treatment to understand many-body problem, describe the Kohn-Sham equation, pseudo-potential, exchange correlation functions for the material properties.
4. Distinguish different approaches for the density functional theory and compute its ground state energy and density, understand the modern theoretical methods based on ab initio simulations and they are so reliable that one can predict material properties.
5. To use an understanding of our galaxy to contrast and compare it with other galaxies as to type, contents, age, luminosity, motion, and size, to use cosmological models to analyze the size, age, structure, and motion of the universe overall.
6. Have a deep understanding of the physics and evolution of the smooth, homogeneous Universe starting from the Big Bang, to understand the dark matter issue and possible solutions and implications.
7. Solve numerical based on above concepts and topics.

Course Structure

Unit-1

Statistical Mechanics [NET]: Phase space, micro- and macro-states. Micro-canonical, canonical and grand-canonical ensembles and partition functions. Free energy and its connection with thermodynamic quantities. Classical and quantum statistics. Ideal Bose and Fermi gases. Principle of detailed balance. Blackbody radiation and Planck's distribution law. First- and second-order phase transitions. Diamagnetism, paramagnetism, and ferromagnetism. Ising model. Bose- Einstein condensation. Diffusion equation. Random walk and Brownian motion.

Unit-2

Relativistic Quantum Mechanics: Klein-Gordan Equation, Interpretation of the Klein-Gordon Equation, particle in a Coulomb field, Dirac‘s Equation for a Free Particle, Dirac Matrices, Co- variant from Dirac Equation, Probability density, Plane wave solution, Negative Energy States, Spin of a Dirac Particle, Magnetic moment of the electron, Spin orbit Interaction, Radial Equation for an electron in a Central Potential, The hydrogen atom.

Unit-3

Density Functional Theory : Review of molecular dynamics, Many-electron Schrodinger equation, Variational method for many-electron system, Self-consistent field method, Hartree theory and Hartree-Fock theory, Slater‘s treatment of HartreeFock theory, Many-electron theory in terms of the density – Thomas Fermi and Thomas Fermi-Dirac methods, Modern density-functional theory – Hohenberg-Kohn theorem and Kohn-Sham method, Treatment of exchange-correlation in density-functional theory, Approximate functionals, Applications to atoms, molecules, and solids; perturbation theory in DFT

Unit-4

Modern Cosmology: Standard Model of Cosmology, Hubble‘s law and the expanding universe, Big Bang theory, FRW metric, Friedman equation, different components of the universe, Distant measures in cosmology, The Cosmic Microwave Background, Recombination and Decoupling of photons, Baryon Acoustic Oscillations, Big Bang Nucleosynthesis, Inflation and the very early universe, An overview of dark matter problem

Reference Books

1. Statistical Mechanics, Kerson Huang, Wiley
2. Quantum Mechanics (Second Edition) G. ARULDHAS PHI Learning Private Limited
3. A Text Book of Quantum Mechanics P.M Mathew and K Venkatesan TATA McGRAW-HILL PUBLISHING COMP. LTD
4. Quantum Mechanics Theory and Application (5th Edition) Ajoy Ghatak and S Lokanathan Trinity Press

5. Quantum Mechanics Leonard Schiff McGRAW-HILL PUBLISHING COMP. LTD
6. The ABC of DFT Kieron Burke and friends Department of Chemistry, University of California, Irvine.
7. Electronic Structure: Basic Theory and Practical Methods by R. Martin
8. Introduction to Cosmology, Barbara Ryden, Cambridge University Press; 2 edition
9. An introduction to modern cosmology, Andrew Liddle, Wiley-Blackwell; 2nd edition
10. Modern cosmology, Scott Dodelson, Elsevier

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M.Sc. Physics Syllabus

Semester-4

CORE Paper: Nuclear Physics & Atomic-Molecular Physics
Course Code: PPH-4803
No. of credits: 4
Learning Hours: 60

Course Objectives

At the end of the course student will be able to

1. Understand the importance of models in describing the properties of nuclei and nuclear collisions.
2. Understanding of nuclear reactions mechanisms, compound nuclei and direct reactions.
3. Understand of Parity non-conservation in weak-interaction and relativistic kinematics.
4. Solve numerical based on above concepts and topics.

Course Structure

Unit-1

Elementary ideas of alpha, beta and gamma decays and their selection rules. Binding energy, semi-empirical mass formula, liquid drop model. Evidence of shell structure, single-particle shell model, its validity and limitations. Rotational spectra.

Unit-2

Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces. Deuteron problem. Nuclear reactions, reaction mechanism, compound nuclei and direct reactions.

Unit-3

Elementary particles: The four basic forces, Particles and antiparticles, Families of particles, conservation Laws, particle interactions and decays, energetics of particle reactions, the quark model, the standard model, Numerical Examples. Introduction to Universe.

Unit-4

Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectrum lines, LS JJ couplings. Zeeman, Paschen-Bach Stark effects. Frank-Condon principle. Born-Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules.

Reference Books

1. Nuclear Physics, Kenneth Krane
2. Nuclear Physics, S B Patel
3. Nuclear Physics, S N Ghoshal
4. Atomic Molecular Spectra Laser By Raj Kumar

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M.Sc. Physics Syllabus

Semester-4

CORE Paper: Atmospheric Sciences & Plasma Physics
Course Code: PPH-4804
No. of credits: 4
Learning Hours: 60

Course Objectives

At the end of the course student will be able to

1. Fundamentals of plasma physics describing variety of plasma occurring naturally/artificially
2. Single particle picture under various electromagnetic field configuration, which will help to understand concept of confinement in tokamak device.
3. Collision phenomena in plasma describing collisional transport and resistivity.
4. Fluid and kinetic description of plasma state, plasma waves and its experimental aspects
5. This overall prepare students foundation for further advanced plasma course like magnetically confined thermonuclear fusion reactor: tokamak
6. Get the knowledge of radiative transfer within different layers of Atmosphere
7. Able to solve problems related to atmospheric science using their computational skills
8. Understand the vast field of Atmospheric science
9. Solve numerical based on above concepts and topics.

Course Structure

Unit-1

Introduction to Plasma Physics: Occurrence of plasma in nature, definition of plasma, concept of temperature, Debye shielding, plasma parameter, criteria for plasmas, applications of plasma physics.
Single Particle Motions: Introduction, uniform E and B fields, non-uniform B field, non-uniform E field, time-varying E field, time varying B field, adiabatic invariants

Unit-2

Plasma as Fluids: Relation of plasma physics with ordinary electromagnetics, fluid equation of motion, fluid drifts perpendicular to B, fluid drift parallel to B, plasma approximation.
Waves in Plasmas: Introduction to waves, plasma oscillations, electron plasma waves, sound waves, ion waves, validity of plasma approximation, comparison of ion and electron waves, electrostatic electron oscillations perpendicular to B, electrostatic ion waves perpendicular to B, lower hybrid frequency, electromagnetic waves with B = 0, experimental applications, electromagnetic waves perpendicular to B, cut-offs and resonances, electromagnetic waves parallel to B, hydromagnetic waves, magnetosonic waves, CMA diagram.

Unit-3

Electrostatics: Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces.

Scalar and vector potentials, gauge invariance. Electromagnetic waves in free space. Dielectrics and conductors. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction. Dynamics of charged particles in static and uniform electromagnetic fields.

Unit-4

Fundamentals of Radiative Transfer; Radiative transfer equation and solution of it in simple cases; Remote Sensing; Radiative Effects of aerosols.

Reference Books

1. Fundamental Astronomy, Hannu Karttunen, Springer
2. Radiative Transfer in the Earth System|| by Charlie Zender
3. Electrodynamics, David Griffiths, Cambridge University Press

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M.Sc. Physics Syllabus

Semester-4

CORE Paper. Physics Laboratory
Course Code: PPH-4805L
No. of credits: 4
Learning Hours: 60

Course Objectives

At the end of the course student will be able to

1. Will be able to demonstrate the Zeeman Effect.
2. Will be able to demonstrate Hysteresis Loop Tracer.
3. Will be able to demonstrate the Electron Spin Resonance (ESR)
4. Will be able to demonstrate the Optical Fiber Experiment.
5. Will be able to measure the Permittivity of Air.
6. Will be able to demonstrate the Kerr Effect.
7. Will be able to measure Mutual Inductance using Lock-in Amplifier.
8. Will be able to demonstrate Phase Locked Loop (PLL).
9. Will be able to demonstrate Data Acquisition using Coupled Pendulum and Microcontroller 8081.
10. Will be able to demonstrate Pulse Width Modulation and LVDT Transducer and Strain Gauge

Course Structure

1. Zeeman Effect
2. Hysteresis Loop Tracer

3. Electron Spin Resonance (ESR)
4. Optical Fiber Experiment
5. Measurement of Permittivity of Air
6. Kerr Effect
7. Measurement of Mutual Inductance using Lock-in Amplifier
8. Phase Locked Loop (PLL)
9. Data Acquisition using Coupled Pendulum
10. Microcontroller 8081
11. Pulse Width Modulation
12. LVDT Transducer and Strain

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M.Sc. Physics Syllabus

Semester-4

CORE Paper. Project and Dissertation
Course Code: PPH-4806L
No. of credits: 4
Learning Hours: 60

Course Objectives

At the end of the course student will be able to

1. Will be trained in identifying Projects by doing literature survey in forms of Research papers, journals and looking for ideas in internet.
2. He/She is also encouraged to come with original ideas which explain the concepts of Physics and electronics.
3. Will be trained in having -Hands on experience with designing projects using various instruments, collecting data and in its analyses.
4. Will be able to document his project by writing synopsis and project report

Course Structure

Students are expected to finish their Project work by the end of Semester 4 and submit their Dissertation. The internal as well as external evaluation will be based on their Project.