PHYSICS- 11: QUANTUM MECHANICS AND APPLICATIONS-I

Time dependent Schrodinger equation and dynamical evolution of a quantum state; Probability and probability current densities in three dimensions; Position, momentum & Energy operators; commutator of position and momentum operators; Expectation values of position and momentum; (3 Lectures)

Time independent Schrodinger equation- 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; Application to the spread of Gaussian wave packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wave function; Position-momentum uncertainty principle; (10 Lectures)

General discussion of bound states in an arbitrary potential - continuity of wave function, boundary condition & emergence of discrete energy levels; application to one dimensional problems-square-well potential; Kronig-Penney model and appearance of energy bands in periodic potentials, like in crystal lattices; Elementary band theory of solids; effective mass of electrons; concept of holes; energy band diagrams; band-gap; conduction and valence bands; conductor, insulator and semiconductor; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigen functions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle; (15 Lectures)

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for the second order partial differential equation; angular momentum operator and quantum numbers; Radial wave functions from Frobenius method; shapes of the probability densities for ground and the first excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells; (10 Lectures)

Magnetic dipole moment and interaction energy in magnetic field; Stern-Gerlach experiment: electron spin & spin eigenvalues; Spin angular momentum; Pauli matrices (qualitative discussion) (10 Lectures)

Suggested study: (1) Bound states in a Delta function potential, (2) Zeeman effect - normal and anomalous, (3) Spin-orbit coupling in atoms - LS and jj couplings, (4) Understanding the diffraction due to a narrow slit as the spread of a wavepacket, (5) Why there is no classical limit of spin angular momentum while there is a classical limit for orbital angular momentum.

Reference Books:
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Theory, David Bohm, 1951, Dover Publications

Additional Books for Reference
- Introduction to Quantum Mechanics, David J. Griffith, 2nd Ed. 2005, Pearson Education
PHYSICS PRACTICAL-V
(Students have to perform at least 5 experiments from the section VC. Additional experiments may be included with the approval of the committee of courses)

PHYSICS LAB.-VC

1. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (from room temperature to 200 °C) and to determine its band gap.
2. To determine the Hall coefficient of a semiconductor sample.
3. To determine the Planck’s constant using LEDs of at least 4 different colours.
4. To determine the wavelength of H-alpha emission line of Hydrogen atom.
5. To determine the absorption lines in the rotational spectrum of Iodine vapour.
6. To study V-I characteristics of PN diode, and Light emitting diode
7. To study the Characteristics of a Photo-diode.
8. To design a digital to analog converter (DAC) of given specifications.
9. To study the analog to digital convertor (ADC) IC.

Reference Books:

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PHYSICS-12: ELECTROMAGNETIC THEORY


**Electromagnetic Wave Propagation in Unbounded Media**: Plane electromagnetic (EM) waves through vacuum and isotropic dielectric medium, transverse nature of plane electromagnetic waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere. (10 Lectures)

**Polarization of Electromagnetic Waves**: Description of linear, circular and elliptically polarised light (analytical treatment). (2 Lectures)

**Electromagnetic Wave in Bounded Media**: Boundary conditions at a plane interface between two media. Reflection and Refraction of plane waves at a 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) (12 Lectures)

**Waveguides**: Propagation of plane EM waves in planar dielectric waveguides. (3 Lectures)


**Electrodynamics and Relativity**: Electric and Magnetic fields due to a parallel plate capacitor and a long solenoid viewed in rest and moving frames of reference. Transformations of Electric and Magnetic fields deduced from these examples. (5 Lectures)

**Reference Books**:
- Introduction to Electromagnetic Theory, Tai L. Chow, 2006, Jones and Bartlett Learning
- Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
- Electromagnetic Field Theory for Engineers & Physicists, Gunther Lehner, 2010, Springer

**Additional Books for Reference**

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PHYSICS PRACTICAL-VI
(Students have to perform at least 4 experiments from the section VIA. Additional experiments may be included with the approval of the committee of courses)

PHYSICS LAB.-VIA

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 Babinet’s compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the value of c/m by (a) Magnetic focussing or (b) Bar magnet.
6. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction of light through an ultrasonic grating.
7. To study the reflection, refraction of microwaves
8. To study Polarization and double slit interference in microwaves.

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PHYSICS- 13: SOLID STATE PHYSICS


Ferroelectric Properties of Materials: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop (4 lectures)


Reference Books:
- Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
- Solid-state Physics, H.Ibach and H Luth, 2009, Springer
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
PHYSICS PRACTICAL-VI
(Students have to perform at least 4 experiments from the section VIB. Additional experiments may be included with the approval of the committee of courses)

PHYSICS LAB.-VIB
1. Measurement of susceptibility of paramagnetic solution (Quinck’s Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. Measurement various magnetic parameters of ferromagnetic substances, like coercivity, retentivity, saturation magnetization and hysteresis loss
4. To determine the Coupling Coefficient of a Piezoelectric crystal.
5. To measure the Dielectric Constant of a dielectric Materials with frequency
6. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
7. To determine the refractive index of a dielectric layer using SPR
PHYSICS- 14: STATISTICAL MECHANICS
(Include related problems for each topic)


(14 Lectures)


Bose-Einstein Statistics: B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Thermodynamic functions of photon gas, Bose derivation of Planck’s law. (12 Lectures)


Reference Books:
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
- An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press
PHYSICS PRACTICAL-VI
(Students have to perform at least 4 experiments from the section VIC. Additional experiments may be included with the approval of the committee of courses)

PHYSICS LAB.-VIC
1. To determine the refractive index of liquid by total internal reflection using Wollaston’s air-film.
2. To determine the refractive Index of (1) Glass and (2) a Liquid by total internal reflection using a Gaussian eyepiece.
3. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
4. To verify the Stefan’s law of radiation and to determine the value of Stefan’s constant.
5. To determine the value of Boltzmann constant using forward characteristics of a PN diode.
6. To study the PE Hysteresis loop of a Ferroelectric Crystal.
7. To draw the BH curve of iron using a Solenoid and determine the energy loss from Hysteresis.

Reference Books
- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Practical Physics, C.L Arora, 2001, S. Chand and Co.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal, New Delhi
PHYSICS- 15: MATHEMATICAL PHYSICS-IV

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

Linear Algebra


**Tensors**: Tensors as multilinear transformations (functionals) on vectors. Examples: Moment of Inertia, dielectric susceptibility. Components of a tensor in a basis. Symmetric and antisymmetric tensors. The completely antisymmetric tensor. Non-orthonormal and reciprocal bases. Summation convention. Inner product of vectors and the metric tensor. Coordinate systems & coordinate basis vectors. Reciprocal coordinate basis. Components of metric in a coordinate basis and association with infinitesimal distance. Change of basis: relation between coordinate basis vectors. Change of tensor components under a change of coordinate system. Example: Inertial coordinates and bases in Minkowski space, Lorentz transformations as coordinate transformations, the Electromagnetic tensor and change in its components under Lorentz transformations. (14 Lectures)

Calculus of Variations


Reference Books:
• Linear Algebra, W. Cheney, E.W. Cheney and D.R. Kincaid, 2012, Jones and Bartlett Learning
• Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole

Additional Books for Reference
• The Mathematics of Physics and Chemistry, H. Margenau and G. M. Murphy, 1956, Van Nostrand
PHYSICS PRACTICAL-VII
(Students have to perform at least 5 simulations and 2 experiments from the section VIIA. Additional experiments may be included with approval of the committee of courses)

PHYSICS LAB.-VIIA

Scilab based simulations experiments based on Mathematical Physics problems like

A. Solve differential equations:
   \[ \frac{dy}{dx} = e^x \text{ with } y = 0 \text{ for } x = 0 \]
   \[ \frac{dy}{dx} + e^{-x}y = x^2 \]
   \[ \frac{d^2y}{dt^2} + 2 \frac{dy}{dt} = -y \]
   \[ \frac{d^2y}{dt^2} + e^4\frac{dy}{dt} = -y \]

B. Dirac Delta Function:
   Evaluate \[ \frac{1}{\sqrt{2\pi}\sigma^2} \int e^{-\frac{(x-2)^2}{2\sigma^2}} (x + 3)dx \]
   for \( \sigma = 1, 0.1, 0.01 \) and show it tends to 5.

C. Fourier Series:
   Program to sum \( \sum_{n=1}^{\infty} (0.2)^n \)
   Evaluate the Fourier coefficients of a given periodic function (square wave)

D. Frobenius method and Special functions:
   \[ \int_{-1}^{+1} P_n(\mu)P_m(\mu)d\mu = \delta_{n,m} \]
   Plot \( P_n(x), f(x) \)
   Show recursion relation

E. Complex analysis: Integrate \( 1/(x^2+2) \) numerically and check with computer integration.

F. Integral transform: FFT of \( e^{-x^2} \)

G. Linear algebra:
   Multiplication of two 3 x 3 matrices
   Eigenvalue and eigenvectors of
   \[
   \begin{pmatrix}
   2 & 1 & 1 \\
   1 & 3 & 2 \\
   3 & 1 & 4 
   \end{pmatrix}
   \begin{pmatrix}
   1 & -i & 3 + 4i \\
   +i & 2 & 4 \\
   3 - 4i & 4 & 3 
   \end{pmatrix}
   =
   \begin{pmatrix}
   2 & -i & 2i \\
   +i & 4 & 3 \\
   -2i & 3 & 5 
   \end{pmatrix}
   \]

List of Experiments
1. Study of Electron spin resonance - determine magnetic field as a function of the resonance frequency
2. Zeeman effect: with external magnetic field; Hyperfine splitting
3. Quantum efficiency of CCDs
4. To show the tunneling effect in a tunnel diode using forward biased I-V characteristics.
5. Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.
PHYSICS- 16: QUANTUM MECHANICS AND APPLICATIONS-II


Suggested study: (1) Matrix mechanics and the Heisenberg picture. (2) Coherent states. (3) Lattice vibrations and phonons (4) Neutron interference experiment in gravity. (5) Two state systems: atomic clocks; nuclear magnetic resonance; neutrino oscillations. (6) Quantum entanglement: Schrodinger’s cat and EPR paradoxes; quantum computation - qubit as a superposition of |0> and |1> binary states, entangled qubits, parallel branches and parallel processing.

Reference Books:
- Quantum Mechanics, Brian H. Bransden and C. Charles Jean Joachain, 2000, Printice Hall
- Quantum Mechanics, Eugen Merzbacher, 3rd Ed., 1997, John Willey and Sons, Inc.
- The principles of quantum mechanics, P.A.M. Dirac’s, 2009, Springer
PHYSICS PRACTICAL-VII
(Students have to perform at least 5 simulations and 2 experiments from the section VIIB. Additional experiments may be included with approval of the committee of courses)

PHYSICS LAB.-VIIB

*PSPICE simulation for electrical networks and electronic circuits*

A. To verify the Thevenin and Norton Theorems.
B. Design and analyze the series and parallel LCR circuits
C. Design the low pass and high pass passive filters of given cutoff frequency
D. Design the inverting and non-inverting amplifier using an Op-Amp of given gain
E. Design and Verification of op-amp as integrator and differentiator  
F. Design the first order active low pass and high pass filters of given cutoff frequency  
G. Design the active band pass and band reject pass filters of given bandwidth  
H. Design and analyze the Clippers and Clampers circuits using junction diode  
I. Design a Wein’s Bridge oscillator of given frequency.  
J. Design clocked SR and JK Flip-Flop’s using NAND Gates  
K. Design 4-bit asynchronous Flip-Flop’ s using Flip-Flop ICs  
L. Design the CE amplifier of a given gain and its frequency response.  
M. Design an astable multivibrator using IC555 of given duty cycle.  
N. Design a monostable multivibrator of given pulse width using IC555 Timer  

List of experiments:  
1. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).  
2. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.  
3. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of length of about 2m, understanding of importance of grounding using function generator of mV level and a digital oscilloscope.  
4. To design and study the Sample and Hold Circuit.  
5. Glow an LED via USB port of PC  
6. Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port  

Reference Books:  
- Introduction to PSPICE using ORCAD for circuits & Electronics, M.H.Rashid, 2003, PHI Learning  
UNIT-1
Devices: Characteristic and Equivalent Circuits of UJT and JFET. Metal-semiconductor and metal oxide semiconductor junctions. MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, Charge coupled devices. (13 Lectures)

UNIT-2
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 (3 Lectures)
Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters. (4 Lectures)
Multivibrators: Astable and Monostable Multivibrators using transistors. (2 Lectures)
Phase Locked Loop (PLL): Basic Principles, Phase detector (XOR and edge triggered), Voltage Controlled Oscillator (Basics, varactor). Loop Filter – Function, Loop Filter Circuits, transient response, lock and capture. Basic idea of PLL IC (565 or 4046). (4 Lectures)

UNIT-3

UNIT-4
Introduction to communication systems: Block diagram of 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. basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK. (12 lectures)

Reference Books:
- Physics of Semiconductor Devices, S.M. Sze & Know K. Ng, 3rd Ed., 2008, John Wiley and Sons
PHYSICS PRACTICAL-VIII
(Students have to perform at least 5 experiments from the section VIIIA. Additional experiments may be included with the approval of the committee of courses)

PHYSICS LAB.-VIIIA

1. To design a power supply of given rating using bridge rectifier and study effect of C-filter
2. To design the active Low pass and High pass filters of given specification
3. To design the active filter (wide band pass and band reject) of given specification
4. To study the output and transfer characteristics of a FET
5. To design a common source FET Amplifier and study its frequency response.
6. Determine output characteristics of a LVDT and measure displacement using LVDT
9. Study of distance measurement using ultrasonic transducer.
10. Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75)
11. To measure the change in temperature of ambient using Resistance Temperature Device (RTD)
13. Study of possible radiation in different materials (eg. KSO₄) using GM at operating voltage.
PHYSICS-18: CLASSICAL DYNAMICS

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


Suggested Study: Principle of Virtual Work and d’Alebert’s Principle; Canonical transformations; Aberration of Starlight; Synchrotron Radiation.

Reference Books:
PHYSICS PRACTICAL-VIII

(Students have to perform at least 5 experiments from the section VIIIIB. Additional experiments may be included with the approval of the committee of courses)

PHYSICS LAB.-VIIIIB

1. To study the output characteristics of a MOSFET.
2. To study the characteristics of a UJT and design a simple Relaxation Oscillator.
3. To design an Amplitude Modulator using Transistor.
4. To design PWM, PPM, PAM and Pulse code modulation using ICs.
5. To design an Astable multivibrator of given specifications using transistor
6. To study a PLL IC (Lock and capture range)
7. Generation of DSB-SC AM signal and SSB AM signal
8. To study envelope detector for demodulation of AM signal
9. Study of ASK and FSK modulator
10. Study of PSK modulator and demodulator.
11. To study ASK encoded data and detection of unique code in RFID technology.

Reference Books:

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