AP4C11 NUCLEAR PHYSICS AND ASTROPHYSICS Unit

I

Nuclear Properties and Forces (4 hrs)


Nuclear Models (14 hrs)

Binding energy, semi-empirical mass formula, liquid drop model. Evidence of shell structure, single-particle shell model, its validity and limitations, Spin orbit coupling, Schmidt’s lines and prediction of angular momentum and parity of nuclear ground states. Collective model of Bohr and Mottelson – rotational States and Vibrational levels. Text Books:

Introductory Nuclear Physics, K. S. Krane, Wiley.
Unit II

Radioactivity, Fission and Fusion (18 hrs)

Radio activity, Units, alpha and beta decay, Gamow's theory, neutrino, Fermi's theory of beta decay, Radiation hazards. Nuclear fission, controlled fission reactions, fission reactors, nuclear fusion, controlled Fusion reactors.

Detectors, accelerators

Particle detectors - Ionization chamber, GM counter, bubble chamber, cloud chamber. Particle accelerators - Van de Graff generator, Cyclotron, Synchrotron.

Text Books:

- Introductory Nuclear Physics, K. S. Krane, Wiley.

Unit III

Particle Physics (18 hrs)


Text Books:

- Introductory Nuclear Physics, K. S. Krane, Wiley.
Unit IV
Astrophysics (18 hrs) Sun

**Expanding universe**-red shift-Hubble’s law. Fundamental assumptions - homogeneity and isotropy, the FRW metric, density evolution, critical density, cosmological constant. Conditions in the early universe – big bang nucleosynthesis.

**Galaxies**
Milky way galaxy-stellar population –spiral structure.

**Compact Objects**
Physical properties of black holes, white dwarfs, and neutron stars, formation of compact objects, pulsar phenomena, gravitational and neutrino radiation from supernova collapse and binary coalescence.

Text Books:
- Introduction to Cosmology, J. V. Narlikar, Cambridge University Press.
- Astrophysics: Stars and Galaxies, K.D.Ahbyankar

**Reference Books:**
Subatomic Particles, Frauenfelder and Henley, PHI.
The Ideas of Particle Physics, G. D. Coughlan and J. E. Dodd.
Nuclear Physics, I. Kaplan, Narosa publishing House, (1962).
Nuclear Radiation detectors, Price.
Particle Hunters, Neeman, Y. Kirch, Cambridge Univ. Press.
The New Cosmology, Albrecht Unsold.
Astrophysics, B. Basu.
The Physical Universe, F. H. Shu.
AP4C12 COMPUTATIONAL PHYSICS Unit

I
Numerical Methods of Analysis (18 hrs)

Text Book:
Introductory Methods of Numerical Analysis, S. S. Sastry, Prentice Hall India.

Unit II
Fortran (18 hrs)
Flow charts, Algorithms, Integer and floating point arithmetic, Precision, Variable types, Arithmetic statements, Input and output statements, Control statements, Executable and non-executable statements, Arrays, Repetitive and logical structures, Subroutines and functions, Operation with files, Operating systems, Creation of executable programs.

Text Book:
Computer Programming in FORTRAN 77, Rajaraman.
Unit III

Object Oriented Analysis and C++ (18 hrs)

Principle of Object Oriented Programming, Software evaluation, OOP paradigm, Basic concept of OOP, Benefits of OOP, Application of OOP, Introduction to C++, Tokens, Keywords, Identifiers, Constants, Operators, Manipulators, Expressions and control structure, Pointers, Functions, Function prototyping, Parameters passing in functions, Values Return by functions, Inline functions – friend and virtual functions, Classes, objects, constructors and destructors, Operator overloading, Type conversions, Type of constructors, Function over loading

Text Books:

Object Oriented Programming with C++, Balagurusamy, TMH.

Unit IV

Matlab Programming (18 hrs)


Control Flow Statements: if, else, else if, switch Statements-for, while Loop Structures-break Statement-Input/Output Commands-Function m Files-Script m Files-Controlling Output
Text Books:

- Engineering and Scientific Computations Using Matlab, Sergey E. Lyshevski, Wiley
- Matlab Programming-David Kuncicky, Prentice Hall.

Reference Books:

- Applied Numerical Analysis, Gerald, Person Educaton.
- Numerical Methods for Engineers and Scientists, Joe D. Hoffman.
- Computational Methods in Physics and Engineering, Wong.
- Computer Oriented Numerical Methods, Rajaraman.
- Programming in C++, Schaum’s Series.
- Getting Started With Matlab, Rudra Pratap, Oxford University Press, New Delhi.
AP4E03 PHOTONICS – II Unit

I

Fiber Optic Communication (18 hrs)
Fibre optic communication system- Advantages of fiber optic system- System design considerations for point to point links- Digital systems- Link power budget- Rise time budget- Line coding- Analog systems- System architecture- Point to point links- Distribution networks- Local area networks

Text Book:

Unit II
Optical Amplifiers and Detectors (18 hrs)
Qualitative ideas of semiconductor optical amplifiers, Erbium doped fiber amplifiers and Raman amplifiers
Optical detection principle-Absorption coefficient- Quantum efficiency- Responsivity- Long wavelength cutoff- PN photo diode- PIN photo diode- Avalanche photo diode- Photo transistor-Photo conducting detectors- Photomultiplier- CCD- Photo voltaic effect and solar cells- Noise- Thermal noise- Dark current noise- Quantum noise

Text Books:

Unit III

Fiber Cables and Connections (18 hrs)
Fiber material requirements- Fiber fabrication methods- Liquid – phase(Melting) Methods – Vapour-phase deposition methods- OVPO method- VAD method- MCVD method- PCVD method-Fiber optic cables-Fiber connections and related losses- Loss due to Fresnel reflection- fiber to fiber misalignment losses- loss due to other factors- Connection losses due to intrinsic parameters- Fiber splices- Fusion splices- Mechanical splices-Multiple splices- Fiber optic connectors- Butt-jointed connectors- Expanded beam connectors- multi fiber connectors

Text Book:

Unit IV

Frequency Multiplication and other Nonlinear Effects (18 hrs)

Text Book:
Reference Books:


AP4E04 FIBRE OPTICS Unit

I

Optical Waveguides (18 hrs)
Ray theory theory of transmission - Total internal reflection - Acceptance angle - Numerical aperture - Skew Rays. EM Theory for Optical propagation – Modes in a planar waveguide – Phase velocity and group velocity – Evanescent field - Optical fiber as a cylindrical waveguide - Modes – Mode coupling (elementary idea) – Classification of fibers – Step index fiber – Graded index fiber – Single mode fiber – Number of modes and cut off parameters – Mode field diameter and spot size

Text Book:
1. Optical Fiber Communications, John M. Senior, PHI (1994)

Unit II

Transmission Characteristics of Optical Fibers (18 hrs)
– Over all fiber dispersion – Modal birefringence – Polarization maintaining fibers.

Text Book:

1. 

Unit III
Optical Fiber Measurement s (18 hrs)


Text Book:

1. 

Unit IV
Optical Sensor Systems (18 hrs)

Intensity modulated sensors – Phase modulated sensors – Interferometric sensors – Sagnac effect and Fiber optic gyroscope – Polarization modulated sensors – Spectrally modulated sensors – Temperature, pressure, force and chemical sensors

Text Book:

1. 

Reference Books:


AP4P04   PHOTONICS PRACTICALS

Determination of Wavelength of laser beam using reflection and
diffraction gratings
Beam profile of a laser
Bending laws of an optical fiber
Numerical aperture of an optical fiber
Data transmission and reception through optical fiber link
Coupling laws of an optical fiber
Michelson Interferometer
Comparison of resolving limit of optical instruments with human eye (A
world view of Physics by Prof. D.P. Khandelwal et al – Page 300-
301, South Asian Publishers Pvt. Ltd, New Delhi 1999)
Characteristics of photo diode, photo transistor, LDR, LED
Solar cell characteristics
Dispersion through a medium – C++
Young’s double slit – Interference - C++
Diffraction due to a grating – C++
Polarization birefringence – C++
4.3 M.Sc. PHYSICS - NEW AND RENEWABLE ENERGY

4.3.1 Course Code

The first two letters PH stand for Physics, and the letters C, P, E, D and V have the usual meaning. The letter R stands for Renewable Energy. Here the core courses, Electives and Practicals are numbered from 1 to 4. The third character of the Code running from 1 to 4 indicate the semester concerned. The Course and course code are given in Table 4.2

<table>
<thead>
<tr>
<th>SEM</th>
<th>Name of the course with course code</th>
<th>No. of Hrs/week</th>
<th>No. of credit</th>
<th>Total Hrs/SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>PH1RC1: Mathematical Physics- I</td>
<td>4</td>
<td>4</td>
<td>72</td>
</tr>
<tr>
<td>I</td>
<td>PH1RC2: Classical Mechanics and Relativity</td>
<td>4</td>
<td>4</td>
<td>72</td>
</tr>
<tr>
<td>I</td>
<td>PH1RC3: Electro Dynamics and Nonlinear Optics</td>
<td>4</td>
<td>4</td>
<td>72</td>
</tr>
<tr>
<td>I</td>
<td>PH1RC4: Advanced Electronics</td>
<td>4</td>
<td>4</td>
<td>72</td>
</tr>
<tr>
<td>I</td>
<td>PH1RP1: General Physics Practicals</td>
<td>9</td>
<td>3</td>
<td>162</td>
</tr>
<tr>
<td>II</td>
<td>PH2RC1: Mathematical Physics- II</td>
<td>4</td>
<td>4</td>
<td>72</td>
</tr>
<tr>
<td>II</td>
<td>PH2RC2: Elementary Quantum Mechanics</td>
<td>4</td>
<td>4</td>
<td>72</td>
</tr>
<tr>
<td>II</td>
<td>PH2RC3: Thermodynamics and Statistical Mechanics</td>
<td>4</td>
<td>4</td>
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</tr>
<tr>
<td>II</td>
<td>PH2RC4: Condensed Matter Physics</td>
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<tr>
<td>II</td>
<td>PH2RP2: Computational Physics Practicals</td>
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<tr>
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<td>PH3RC1: Advanced Quantum Mechanics</td>
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<td>PH3RC2: Numerical Methods in Physics</td>
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</tr>
<tr>
<td>III</td>
<td>PH3RE2: Renewable Energy Sources</td>
<td>4</td>
<td>4</td>
<td>72</td>
</tr>
<tr>
<td>III</td>
<td>PH3RE3: Microprocessors and Microcontrollers</td>
<td>4</td>
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<tr>
<td>III</td>
<td>PH3RP3: Electronics Practicals</td>
<td>9</td>
<td>3</td>
<td>162</td>
</tr>
<tr>
<td>IV</td>
<td>PH4RC1: Atomic and Molecular Spectroscopy</td>
<td>4</td>
<td>4</td>
<td>72</td>
</tr>
<tr>
<td>IV</td>
<td>PH4RC2: Advanced Nuclear Physics</td>
<td>4</td>
<td>4</td>
<td>72</td>
</tr>
<tr>
<td>IV</td>
<td>PH4RE3: Solar Thermal Collection and Storage</td>
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<td>72</td>
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<tr>
<td>IV</td>
<td>PH4RE4: Solar Photovoltaics</td>
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<tr>
<td>IV</td>
<td>PH4RP4: Renewable Energy Practicals</td>
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<td>3</td>
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<tr>
<td>IV</td>
<td>PH4D05: Project/Dissertation</td>
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<tr>
<td>IV</td>
<td>PH4V06: Viva Voce</td>
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<td>2</td>
<td>Nil</td>
</tr>
</tbody>
</table>

Table 4.2 Course and course code of M.Sc. Physics – New and Renewable Energy
SEMESTER – I

PH1RC1 MATHEMATICAL PHYSICS –I Unit

I

Vector Analysis (15 Hrs)
Rotation of the coordinate axes, Scalar and Vector products, Gradient, Divergence and Curl, Vector integration, Gauss’ and Stokes theorems, Potential theory, Gauss’ law, Poisson’s equation, Helmholtz theorem, Orthogonal coordinates, Differential vector operators, Rectangular, Cylindrical and Spherical polar coordinates.

Error Analysis (3 Hrs)
Propagation of errors, Plotting of graphs, Least square fitting, Goodness of fit, Chi square test.

Unit II

Matrices (15 Hrs)

Probability (3 Hrs)
Definitions, Simple properties, Binomial, Poisson and Normal distributions.

Unit III Tensors
(18 Hrs)
Definition of Tensors, Associated Tensors, Metric Tensor, Contraction, Direct Product, Quotient Rule, Covariant Differentiation, Christoffel Symbols, Levi Cevita Symbol, Pseudo Tensors, Dual Tensors, Geodesic.
Unit IV

Differential Equations and Special Functions (18 Hrs)

Beta, Gamma and Dirac Delta functions (Properties only), Series solution of linear second order differential equations – Frobenius method, Bessel function of the first kind (Generating function, Recurrence relations, Orthogonality), Neumann function, Spherical Bessel function, Legendre polynomials (Generating function, Recurrence relations, Orthogonality, Rodrigues’ formula), Spherical Harmonics, Hermite polynomials, Laguerre polynomials.

Reference Books:

Mathematical Physics, B.D. Gupta, Vikas Pub.House, New Delhi

Mathematical Physics, B.S. Rajput, Y Prakash 9th Ed, Pragati Prakashan


Mathematical Physics, H.K Dass & R. Verma, S.Chand & Co.

Elements of Group Theory for Physicists, A.W. Joshy, New Age India.

Mathematical Physics, Sathyaprakash, Sultan Chand & Sons, New Delhi.
PH1RC2 CLASSICAL MECHANICS AND RELATIVITY

Unit I

Hamiltonian Methods (18 Hrs)

Unit II

Rigid Body Dynamics (12 Hrs)
Independent Coordinates – Orthogonal Transformations – Inertia Tensor – Euler’s Angles.
Force free motion of rigid body - Cases of symmetric top - Heavy Symmetric top, fast top - Sleeping top - Precession of Charged bodies in magnetic field - Infinitesimal rotation - Coriolis Force and its effects.

Theory of Small Oscillations (8 Hrs)
Unit III

Continuous Systems and Fields & Perturbation Theory (16 Hrs)

Lagrangian formulation for continuous systems - sound vibrations in gas - Hamiltonian formulation for continuous systems - description of fields.

Classical perturbation theory - time dependent perturbation - illustration case of simple pendulum with finite amplitude – Kepler problem and precession of the equinoxes of satellite orbits - time independent perturbation - first order with one degree of freedom.

Unit IV Relativity

(18 Hrs)

Review of Lorentz transformation - variation of length, mass and time with velocity - law of addition of velocities - mass energy relation - relativistic Doppler effect - four vectors. Lagrangian and Hamiltonian of a relativistic particle - charged particle in electromagnetic field - invariance of Maxwell's equations - electromagnetic field tensor.


Reference Books:

Classical Mechanics, A.K. Raychauduri, Oxford Univ. Press
Dynamics, S.N. Rasband, John Wiley & Sons, 1983
PH1RC3 ELECTRODYNAMICS AND NON LINEAR OPTICS

Unit I

Electrostatic Fields in Matter and Electrodynamics (10 hours)
Review of Electrostatics and Magnetostatics, Time varying fields and Maxwell’s equations, Potential formulations, Gauge transformations, boundary conditions, wave equations and their solutions, Poynting theorem, Maxwell’s stress tensor

Electromagnetic Waves (8 hours)
Maxwell’s equations in phaser notation. Plane waves in conducting and non-conducting medium, Polarization, Reflection and transmission (Normal and Oblique incidence), Dispersion in Dielectrics, Superposition of waves, Group velocity.

Text Book:
Introduction to Electrodynamics, D.J Griffiths, PHI.
Unit II

**Relativistic Electrodynamics (18 hours)**

Structure of space time: Four vectors, Proper time and proper velocity, Relativistic dynamics-Minkowiski force, Magnetism as a relativistic phenomenon, Lorentz transformation of electromagnetic field, electromagnetic field tensor, electrodynamics in tensor notation, Potential formulation of relativistic electrodynamics.

Text Book:

1.

Unit III

**Electromagnetic Radiation (20 hours)**

Retarded potentials, Jefimenkos equations, Point charges, Lienard-Wiechert potential, Fields of a moving point charge, Electric dipole radiation, Magnetic dipole radiation, Power radiated by point charge in motion.

Radiation reaction,

Physical basis of radiation reaction.

Text Book:

1.

Unit IV

**Non Linear Optics (16 hrs)**

phase conjugate optics – sum frequency generation – difference in frequency generation – saturable absorption.
Text Book:


Reference books:
Antennas, J.D. Kraus, Mc-Graw Hill.
Classical Electrodynamics, J. D. Jackson, Wiley Eastern Ltd.
Lasers and Non Linear optics, B.B Laud, New Age International.
Introduction to Optics, Germain Chartier, Springer.
Contemporary optics, A.Ghata & K. Thyagarajan, McMillan India Ltd.

PH1RC4 ADVANCED ELECTRONICS

Unit I

Operational Amplifiers (18 Hrs)
Review of differential amplifiers - review of operational amplifiers - differential amplifier with one and two op amps - Frequency response of an op amp - compensating networks

General Linear Applications
DC and AC amplifiers – AC amplifier with single supply voltage – Peaking amplifier – Summing, Scaling, averaging amplifiers – Instrumentation
amplifier using transducer bridge – Differential input and differential output amplifier – Low voltage DC and AC voltmeter - Voltage to current converter with grounded load – Current to voltage converter – Very high input impedance circuit – integrator and differentiator.

Text Book:

1. Op amps and linear Integrated Circuits, R.A.Gayakwad, PHI

Unit II

Active Filters and Oscillators (11 hrs)
Active filters – First order and second order low pass Butterworth filter - – First order and second order high pass Butterworth filter- wide and narrow band pass filter - wide and narrow band reject filter - All pass filter – Oscillators: Phase shift and Wien bridge oscillators – square, triangular and saw tooth wave generators- Voltage controlled oscillator.

Text Book:

1. Op amps and linear Integrated Circuits, R.A.Gayakwad, PHI (Chap 7)

Comparators and Converters (7 hrs)
Basic comparator - Zero crossing detector - Schmitt Trigger – Comparator characteristics - Limitations of op-amp as comparators - Voltage to frequency and frequency to voltage converters - D/A and A/D converters- Peak detector – Sample and Hold circuit.

Text Book:

1. Op amps and linear Integrated Circuits, R.A.Gayakwad, PHI (Chap 8)
Unit III

Power semiconductor Devices (18 Hrs)

Power Electronics - power semiconductor devices - power diodes, SCR, Power MOSFET, Types of Power Electronic Circuits.

Text Book:

Power Electronics, R.S Anandha Murthy, V Nattarasu, 2nd Edn
    Pearson, (Chapter 1)

Thyristor commutation techniques - Natural commutation, forced commutation, self commutation, impulse commutation, external pulse commutation, load side commutation, line side commutation.

Controlled Rectifiers - Principle of phase - controlled connector operation - Single phase semi converter - single phase full converters - single phase dual converters - single phase series converters

Static Switches - Single phase AC switches - three phase AC switches - three phase reversing switches - DC switches

Text Book:


Unit IV Inverters

(18 Hrs)

Text Book:
1. Power Electronics - Circuits - Devices and Applications, M.H.
   Rashid, PHI, 1988

Reference books:
Op amps and linear Integrated Circuits, R.A. Gayakwad, PHI
Integrated Electronics, Millman J & Halkias CC, MGH
M H Rashid - Power Electronics - Circuits - Devices and Applications
(PHI-1988)
Power Electronics R.S Anandha Murthy, V Nattarasu, 2nd Edn. Pearson

PH1RP1  GENERAL PHYSICS PRACTICALS
(Error Analysis of the experiment is to be done)
By Cornu’s method, set up elliptical/hyperbolic fringes, and hence
determine Young’s modulus, Rigidity modulus and Poisson’s ratio of
the given material.
Photograph the absorption spectrum of KMnO₄ with a standard
spectrum superimposed over it.
Analyze the given absorption spectrum of KMnO₄ and determine the
wavelengths of the absorption bands evaluating the Hartmann’s
constants using wavelengths of the superimposed standard spectrum.
By Frank-Hertz experiment determine the excitation potentials of a
gas. Hence deduce the wavelengths of the spectral lines expected.
Determine the Hall coefficient, carrier concentration and mobility of
the given specimen by the Hall probe method.
Determine the resistivity of the given semiconducting crystal at different temperatures by the Four Probe method. Hence calculate the band gap energy.

Determine the band gap energy of silicon.

Study the variation of magnetic susceptibility of the given solid by Gouy’s method. Also calculate the magnetic moment per molecule/atom of the solid.

Study the variation of magnetic susceptibility with concentration of the given salt in water. Hence show that water is diamagnetic.

Determine \( \lambda \) and \( d \lambda \) of sodium light using Michelson Interferometer. Also determine the thickness of the given mica sheet.

Determine the hysteresis loss of the given specimen in the form of a ring by ballistic method. Also calculate the retentivity and coercivity of the material.

Determine the coefficient of viscosity of the given liquid by oscillating disc method.

Study the V-I characteristics of the given photodiode. Also study the variation of photodiode current with light intensity and determine the dark resistance of the diode.

Calibrate the given silicon diode as a temperature sensor.

Study the characteristics of the given thermistor. Determine the temperature coefficients \( \alpha \) and \( \beta \) of the given thermistor.

Study the beam profile of the given LASER. Determine the spot size from the intensity distribution.

Study the bending losses in the given optical fiber for different bends.
SEMESTER – II

PH2RC1 MATHEMATICAL PHYSICS – II

Unit I
Functions of a Complex Variable (18 Hrs)
Complex algebra, Cauchy-Riemann conditions, Cauchy’s integral theorem, Cauchy’s integral formula, Taylor and Laurent expansion, Poles, Residues, Residue theorem, Evaluation of definite integrals.

Unit II
Integral Transforms (18 Hrs)
Laplace transforms, Solution of differential equations using Laplace transforms (LCR circuit, Electromagnetic waves in dispersive medium, Damped driven oscillator, and Earth’s nutation), Fourier transform, Fourier transform of full wave rectifier, Square wave and finite wave train, Momentum representation for Hydrogen atom (ground state) and Harmonic oscillator.

Unit III
Group Theory (18 Hrs)
Review of introductory definitions and concepts, Unitary representations, Schur’s lemmas, Orthogonality theorem and interpretations, Character of a representation, Character Tables and examples, Irreducible representations of Abelian and Non Abelian groups, Connection with quantum numbers, Symmetry group of the Schrodinger equation, Symmetry and degeneracy, Basic functions of irreducible representations, SU(2) group, SU(3) group, Applications to Nuclear and Particle Physics (qualitative only).
Unit III

Second Order Differential Equations & Green’s Function (18 Hrs)

Partial differential equations of Physics, Boundary conditions, Hermitian operators and their properties, Schmidt orthogonalization, Heat equation, Laplace’s and Poisson’s equations, Nonlinear partial differential equations, Separation of variables (Cartesian, Spherical polar and Cylindrical coordinates),

Non homogeneous equations, Green’s function eigenfunction expansion, 1-dimensional Green's function, Green's function integral-differential equation, eigenfunction, eigenvalue equation Green's function and Dirac delta function.

Reference Books

Mathematical Physics, B.D. Gupta, Vikas Pub.House, New Delhi
Mathematical Physics, B.S. Rajput, Y Prakash 9th Ed, Pragati Prakashan
Mathematical Physics, H.K Dass & R. Verma, S.Chand & Co.
Elements of Group Theory for Physicists, A.W. Joshy, New Age India.
Mathematical Physics, Sathyaprakash, Sultan Chand & Sons, New Delhi.
PH2RC2 ELEMENTARY QUANTUM MECHANICS

Unit I
The Formation of Quantum Mechanics (22 Hrs)
Linear vector space, Orthonormality and linear independence, Schmidt’s orthogonalization procedure, Hilbert space, dimension and basis, Operators and their properties, commuting operators, Eigen values and Eigen vectors, Bra and ket notation for vectors, representation theory, coordinate and momentum representation, fundamental postulates, Expectation values and probabilities, Superposition principle, observables and operators, The uncertainty principle.

Unit II
Quantum Dynamics (12 Hrs)
The equation of motion, Schrodinger Heisenberg and interaction pictures, Linear harmonic oscillator in Schrodinger and Heisenberg pictures, Hydrogen atom
Symmetry and Conservation laws
Space time symmetries, Displacement of space and conservation of linear momentum, translation in time and conservation of energy, Rotation in space and conservation of angular momentum, Space inversion time reversal, identical particles, Symmetry of Wavefunctions, Spin and statistics, Pauli’s exclusion principle, the Helium atom.

Unit III
Theory of Angular Momentum (20 Hrs)
Angular momentum operators, matrix representation of angular momentum operators, Pauli spin matrices, orbital angular momentum, spherical
harmonics, Addition of angular momenta, Clebch Gordon coefficients, calculation of CG coefficients j=1/2 and j=1 cases.

Unit IV

The Theory of Scattering (18 Hrs)

Scattering cross section and Scattering amplitude, Low energy scattering by a central potential, Partial wave analysis, phase shift and potential, scattering length, optical theorem, Scattering by a square well potential, The Ramsuuer Townsend effect, Scattering by hard sphere, resonance scattering, high energy scattering, The integral equation, Born approximation. Validity condition of Born approximation.

Text Book:

1. Reference Books:

   Quantum Mechanics, Concepts and applications, N. Zettili, John Wiley & sons
   Quantum Mechanics, L.I.Schiff, MGH
   A text book of Quantum Mechanics, P. M. Mathews & K. Venkatesan, TMGH
   Modern Quantum Mechanics, J.J. Sakuerai, Pearson Education.
   Quantum Mechanics, A Messiah, Wiley.
   Quantum Physics, Stephen Gasiorowics, Wiley.
   Quantum Mechanics A. Ghatak & S. Lokanathan, Kluwer Academic Publishers
   The Introduction to Quantum Mechanics, D.J. Griffiths, Pearson.
   Introductory Quantum Mechanics, Richard L. Liboff, Pearson.
PH2RC3 THERMODYNAMICS AND STATISTICAL MECHANICS

Unit I

Fundamental of Thermodynamics (10 Hrs)


Text Book:


Foundations of Statistical Mechanics (8 Hrs)


Text Book:

Unit II

The Canonical Ensemble (12 Hrs)

A system in contact with a heat bath – the partition function – definition of the entropy in the canonical ensemble – the bridge to thermodynamics through partition function – condition for thermal equilibrium – thermodynamic quantities from partition function – case of a two level system – single particle in a one dimensional box – single particle in a three dimensional box – expression for heat and work – rotational energy levels for diatomic molecules – vibrational energy levels for diatomic molecules – factorizing the partition function – equipartition theorem – minimizing the free energy.

Text Book:


Statistics of Identical Particles (4 Hrs)


Text Book:


Unit III

Maxwell Distribution and Planck’s Distribution (12 Hrs)

The probability that a particle is in a quantum state – density of states in k space – single particle density of states in energy – distribution of speeds of particles in a classical gas – blackbody radiation – Rayleigh-Jeans theory –
Planck’s distribution – derivation of the Planck’s distribution – the free energy – Einstein’s model vibrations in a solid – Debye’s model of vibrations in a solid.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M. Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition. (Chapter 7 and 8)

**Grand Canonical Ensemble (8 Hrs)**

Systems with variable number of particles – the condition for chemical equilibrium – the approach to chemical equilibrium – chemical potential – reactions – external chemical potential – grand canonical ensemble – partition function – adsorption of atoms on surface sites – grand potential.

Text Book:


**Unit IV**

**Fermi and Bose Particles (6 Hrs)**


Text Book:


**Phase Transitions (12 Hrs)**

Phases – thermodynamic potential – approximation – first order phase transition - Clapeyron equation – phase separation – phase separation in

Text Book:


Reference Books:

Statistical Mechanics, Kerson Huang, John Wiley and Sons (2003).
Problems and solutions on Thermodynamics and Statistical mechanics, Yung Kuo Lim, World Scientific Pub. (1990)

PH2RC4 CONDENSED MATTER PHYSICS

Unit I

Crystal structure and Nanomaterials (6 Hrs)

Review of crystal lattice fundamentals and interpretation of Bragg’s equation, Ewald construction, the reciprocal lattice, reciprocal lattice to SC,
BCC and FCC lattices, properties of reciprocal lattice, diffraction intensity-
atomic, geometrical and crystal structure factors- physical significance.
Nanomaterials: Definition, Synthesis and properties of nanostructured
materials
Text Book:
Wahab, Narosa 2nd Edn. 2010, (Chapter 8 & Ref. Book 8)

**Free electron theory of metals (12 Hrs)**
Review of Drude-Lorentz model- electrons moving in a one dimensional
potential well - three dimensional well - quantum state and degeneracy -
density of states - Fermi-Dirac statistics - effect of temperature on Fermi-
Dirac distribution - electronic specific heat - electrical conductivity of metals
- relaxation time and mean free path - electrical conductivity and Ohm’s law -
Widemann-Franz-Lorentz law - electrical resistivity of metals.
Text Book:
Wahab, Narosa 2nd Edn. 2010, (Chapter 10)

**Unit II**

**Band Theory of Metals (6 Hrs)**
Bloch theorem - Kronig- Penney model - Brillouin zone construction of
Brillouin zone in one and two dimensions – extended - reduced and periodic
zone scheme of Brillouin zone (qualitative idea only) - effective mass of
electron - nearly free electron model – conductors - semiconductors -
insulators.
Text Book:

**Band Theory of Semiconductors (10 Hrs)**

Generation and recombination - minority carrier life - time - mobility of current carriers - drift and diffusion and general study of excess carrier movement- diffusion length.

Text Book:

Free carrier concentration in semiconductors - Fermi level and carrier concentration in semiconductors - mobility of charge carriers - effect of temperature on mobility - electrical conductivity of semiconductors - Hall effect in semiconductors - junction properties- metal-metal, metal-semiconductor and semiconductor-semiconductor junctions.

Text Book:

**Unit III**

**Lattice dynamics (12 Hrs)**

Vibrations of crystals with monatomic basis – diatomic lattice – quantization of elastic waves – phonon momentum.

Text Book:
1. Introduction to Solid State Physics, C. Kittel, 3rd Edn. Wiley India. (Chapter 4).
Anharmonicity and thermal expansion - specific heat of a solid - classical model - Einstein model - density of states - Debye model - thermal conductivity of solids - thermal conductivity due to electrons and phonons - thermal resistance of solids.

Text Book:


**Dielectric properties of solids (4 Hrs)**

Review of basic terms and relations, ferroelectricity, hysteresis, dipole theory- Curie- Weiss law, classification of ferroelectric materials and piezoelectricity.

Text Book:


Ferroelectric-domain, antiferroelectricity and ferrielectricity. Text Book:


**Optical properties of solids (4 Hrs)**

Drude model - ionic conduction - optical refractive index and relative dielectric constant - optical absorption in metals, insulators and semiconductors.

Text Book:

Unit IV

Magnetic properties of solids (10 Hrs)


Text Book:


Superconductivity (8 Hrs)


Text Book:

1. Introduction to Solid State Physics, C. Kittel, 3rd Edn. Wiley India. (Chapter 12).

Reference Books:


Solid State Physics, Dan Wei, Cengage Learning (2008)
Solid State Physics, A.J. Dekker, Macmillan & Co Ltd. (1967)

PH2RP2 COMPUTATIONAL PHYSICS PRACTICALS

[Programs are to be written in C++ language for experiments in section A and Section B. Method, algorithm and flow chart are to be developed. For Section C suitable simulation software can be used.]

Section - A: (Graphics)
Write and execute a program to demonstrate the motion of a spherical body in a viscous medium. Study the effect on motion by changing the mass, size of the body and the medium.
Write and execute a program for the motion of a projectile in air. Study the motion for different angles of projection.
Write and execute a program to find the variation in position, velocity and acceleration of a damped harmonic oscillator. How do the oscillations go from the undamped to the critically damped and to over damped with variation in damping coefficient?
Write and execute a program to find the variation in acceleration, velocity, position and energy of a driven oscillator. Plot the position versus time graph for different driving conditions.

Write and execute a program to generate a pattern of standing waves. Run this program with different values of amplitude, wavelength and velocity.

Write and execute a program to analyze a series LCR circuit with an AC source. Verify the resonance condition.

Section – B: (Numerical methods)

Write and execute a program for solving a system of linear equations using Gauss elimination method.
Write and execute a program to find the root of a non linear equation by bisection method.
Write and execute a program for the numerical integration of a function using trapezoidal method.
Write and execute a program for the numerical integration of a function using Simpson’s 1/3 rule.
Write and execute a program to solve the given ordinary differential equation by using Euler method.
Write and execute a program to solve the given ordinary differential equation by using Runge-Kutta fourth order method.

Section – C: (Circuit Simulation)

Design and simulate a single stage RC coupled amplifier with feedback. Study the frequency response
Design and simulate a two stage RC coupled amplifier with feedback. Study the frequency response.
Design and simulate an RC phase shift oscillator using BJT and observe the sinusoidal output waveform.
Design and simulate the first order and second order low pass Butterworth filter for a cut off frequency of 1KHz. Obtain the frequency response curve and determine the roll off rate.
Design and simulate a differential amplifier using transistors with constant current source. Study its frequency response. Also determine its CMRR.
Design and simulate a differentiator and integrator using Op-amp. Obtain the output waveform for an input square wave.

SEMESTER – III

PH3RC1 ADVANCED QUANTUM MECHANICS

Unit I

Approximation Methods for Time-Independent Problems (18 Hrs)
Time-independent perturbation theory, Non-degenerate and degenerate cases, Anharmonic oscillator, Stark and Zeeman effects in hydrogen. The WKB approximation, connection formulae, validity of the approximation, barrier tunnelling, application to decay - Bound states, Penetration of a potential barrier,
Variational method
The variational equation, ground state and excited states, the variation method for bound states, application to ground state of the hydrogen and Helium atoms.

Unit II
Time Dependent Perturbation Theory (18 Hrs)
Time dependent perturbation theory Transition probability, constant perturbation, Transition to continuum, Harmonic perturbation, Interaction of an atom with the electromagnetic field, Induced emission and absorption, The electric dipole approximation, The Born approximation and scattering amplitude.

Unit III
Relativistic Quantum Mechanics (22 Hrs)

Unit IV
Quantization of fields (14 Hrs)
The principles of canonical quantization of fields, Lagrangian density and Hamiltonian density, Second quantization of the Schrodinger wave field for
bosons and fermions, Quantization of Electromagnetic waves Coulomb’s
gauge.

Text Book:
1. Quantum Mechanics, V.K. Thankappan, Wiley Eastern

Reference Books:
Quantum Mechanics, Concepts and applications, N. Zettili, John Wiley &
sons
Quantum Mechanics, L.I.Schiff, MGH
Advanced Quantum Mechanics, J.J. Sakuerai, Pearson Education.
A text book of Quantum Mechanics, P. M. Mathews & K. Venkatesan,
TMGH
Quantum Physics, Stephen Gasiorowics, Wiley

PH3RC2 NUMERICAL METHODS IN PHYSICS
Unit I (18 Hrs)
Interpolation and Curve fitting - Errors in Polynomial Interpolation - Finite
differences(Forward differences, Backward differences, Central differences)
- Detection of errors by use of difference tables-Differences of a polynomial
– Newton’s formulae for interpolation - Central difference interpolation
formulae (Gauss central difference formulae, Stirlings formulae, Evretts
formula) - Interpolation with unevenly spaced points (Lagrange’s
interpolation formulae, Error in Lagrange’s interpolation formulae,
Hermite’s interpolation formulae)
Least squares curve fitting procedures (Fitting a straight line, Nonlinear curve fitting, Curve fitting by a sum of exponentials) - Weighted least squares approximation (Linear Weighted least squares approximation, Nonlinear Weighted least squares approximation) – Method of least squares for continuous Functions (Orthogonal polynomials, Gram-Schmidt orthogonalization process)

**Unit II (18 Hrs)**


**Unit III (18 Hrs)**

Linear system of equations - Solution of linear systems-Matrix inversion method - Gauss elimination method - Gauss-Jordan Method - Modification of Gauss method to compute the inverse of a matrix - Solution of linear systems-Iterative methods - The eigen value problem-Power method and Jacobi’s method to solve eigenvalue problems. (10 Hrs)

Numerical solution of ordinary differential equations - Solution by Taylor’s series - Picards method of successive approximations - Euler’s method - Runge-Kutta methods-Predictor-Corrector methods. (8 Hrs)

**Unit IV (18 Hrs)**

Numerical Solutions of partial differential equations - Finite difference approximations to derivatives - Laplace equation-Jacobi’s method - Gauss Seidal method - Successive over relaxation - The ADI method - Parabolic
equations - Iterative methods for the solution of equations - Hyperbolic equations

Text Books:

Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.

Reference Books:

An Introduction to Computational Physics, Tao Pang, CUP

PH3RE2 RENEWABLE ENERGY SOURCES

Unit I

Wind Power (18 Hrs)

Energy and power in wind - wind turbines - power and energy from wind turbines - commercial development and wind energy potential - economics - cost calculation - capital cost.

Wave Energy

Wave energy - wave motion - power from wave energy
Unit II

**Hydroelectricity (18 Hrs)**

Stored potential energy - power head and flow rate - world resource - types of hydroelectric plants - low, medium and high heads - estimation of power - economics of hydroelectric projects.

**Tidal Power**

Nature of resource - basic physics - power generation - economical and environmental factors.

**Ocean Thermal Energy Conversion (OTEC)**

Introduction - OTEC power generation

Unit III

**Geothermal Energy (18 Hrs)**

Earth as a heat engine – miming of geothermal heart - physics of geothermal resources – technologies for geothermal exploration - economics and world potential - of geothermal energy.

**Biomass**

Biomass as a fuel – extraction of energy agricultural resides – energy from refuse - energy from crops new technologies - gas turbine - biomass fuel cell – photo biological fuel production - economics of biomass.

Unit III

**Fuel Cells (18 Hrs)**

Hydrogen Energy


Reference Books:

- Solar Energy Principles of Thermal Collection and Storage, S.P. Sukhatme, 2nd Ed. TMH
- Solar energy, H. P. Garg and J Prakashi, TMH 1997
- Renewable Energy Source and Conversion Technology, N.K Bansal, M. Kleemann & M. Melss, TMH.

PH3RE3 MICROPROCESSORS AND MICROCONTROLLERS

Unit I

8085 Architecture and Data Transfer Schemes. (18 Hrs)

8085 architecture - instruction set (assignment &discussion)) - instruction timings and execution - 8085 interrupts - 8085 Input /Output - standard I/O-memory mapped I/O - address space partitioning - memory interfacing - bus
contention - data transfer schemes - classification of data transfer schemes - programmed data transfer - synchronous transfer - asynchronous transfer - interrupt driven data transfer - multiple interrupts - multiple devices, single interrupt level - software polling - hardware polling - direct memory access data transfer.

Text Books:
Introduction to Microprocessors 3rd Ed. Aditya P. Mathur, TMH

Unit II
Interfacing Devices & Memory Devices (18 Hrs)
Basics of programmable I/O - the 8155 IC - the 8255 PPI - key board and display interface 8279 - serial communication - The USART - 8251 - DMA controller - 8257 - Programmable Interrupt controller – 8259- (Architecture and programming for all devices) – EPROM and RAM memory devices - 2764 and 6264.

Text Books:
Microprocessors and Microcomputer Based System Design, M. Rajiquzzaman, Universal book stall, New Delhi

Unit III
Interfacing 8055 & Architecture of 8086 (18 Hrs)
Review of operational amplifier characteristics – transducers and its classification-lightsensors– Eg(1)Photoconductive cell (2)
Semiconductor photo diode - temperature sensors –Eg (1) Thermocouple (2) Thermister – force sensors – Eg - Strain gauges - the 8085 based data acquisition system - interfacing ADC (0808) – concept of sample and hold circuit (LF 398) - clock for A/D converter – (circuit) - ADC 0808 (internal diagram) - interfacing circuit for 8085.

**8086 IC**

Architecture of IC 8086 - addressing modes - instruction set (assignment and discussion ) - pin layout – (sample programs using debug utilities) - minimum mode and minimum system mode interface – comparison 8086 & 8088.

**Text Books:**


Electronic Instrumentation, H.S. Kalsi, 2nd Edn. TMH.

The 8088 and 8086 microprocessors, W.A. Triebel & A.Singh, PHI


**Unit IV**

**Micro Controllers (18 Hrs)**

Introduction - Difference between microprocessors and micro controllers - types of micro controllers (MC) - internal architecture of typical MC (Intel 8051) - peripheral features - programming concepts – assembly language programming – jump – loop - call instructions - I/O port programming – Address modes – Arithmetic, logic instructions and programs – 8051
programming in C - (sample programs using Kiel utilities) - LCD interfacing.

Text Books:

Reference Books:
- Introduction to Microprocessors, 3rd Ed. Aditya P. Mathur, TMH.
- 0000 to 8085 - Introduction to Microprocessors for Engineers and Scientists, P.K Ghosh, P.R. Sridhar, PHI Learning Pvt. Ltd.
- The 8086 Microprocessor: Programming and interfacing the P.C., K.J. Ayala, Penram Pub. India

**PH3RP3 ELECTRONICS PRACTICALS**
(Use of Bread Boards for assembling electronics circuits is permitted. For Microprocessor experiments microprocessor kit, suitable simulation software or convenient Hex editors are permitted)

Design and construct a two stage RC coupled amplifier with feedback. Study the frequency response.
Design and construct a differential amplifier using transistors with constant current source. Study its frequency response. Also determine its CMRR.

Design and construct a push-pull power amplifier using transistors in complementary symmetry arrangement. Plot load impedance versus output power graph and determine the optimum load. Also study the frequency response.

Design and construct an RF amplifier. Study the effect of damping on the frequency response.

Design and construct a voltage controlled oscillator (VCO) using transistors. Plot the graph connecting frequency and control voltage. Repeat the experiment covering the entire audio frequency range.

Design and construct a differential amplifier using suitable operational amplifier (Op-amp) and study its frequency response. Also determine its CMRR.

Design and construct the first order and second order low pass Butterworth filter for a cut off frequency of 800 Hz. Draw the frequency response curve and determine the roll off rate.

Design and construct the first order and second order high pass Butterworth filter for a cut off frequency of 2 kHz. Draw the frequency response curve and determine the roll off rate.

Design and construct a band pass filter with multiple feedback using an operational amplifier (Op-amp) so that \( f_0 = 2 \) kHz. \( Q = 3 \) and \( A_F = 10 \). Draw the frequency response curve and determine the pass band.
Design and construct a Wein Bridge Oscillator incorporating the amplitude stabilization for a frequency of 2 kHz. Using an operational amplifier (Op-amp). Repeat the experiment for different frequencies.

Using an operational amplifier (Op-amp) design and construct a voltage regulator with short circuit protection to obtain a regulated output of 6 volt. Study the load regulation and source regulation.


Using an operational amplifier (Op-amp) design and construct a triangular wave from generator for 1 kHz. With amplitudes 5 V. Measure the amplitude and frequency. Compare with theoretical values. Repeat the experiment for the frequencies of 500 Hz, 2 kHz, 3 kHz and 4 kHz.

Design and construct a voltage controlled oscillator (VCO) using IC555. Study variation of output frequency with control voltage and compare with the theoretical value. Also determine the duty cycle and compare with the theoretical value.

Design and construct a 4-bit binary synchronous counter using JK flip flops. Construct the up counter and convert it to a down counter.

Design and construct an amplitude modulator. Determine the percentage modulation. Trace the wave forms. Repeat the experiment for different amplitudes of the modulating signal.

Write and execute a program to control the speed of the stepper motor interfaced with a microprocessor. Rotate the motor in the clockwise
and anticlockwise directions using the program. Repeat the experiment for various time delays.

Write and execute a program to measure an analog voltage using a microprocessor kit with an ADC. Repeat for five different analog voltages. Draw a graph connecting the theoretical and measured values.

Write and execute a program for generating any two types of wave forms (triangular, square, saw-toothed, sine etc.) using microprocessor in association with a D/A interfaced card. Observe the wave forms using CRO. Measure the frequencies using the CRO and compare it with theoretical values.

SEMESTER – IV

PH4RC1 ATOMIC AND MOLECULAR SPECROSCOPY

Unit I

Atomic Spectra (18 Hrs)

Text Book:
2. Introduction of atomic spectra, H.E. White, Mc Graw Hill

Unit II

Microwave and Infra Red Spectroscopy (18hrs)

Microwave Spectroscopy: Rotational spectra of diatomic molecules. Intensity of spectral lines, effect of isotopic substitution.
Non–rigid rotator, rotational spectra of polyatomic molecules - linear, symmetric and asymmetric top molecules. Information derived from rotational spectra.

IR Spectroscopy: Vibrating diatomic molecules as anharmonic oscillators, diatomic vibrating rotator – break down of Born Oppenheimer approximation, vibrations of polyatomic molecules, overtone and combination frequencies, influence of rotation on the spectra of polyatomic molecules - linear and symmetric top molecules, analysis by IR technique, IR spectrometer, Fourier Transform Spectroscopy.

Text books:
- Fundamentals of molecular spectroscopy, C.N. Banwell, MGH.
- Molecular structure and spectroscopy, G. Aruldas, PHI Learning Pvt. Ltd.

Unit III

Raman and Electronic Spectroscopy (18 Hrs)

Pure rotational Raman Spectra - linear and symmetric top molecules, vibration Raman spectra – Raman activity of vibrations, mutual exclusion
principle, rotational fine structure, structure determination from Raman and IR spectroscopy. Non-linear Raman effects - hyper Raman effect, classical treatment, stimulated Raman effect, CARS

**Electronic Spectroscopy:** Electronic spectra of diatomic molecules, intensity of spectral lines, Frank–condon principle, dissociation energy and dissociation products, rotational fine structure of electronic-vibrational transition, Fortrat diagram, pre-dissociation.

Text books:

- Fundamentals of molecular spectroscopy, C.N. Banwell, MGH
- Molecular structure and spectroscopy, G. Aruldas, PHI Learning Pvt. Ltd.
- Lasers and Non-Linear Optics, B.B Laud, Wiley Eastern
- Raman Spectroscopy, D.A. Long, MGH.

**Unit IV**

**Spin Resonance Spectroscopy. (18 Hrs)**

**NMR:** Quantum mechanical description, classical description, the Bloch equations - relaxation processes, Chemical shift, spin–spin coupling for hydrogen molecule, experimental technique – CW and FTNMR spectrometer, applications.

**ESR:** Theory of ESR, thermal equilibrium and relaxation, experimental techniques, g- factor, hyperfine structure, applications, – Mossbauer effect, recoilless emission and absorption, experimental methods, hyperfine interactions – chemical isomer shift, magnetic hyperfine interactions, electronic quadrupole interactions, applications.
Text Book:

Spectroscopy Straughan & Walker, Vol.1&2, John Wiley & Sons

Reference Books:

Introduction to molecular spectroscopy, G.M. Barrow, Mc Graw Hill.
Elements of spectroscopy, Gupta, Kumar & Sharma, Pragathi Prakshan.
Elementary Organic Spectroscopy, Y.R. Sharma, S. Chand and Co.
Spectroscopy of organic compounds, P.S. Kalsi, New age.
Molecular structure and spectroscopy, G.Aruldas, PHI

PH4RC2 ADVANCED NUCLEAR PHYSICS

Unit I

Nuclear Decay (18 Hrs)

Gamma decay – energetics, multipole moments, transitions and radiations – classical and quantum mechanical aspects, selection rules, angular correlation and internal conversion.

Nuclear radiation detectors: Gas detectors – Ionization chamber, Proportional counter and G. M. counter, Scintillation detector, Photo Multiplier Tube (PMT).

Text Books:

- Introductory Nuclear Physics, K.S. Krane, Wiley
- Nuclear Radiation Detection, Measurements and Analysis, K. Muraleedhara Varier, Narosa

**Unit II**

**Nuclear Forces (18 Hrs)**

General characteristics of nuclear forces, The Deuteron – binding energy, spin, parity, electromagnetic moments, simple theory of the deuteron structure, spin dependence, tensor force, and two nucleon scattering experimental data, scattering cross sections, low energy n-p scattering, partial waves, phase shift, singlet and triplet potentials, scattering length and its sign, effective range theory, low energy p-p scattering, exchange forces and Yukawa theory (Qualitative only).

Text Books:

- Introductory Nuclear Physics, K.S. Krane, Wiley
- Nuclear Physics- Theory and Experiment, R.R. Roy & B.P. Nigam, Wiley Eastern
Unit III

Nuclear Models, Nuclear Fission and Fusion (18 Hrs)

Nuclear models: Shell model, single particle potentials, spin-orbit coupling, single particle models, spins and parities of ground states, quadrupole moments, magnetic moments and Schmidt limits, Nordheim’s rules, isospin symmetry,

Nuclear fission and Fusion: Compound nucleus reactions, fission process, characteristics, energy released, neutrons released in fission, cross sections, types of nuclear reactors, fusion process, characteristics of fusion, solar fusion, controlled fusion reactors.

Text Books:

- Introductory Nuclear Physics, K.S. Krane, Wiley
- Nuclear Physics- Theory and Experiment, R.R. Roy & B.P. Nigam, Wiley Eastern

Unit IV

Particle Physics (18 Hrs)

Types of interactions between elementary particles - hadrons and leptons, their masses, spin parity decay structure, the quark model, the confined quarks, coloured quarks, experimental evidences for quark model. The quark-gluon interaction. Gell-mann-Nishijima formula, Symmetries and conservation laws, C, P and CPT invariance and applications of symmetry arguments to particle reactions, parity non conservation in weak interactions. Exchange bosons of the weak interaction, electroweak unification.
Text Books:

The Particle Hunters, Yuval Ne’eman and Yoram Kirsh, 2nd Ed., Cambridge University Press, 1996
Introduction to Elementary Particles, David Griffiths, John Wiley & Sons, 1987

Reference Books:

Introductory Nuclear Physics, Samuel S.M. Wong, PHI.
Concepts of Nuclear Physics, B.L. Cohen, Tata McGraw Hill
Nuclear Physics, Irvin Kaplan, Addison Wesley, 1962
Atomic and Nuclear Physics, S.N. Ghoshal, Volume 2, S.Chand & Co.
Nuclear and Particle Physics, W.E. Burcham and M. Jobes, John Wiley & Sons.
The ideas of particle physics—An introduction for scientist,
PH4RE3 SOLAR THERMAL COLLECTION AND STORAGE

Unit I

Solar Energy Solar Radiation (18Hrs)
Structure of the sun - solar radiation outside the earth’s atmosphere - solar radiation at the earth's surface - instruments for measuring solar radiation and sunshine - solar radiation geometry - solar radiation on titled surfaces

Text Books:

Solar Energy - Principles of Thermal Collection and Storage, S.P. Sukhatme, 2\textsuperscript{nd} Edn. TMH, (Chapter 3)

Thermal Applications Of Solar Energy - An Overview
Devices for thermal collection and storage - thermal applications, water heating, space heating, space cooling and refrigeration, power generation, distillation, drying and cooking

Text Books:

Solar Energy - Principles of Thermal Collection and Storage, S.P. Sukhatme, 2\textsuperscript{nd} Edn. TMH, (Chapter 2)

Selective Surfaces For Solar Energy Conversion
Introduction - heat balance - physical characteristics - use of selective solar energy collectors - anti-reflection coatings - solar reflector materials - type of selective coatings - preparations of selective coatings

Text Books:

Unit II

Flat Plate Collectors (18Hrs)
Performance analysis of fluid flat plate collectors - transmissivity of cover system - transmissivity absorptivity product - overall loss coefficient and heat transfer correlation - collector efficiency factor - collector heat removal factor - effects of various parameters performance - testing procedures performance analysis of conventional air heater - other types of air heaters, testing procedures
Text Books:
Solar Energy - Principles of Thermal Collection and Storage, S.P. Sukhatme, 2nd Edn. TMH, (Chapter 4 & 5)

Unit III

Concentrating Collectors (18 Hrs)
Parameters characterizing solar concentrators - types of concentrating collectors – cylindrical, parabolic concentrators - performance analysis of cylindrical parabolic concentrators - parametric study of cylindrical concentrating collectors - compound parabolic collector (CPC), CPC geometry - performance analysis - central receiver collector (basic ideas)
Text Books:
Solar Energy - Principles of Thermal Collection and Storage, S.P. Sukhatme, 2nd Edn. TMH, (Chapter 6)

Unit IV

Solar Refrigeration and Air-Conditioning (18 Hrs)
Carnot refrigeration cycle - principle of absorption cooling - lithium bromide water absorption system - aqua - ammonia absorption system intermittent
absorption refrigeration system) - vapour compression refrigeration – desiccant cooling

Text Books:

1 Solar Energy, H.P. Garg & J. Prakash, TMGH 1997 (Chapter 12)

**Thermal Energy Storage**

Sensible heat storage - Latent heat storage - thermo - chemic\(_\text{v}\) storage - Solar pond - performance analysis of solar pond

Text Books:


**Reference Books:**

John A Duffie and W. A. Beckman, Solar Engineering of thermal process

2nd Edition John Wiley & Sons, INC.

N K Bansal, M. Klemmann and M. Meliss, Renewable Energy sources and Conversion technology, TMH


**PH4RE4 SOLAR PHOTOVOLTAICS**

**Unit I**

**SolarCellFundamentals(18Hrs)**

Extrinsic semiconductor, controlling carrier concentration – carrier concentration and distribution – density of energy states – carrier distribution


Text Book:

1. Solar Photovoltaic: Applications, Chetan Singh and 4)

Unit II (18 Hrs)


213

Text Book:

Unit III (18 Hrs)

Solar Cell Technologies:
Production of silicon (Si) – Silicon requirement – production of metallurgical grade Si - production of electronic grade Si - production of Si wafers – Si sheets – Si feedstock for solar cell industry – Solar grade production of Si wafers – Si usage in solar SPV - Si wafer based solar cell technology - development of commercial Si solar cells – process flow of commercial Si cell technology – processes used in solar cell technology – high efficiency Si solar cells.

Thin Film Solar Cell Technologies:

Concentrator PV Cells and Systems:
light concentration – concentration ratio – series resistance optimisation of concentrator cells - optics for concentrator SPV.

Text Book:

1. Solar Photovoltaic: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI, 2nd Edn. (Chapters 6, 7, 8 and 9)

Unit IV

Solar Photovoltaic Applications (18 Hrs)


Text Book:

Reference Books:


PH4RP4 RENEWABLE ENERGY PRACTICALS

Solar Cell characteristics
Efficiency of Solar Flat Plate Collectors
Improvement of Power Factor
Efficacy of Lamps
Study of Bio-gas plant (Lab Model)
Stefan - Boltzmann Constant
Fluidized Bed Heat Transfer
Microprocessor based Sun-tracking System (Lab Model)
Performance evaluation of a Single Basin Solar Still
Thermal testing of Box-type Solar Cooker
Determination of heat Loss Factor $F'U_L$ of linear Solar Absorbers using Indoor Test Facility
Determination of Time Constant of Solar Flat Plate Collector
Measurement of Solar Reflectance and Absorptance of surfaces
Study of Effect of Anti-reflection Coatings of Solar Cells
Performance Analysis of a Paraboloid Concentrator
Testing of a Solar Cabinet Drier
Determination of Optical Efficiency of a Seasonally Adjusted Linear Solar Concentrator
Four more experiments of equal standard can be added

4.4 M.Sc. PHYSICS - MATERIAL SCIENCE 4.4.1 Course Code
The first two letters PH stand for Physics, and the letters C, P, E, D and V have the usual meaning. The letter M stands for Material Science. Here the core courses, Electives and Practicals are numbered from 1 to 4. The third character of the Code running from 1 to 4 indicates the semester concerned. Course and Course code of M.Sc. Physics - Material Science are given in Table 4.3
<table>
<thead>
<tr>
<th>SEM</th>
<th>Name of the course with course code</th>
<th>No. of Hrs/week</th>
<th>No. of credit</th>
<th>Total Hrs/SEM</th>
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<tbody>
<tr>
<td>I</td>
<td>PH1MC1: Applied Mathematics for Physics - I</td>
<td>4</td>
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<td>72</td>
</tr>
<tr>
<td>I</td>
<td>PH1MC2: Quantum Mechanics - I</td>
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<td>4</td>
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<td>I</td>
<td>PH1MC3: Advanced Nuclear Physics</td>
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<td>I</td>
<td>PH1MC4: Condensed Matter Physics</td>
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<td>PH1MP1: General Physics Practice</td>
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<td>PH2MC1: Applied Mathematics for Physics - II</td>
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<td>PH2MC2: Electrodynamics and Nonlinear Optics</td>
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<td>PH2MC3: Advanced Electronics</td>
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<td>II</td>
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<td>PH2MP2: Electronics Practice</td>
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<td>III</td>
<td>PH3ME1: Solid State Physics</td>
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<td>III</td>
<td>PH3ME2: Crystal Growth Techniques</td>
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<td>III</td>
<td>PH3MP3: Computational and Advanced Electronic Practice</td>
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<td>IV</td>
<td>PH4MC1: Quantum Mechanics - II</td>
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<td>IV</td>
<td>PH4MC2: Statistical Physics and Astrophysics</td>
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<tr>
<td>IV</td>
<td>PH4ME3: Nanostructures and Characterisation</td>
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<td>IV</td>
<td>PH4ME4: Thin Film and Nanoscience</td>
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*Table 4.3 Course and Course code of M.Sc.Physics - Material Science*
SEMESTER – I

PH1MC1 APPLIED MATHEMATICS FOR PHYSICS- I

Unit 1

Complex Analysis (20 Hrs)

Unit II

Group theory (18 Hrs)
Introductory definitions and concepts- cyclic groups - point groups - reducible and irreducible representations - orthogonality theorem - group character table - applications in molecular and crystal physics - 3d rotational group - lie group and lie algebra - Poincare and Lorentz group - SU(2) and SU(3) - examples from particle physics.

Unit III

Integral transforms (18 Hrs)
Unit IV

Partial Differential Equations (16 hrs)

Partial differential equation – characteristics - boundary conditions - classes of partial differential equations- heat equation- Laplace’s equation - Poisson’s equation - non linear partial differential equation and boundary conditions - separation of variables in Cartesian, circular cylindrical and spherical polar coordinates - non homogeneous equation - Green’s function- symmetry of Green’s functions- forms of Green functions.

Reference Books:


Elements of Group Theory for Physicists, A.W. Joshi, New Age India Pub.. 1997.

Mathematical Physics, Satyaprakash, S. Chand & Sons


Mathematical Physics, B.S Rajput, Pragati Prakasan


Complex Variables, Schaum’s outline, M.R. Spiegel, TMH.
Advanced Mathematics for Eng. & Physics, L.A. Pipes & L.R. Harvill, MGH.
Introduction to Mathematical Methods in Physics, G. Fletcher, TMGH.

PH1MC2 QUANTUM MECHANICS – I

Unit I

Schrodinger Wave equation and Matrix Formulation of Quantum Mechanics (20Hrs)

Schrodinger Wave equation - The one dimensional Wave equation - Extension to three dimensions - Interpretation of the wave function- Energy Eigen functions - One dimensional square well potential. Eigen functions and Eigen values - Interpretive Postulates and Energy Eigen functions momentum Eigen functions.- Discrete Eigen values – Linear Harmonic oscillator – Spherically symmetric potentials in three dimensions – Three dimensional Square well potential – The Hydrogen atom
Matrix Formulation of Quantum Mechanics


Unit II

Symmetry in Quantum Mechanics (18 Hrs)


Angular momentum - Angular momentum operators - angular momentum matrices – spin angular momentum-Total angular momentum operators - Eigen values of Total angular momentum – Clebsch-Gordon coefficients - Recursion relations – Construction procedure calculation of C G coefficients j=1/2 and j=1 cases - Matrix elements for rotated states – Product of Tensor operators- Combination of operator and Eigen state - Wigner-Eckart Theorem.

Unit III

The Quantum theory of Scattering (18 Hrs)

The scattering matrix: The Green’s functions propagator - Freeparticle Green’s functions - Integral equation for $\Psi$ - Integral equation for the


Unit IV

Approximation Methods for Stationary Problems (16 Hrs)


Reference Books:

Modern Quantum Mechanics, J.J. Sakurai. Pearson Education
Quantum Mechanics, A. Messiah, North-Holland Publication Company.
Advanced Quantum Mechanics, Satya Prakash, Kedar Nath Ramnath.


Introduction to Quantum Mechanics, R.H. Dicke & J.P Wittke, Addison Wesley.

Quantum Mechanics, B.N. Srivastava, Pragati Prakashan.

PH1MC3 ADVANCED NUCLEAR PHYSICS Unit

I

Nuclear Structure and Models (18Hrs)


Unit II

Nuclear Interactions (18Hrs)

Nuclear forces - Two body problem - Ground state of deuteron - Magnetic moment - Quadruple moment - Tensor forces - Meson theory of nuclear forces - Yukawa potential - Nucleon-nucleon scattering, scattering cross
section - Low energy n-p scattering-phase shift - proton-proton scattering -
Effective range theory - Characteristics of nuclear force - Spin dependence,
charge independence and charge symmetry - Isospin formalism.

Unit III

Nuclear Reactions and Nuclear Decay (18Hrs)

Reaction dynamics, the Q value of Nuclear reaction, Scattering and reaction
cross sections Compound nucleus formation and breakup, nuclear fission and
heavy ion induced reactions, fusion reactions, types of nuclear reactors.
Theory of stripping reactions.
Beta decay - Fermi’s theory - Fermi-Kurie Plot - Fermi and Gamow - Teller
selection rules - Allowed and forbidden decays - Decay rates - Theory of
Neutrino - Helicity of neutrino - Helicity measurement - Theory of electron
capture - Non-conservation of parity - Gamma decay - Internal conversion -
Multipole transitions in nuclei - Nuclear isomerism - Angular correlation in
successive gamma emissions.

Unit IV

Particle Physics (18Hrs)

Types of interactions between elementary particles - Hadrons and leptons,
their masses, spin parity decay structure, the quark model, the confined
quarks, coloured quarks, Experimental evidences for quark model. The
quark-gluon interaction. Gell-mann-Nishijima formula, Symmetries and
conservation laws, C, P and CPT invariance and applications of symmetry
arguments to particle reactions, parity non conservation in weak interactions.
Exchange Bosons of the weak interaction, electroweak unification.
Reference Books:

The particle Hunters, Yuval Ne’eman & Yoram kirsh, Cambridge University Press.
Concepts of Nuclear Physics, B.L. Cohen, TMH, New Delhi (1971).
Atomic and Nuclear Physics, S.N. Ghoshal, Volume 2, S. Chand & Co.
Nuclear and Particle Physics, W.E. Burcham & M. Jobes, Addison-Wesley, Tokyo.
Subatomic Physics, Frauenfelder & Henley, Prentice-Hall.
PH1MC4 CONDENSED MATTER PHYSICS

Unit I
Lattice Vibrations (16 Hrs)
Vibrations of monatomic and diatomic lattices - acoustic and optical modes -
Quantization of lattice vibrations - Phonon Momentum - Inelastic scattering
of neutrons by phonons.
Lattice Heat Capacity - Einstein model, Density of modes in one and three
dimensions - Debye model of lattice heat capacity – Debye’s $T^3$ law -
Anharmonic crystal Interactions - Thermal Expansion - Thermal
conductivity.

Unit II
Free Electron Theory and Band Theory (18 Hrs)
Energy levels and density of orbitals in one dimension - Free electron gas in
three dimensions - Heat capacity of the electron gas - Electrical conductivity
and Ohm’s law - Motion in magnetic fields - Hall effect-Thermal
conductivity of metals - Wiedemann-Franz law - Nearly free electron model
- Wave equation of electron in a periodic potential - Number of orbitals in a
band - Construction of Fermi Surfaces -Calculation of Energy Bands -
Experimental methods in Fermi surface studies.

Unit III
Dielectric, Ferroelectric and Magnetic properties (20 Hrs)
Theory of Dielectrics: Polarisation, Dielectric constant, Local Electric field,
Dielectric polarisability, Clausius-Mossotti relation, Polarisation from dipole
orientation, Dielectric losses, Ferroelectric crystals, Order-disorder type

Diamagnetism and Paramagnetism: Langevin’s diamagnetism equation, Quantum theory of diamagnetism of mononuclear systems, Quantum theory of paramagnetism, Hund’s rule, Paramagnetic susceptibility of conduction electrons, Ferro, Anti and Ferri magnetism: Curie point and the exchange integral, Magnons, Ferrimagnetic order, Curie temperature and susceptibility of ferrimagnets, Antiferromagnetic order. Weiss theory of ferromagnetism, Ferromagnetic domains, Bloch walls, Origin of domains, Novel magnetic materials: GMR-CMR materials (qualitative)

**Unit IV Superconductivity**

(18 Hrs)

Meissner effect - Type I and Type II superconductors, Heat capacity, Microwave absorption, Energy gap, Isotope effect, Free energy of superconductor in magnetic field and the stabilization energy, London equation and penetration of magnetic field, Cooper pairs and the BCS ground state and BCS Hamiltonian - Flux quantization, Single particle tunnelling, DC and AC Josephson effects, High Tₐ superconductors - description of the cuprates - Applications of Superconductivity.

**Reference Books:**

- Introduction to Solid State Physics, C. Kittel, Wiley Eastern.
- Introduction to Theory of Solids, H.M. Rosenberg, Prentice Hall
- Solid State Physics, A.J.Dekker, Macmillan, 1967

229
Solid State Physics, Gupta Kumar, Pragati Prakasan
Solid State Physics, S.O. Pillai, New Age International 6th Edn. 2010

PH1MP1 GENERAL PHYSICS PRACTICALS

Magnetic susceptibility- Quincke’s method
Magnetic susceptibility- Guoys method
Young’s modulus and Poisson’s ratio – Cornu’s method, (Elliptical or Hyperbolic fringes)
Young’s modulus and Poisson’s ratio – Koenig’s method
Michelson interferometer – thickness of mica sheet
Verification of Hartman’s relation – Mercury and KMnO₄ spectrum
e/m of electron – Thomsons method
Study of thermistor – computation of response equation
Determination of e/k – silicon transistor
Hydrogen spectrum – Rydberg constant
Ultrasonics – velocity of sound in liquids
Oscillating disc – viscosity of liquid
Determination of e – Milliken’s method
Characteristics of a photodiode
B-H curve – Anchor ring
Mutual inductance – Carey Foster’s bridge
Self and mutual inductance – Anderson’s bridge
Arc spectrum of Iron, Copper and Brass
Absorption spectrum of Iodine
Raman effect in liquids – plate measurement
Identification of elements by spectroscopic method

SEMESTER – II

PH2MC1  APPLIED MATHEMATICS FOR PHYSICS - II

Unit I
Vector and Vector Spaces (16 hrs)
Unit II

Matrices, Error analysis and Probability (20 Hrs)


Unit III

Differential Equations and Special Functions (20 Hrs)


Unit IV Tensors

(16 hrs)

Reference Books:


Mathematical Physics, P.K. Chattopadhyya, New Age International.

Theory and Problems of Vector Analysis, M.R. Spiegel, Schaum’s Series


Mathematical Physics, B.D. Gupta, Vikas Pub. House, New Delhi

Mathematical Physics - B.S Rajput, Y Prakash 9th Ed, Pragati Prakashan


Tensor Calculus, Theory & Problems, A.N. Srivastava, University Press, 1992

Vector Analysis and Tensors, M.R. Spiegel, Schaum’s Series

Advanced Mathematics for Eng.& Scientists, Schaum’s outline, M.R. Spiegel,TMH.

Vector Analysis,M. R Spiegel, Schaum’s Series

Data Reduction & Errors Analysis for the Physical Sciences, P.Bevington, D.K.Robinson, MGH.

PH2MC2 ELECTRODYNAMICS AND NON LINEAR OPTICS

Unit I
Electrostatics and Magnetostatics (18Hrs)
Laplace’s Equation – in one, two, three dimensions and its solutions.
Boundary conditions and Uniqueness theorems - Conductors and the second
Uniqueness theorem. Multipole expansion - Approximate Potentials at large
distances - The Monopole and Dipole terms - Origin of coordinates in
Multipole expansions - The electric field of a dipole. Linear Dielectrics -
Susceptibility, Permittivity, Dielectric Constant - Boundary value problem
with linear dielectrics - Energy in dielectric systems - Forces on dielectrics.
Magnetostatics - The divergence and Curl of B - Straight line currents -
Applications of Ampere’s law - Comparison of magnetostatics and
electrostatics. Magnetic vector potential - The vector potential -
Magnetostatic boundary conditions- Multipole expansion of the vector
potential - The auxiliary field H- Ampere’s law in magnetized materials- A
deceptive parallel - Boundary conditions.

Unit II
Electrodynamics and Electromagnetic Waves (20Hrs)
Maxwell’s Equations - Electrodynamics before Maxwell - How Maxwell
fixed up Ampere’s law - Maxwell’s equations - Magnetic charge -
Maxwell’s equations in matter- Boundary conditions. Conservation Laws -
charge and energy - The continuity equation - Poynting’s theorem – Momentum - Newton’s third law in Electrodynamics - Maxwell’s Stress Tensor - Conservation of Momentum - Angular Momentum.

Electromagnetic Waves - Waves in one dimension - Electromagnetic waves in vacuum - Electromagnetic waves ion matter - Absorption and Dispersion - Guided waves.


Unit III
**Radiation and Relativistic Electrodynamics (16Hrs)**

Dipole radiation - Electric dipole radiation and Magnetic dipole radiation - Radiation from an Arbitrary source. Point Charges - Power radiated from a point charge - Radiation reaction - Abraham Lorentz formula.


Unit IV
**Non Linear Optics  (18Hrs)**

- parametric generation of light – frequency up conversion – phase conjugate optics – generation of sum and difference frequencies.

**Reference Books:**

- *Introduction to Electrodynamics*, David J Griffiths, PHI Learning, 2009
- *Lasers and Non Linear optics*, B.B Laud, Wiley eastern.

**PH2MC3 ADVANCED ELECTRONICS**

**Unit I**

**Multistage Amplifiers (18 Hrs)**


Unit II

Operational Amplifiers  (18 Hrs)

Unit III

Active filters, Oscillators and Integrated Circuits (18 hrs)

Active filters – First order and second order low pass Butterworth filter - First order and second order high pass Butterworth filter - wide and narrow band pass filter - wide and narrow band reject filter - All pass filter.


Unit IV

Field effect Transistors, Amplifiers And Digital Signal Processing (18 Hrs)

Junction field effect Transistor - working principles of JFET- difference between JFET bipolar transistor- JFET as an amplifier - output characteristics of JFET- advantages of JFET- parameters JFET.

Amplifiers - Biasing the JFET- gate bias - self bias - setting a Q-point - voltage divider bias- Sourcebias- biasing theenhancementtype MOSFET’s-biasing thedepletiontypeMOSFET’s-smallsignalFET models- small signal low-frequency and high frequencyFETmodels- common source amplifier—common drain .

Reference Books

Op amps and linear Integrated Circuits, R.A. Gayakwad, PHI
A text book of Applied Electronics, R.S. Sedha, S. Chand & Co.
Principles of Electronics, V.K.Mehta and Rohit Mehta S. Chand & Co.
Basic Electronics, B.L. Theraja, S. Chand & Co.
Integrated Electronics, J. Millman and C.C. Halkias, MGH
Signals and Systems Alan S. Willsky, Alan V. Oppenheim, S. Hamid 2nd Edn PHI
Digital Signal Processing, A. Nagaroor Kani, TMGH.
Introduction Digital Signal Processing, Johnny R Johnson, PHI
PH2MC4 CLASSICAL MECHANICS AND RELATIVITY Unit

I

The motion of Rigid Bodies and Theory of Small Oscillations (20 Hrs)
Independent co-ordinates of a rigid body - Orthogonal transformations - Inertia Tensor – Euler’s angles - Euler’s theorem on the motion of a rigid body - Force free motion of a symmetric top - Motion of a heavy symmetric top - Infinitesimal rotation - Precession of Charged bodies in magnetic field - Coriolis Force and its effects. Independent Coordinates – Orthogonal Transformations – Euler’s Angles. Force free motion of rigid body - Cases of symmetric top - Heavy Symmetric top, fast top - Sleeping top.

Theory of Small Oscillations - Formulation of the problem – Eigen value equation – Coupled oscillators – Normal coordinates. Oscillations of linear triatomic molecule

Unit II

Hamiltonian Mechanics (18 Hrs)
The Hamilton Jacobi equation - Hamilton's characteristic function – The Harmonic oscillator in Hamilton Jacobi method - Action angle variables – Kepler’s problem in action angle variables - Transition to Wave mechanics.
Unit III

Canonical Perturbation Theory and Lagrangian Formulation for Continuous Systems And Fields (16 Hrs)

Time dependent perturbation and illustrations - Time independent perturbation theory in first order with one degree of freedom. Time independent perturbation theory to higher order - Kepler problem and precession of the equinoxes of satellite orbits. Lagrangian formulation for continuous systems - sound vibrations in gas - Hamiltonian formulation for continuous systems - description of fields – Noether’s theorem.

Unit IV

The Special Theory of relativity (18 Hrs)

The postulates of Special Theory of relativity-Lorentz transformation – Velocity transformation - Length contraction-Time dilation - Mass in relativity - mass and energy -Relativistic Lagrangian and Hamiltonian of a particle-Lorentz co-variance - four vectors - Invariance of Maxwell’s equations under Lorentz transformations - Electromagnetic field tensor - Principle of Equivalence- Precession of the Perihelion of planetary orbits.

Reference Books:

Classical Mechanics, Goldstein, Poole & Safko, 3rd Edn. Pearson.
Classical mechanics, G. Aruldas, Prentice Hall
Classical mechanics, N. C. Rana & P.S. Joag - TMGH
Classical mechanics, J.C. Upadhyaya, Himalaya.
Classical mechanics, Satyaprakash, Sultan Chand & Company.
Classical mechanics, Gupta & Kumar, Pragati Prakasan.
Classical Mechanics, A.K. Raychauduri, Oxford Univ. Press
Introduction to Dynamics, I. Percival & D. Richards, Cambridge Univ. Press 1982
Lagrangian and Hamiltonian mechanics, M. G. Calkin - Allied Pub. Ltd.

PH2MP2 ELECTRONICS PRACTICALS

RC coupled CE amplifier – two stages with feed back – frequency response and voltage gain
Differential amplifier – using transistors – constant current source – frequency response
Active filters – low pass and high pass – first and second orders – frequency response and roll of rate
Band pass filter using single op-amp
Voltage controlled oscillator using transistors
Voltage regulation using op-amp with short circuit protection
UJT characteristics
Relaxation oscillator using UJT
RF amplifier - frequency response and band width
Op – amp monostable multivibrator, square wave generator
IC 555 monostable multivibrator and astable multivibrator
IC 555 pulse width modulation and linear RAMP generator
Voltage controlled oscillator using IC 555
Shift registers Binary sequence generator
Thermistor characteristics
Synchronous counters and divide by N counters
Op – amp mathematical operations
Op – amp Wein bridge oscillator
Amplitude modulation using transistors
Precision rectifiers – measurement of rectifier efficiency at different frequencies
Op- amp triangular wave generator with specified amplitude

SEMESTER – III

PH3MC1 COMPUTER APPLICATION IN PHYSICS
Unit I
Numerical Methods (20 Hrs)
Curve Fitting -The method of least squares - for fitting a straight line- Fitting a polynomial- Fitting a non-linear function – Fitting a geometric curve - Fitting an exponential curve - Fitting a Hyperbola - Fitting a trigonometric

Unit II

Numerical Differentiation and Integrations (16 Hrs)

Unit III

Object Oriented Programming in C++ (16 Hrs)
Review of C++ - Structures – Functions - Classes and objects – Constructors and Destructors

Unit IV

Operator overloading, Type Conversion and Graphics (20Hrs)
Operator overloading – overloading unary operators - overloading binary operators - Data conversion - Manipulation of strings using Operators - Rules for overloading operators. Inheritance- Derived class and Base class - Derived class Constructors – overriding member Functions - Class Hierarchies - Public and Private Inheritance - levels of Inheritance – Multiple Inheritance.
Reference Books:
Introductory Methods of Numerical Analysis, S.S. Sasthry, PHI.
Computer oriented Numerical Methods, R.S. Salaria, Khanna Pub.
Computer oriented Numerical Methods, V. Rajaraman, PHI.
Object Oriented Programming in C++, E. Balagurusamy, TMGH.
Computer Science C++ Sumita Arora, Gautam Sarkar, Dhanpat Rai & Co.

PH3MC2 ATOMIC AND MOLECULAR SPECTROSCOPY
Unit I
Molecular Vibrations, Infra Red Spectroscopy and Microwave Spectroscopy (18hrs)
Infra Red Spectroscopy – The diatomic Vibrating rotator - Asymmetry of rotation- Vibration band - The Vibration-rotation spectrum of carbon monoxide – The interaction of rotations and Vibrations – Linear molecules - Nuclear spin effect- symmetric top molecules- Interpretation of
vibrational spectra - Group Frequencies. Microwave Spectroscopy - Theory of Microwave Spectroscopy – The diatomic molecule as a Rigid Rotator - The diatomic molecule as a Non – rigid rotator - Rotational spectra of polyatomic molecules - linear molecule - Symmetric and asymmetric top molecules.

Unit II

Electronic Spectroscopy of Atoms, Photoelectron Spectroscopy and UV Spectroscopy (18hrs)

Electronic Spectroscopy - Electronic spectra of diatomic molecules, Intensity of spectral lines, Frank – condon principle, Dissociation energy and dissociation products, Rotational fine structure of electronic vibrational transition, The Fortrat Parabolae, Pre-dissociation.

Photoelectron Spectroscopy - Principle – Instrumentation and Information from Photoelectron spectra.


Unit III

Atomic Spectra (18hrs)

Quantum states of electrons in atoms - Electron spin - spectroscopic terms and selection rules. Spectrum of helium and alkali atoms - Relativistic corrections for energy levels of hydrogen atom - Hyperfine structure and isotopic shift - Width of spectral lines - spin orbit interaction - Derivation of spin orbit interaction energy, fine structure in sodium atom, Landau g-factor, Zeeman effect. Paschen – Bach effect and Stark effect in one electron system, LS and JJ coupling schemes (Vector diagram), Hund’s rule,
Derivation of interaction energy, examples of LS and JJ coupling, Lande interval rule, Hyperfine structure, Width of spectral lines.

Unit IV
X-Ray Spectroscopy, Fluorescence Phosphorescence and Raman Spectroscopy (18hrs)


Fluorescence, Phosphorescence, Excitation spectra, Experimental methods, and Applications. Raman spectroscopy- Characteristic properties of Raman lines- Differences between Raman Spectra and Infra red spectra-Mechanism of Raman Effect- intensity of Raman lines.

Reference Books

Vibrational Spectroscopy, D. N. Satyanarayana, New Age International.
Instrumental Methods of Chemical Analysis, G. Chatwal and S. Anand, Himalaya
Introduction to Infrared and Raman Spectroscopy, Norman D Colthup, Lawrence H Daly and Stephen E Wiberley- Academic press NY.
Instrumental Methods of Analysis, Willard, Merrit, Dean and Settle, CBS Pub.
Instrumental Methods of Chemical Analysis, G.W. Ewing, McGraw Hill
Introduction to Spectroscopy, Pavia, Lampman, Kriz. 3rd Edn.
Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
Elements of Spectroscopy, Gupta, Kumar and Sharama, Pragathi Prakasan.
Elementary Organic Spectroscopy, Y.R. Sharma, S. Chand & Co.
Spectroscopy of organic compounds, P.S. Kalsi, New Age International.
Laser spectroscopic techniques and applications, E.R. Menzel, Practical spectroscopic series vol. 18, Marcel Dekker.
PH3ME1 SOLID STATE PHYSICS Unit

I

Crystals and Symmetry Properties (20 Hrs)
Stereographic projection and point groups – principles – Constructions - Construction with the Wulff net - Macroscopic Symmetry elements- Orthorhombic system- Tetragonal system- Cubic system - Hexagonal system - Trigonal system - Monoclinic system- Triclinic system - Laue groups - Space groups.

Unit II

Optical Properties and Crystal Lasers (16 Hrs)
Unit III

Semiconductor crystals (18 Hrs)
Classification of materials as semiconductors - band Gap - band structure of Silicon and germanium - equations of motion - intrinsic carrier concentration impurity conductivity- Thermoelectric effects in semiconductors – semimetals - amorphous semiconductors - p-n junctions.

Unit IV

Imperfections and Dislocations (18 Hrs)

Reference Books:
Crystallography and crystal defects, A. Kelley, G.W. Groves & P. Kidd, Wiley
Crystallography applied to Solid State Physics, A.R. Verma, O.N. Srivastava, NAI
Lasers and Non-Linear Optics, B B Laud, New Age International.
Solid State Physics, S.L. Gupta and V.Kumar, Pragati Prakashan.
Introduction to Theory of Solids, H.M. Rosenberg, Prentice Hall.
Crystal Defects and Crystal Interfaces, W. Bollmann, Springer Verlag.
Crystalline Solids, Duncan Mc Kie, Christine Mc Kie, Wiley

PH3ME2 CRYSTAL GROWTH TECHNIQUES Unit

I

Crystal Growth phenomena (18 Hrs)
The historical development of crystal growth – significance of single crystals
Crystal growth techniques - the chemical physics of crystal growth. Theories
of nucleation - Gibb’s Thompson equation for vapour, melt and solution-
energy of formation of spherical nucleus- heterogeneous nucleation
kinetics of crystal growth, singular and rough faces, KSV theory, BCF theory
- periodic bond chain theory- The Muller- Krumbhaar model.
Unit II
Crystal Growth from Melt and Solution Growth (18Hrs)
Growth from the melt - the Bridgmann technique – crystal pulling - Czochralski method- experimental set up - controlling parameters advantages and disadvantages.- convection in melts – liquid solid interface shape - crystal growth by zone melting - Verneuil’s flame fusion technique. Low temperature solution growth - methods of crystallization - slow cooling, solvent evaporation, temperature gradient methods - crystal growth system - growth of KDP, ADP and KTP crystals - high temperature solution growth, gel growth.

Unit III
Vapour Growth and Epitaxial Growth (18 Hrs)
Physical vapour deposition - chemical vapour transport – definition, fundamentals, criteria for transport, Specifications, STP, LTVTP & OTP - advantages and limitations of the technique, hydrothermal growth, design aspect of autoclave – growth of quartz, sapphire and garnet. Advantages of epitaxial growth, epitaxial techniques - liquid phase epitaxy, vapour phase epitaxy, molecular beam epitaxy, chemical beam epitaxy and atomic layer epitaxy

Unit IV
Materials for Semiconductor Devices (18Hrs)
Semiconductor optoelectronic properties - band structure - absorption and recombination, semiconductor alloys - group III-V materials selection - binary compounds, ternary alloys, lattice mismatch - lattice mismatched
ternary alloy structures - compositional grading, heteroepitaxial ternary alloy structure - Quaternary alloys.

Semiconductor Devices - Laser diodes, light emitting diodes (LED), photocathodes, microwave Field-Effect Transistors (FET).

Reference Books:

Crystal Growth Processes and Methods, P.S. Raghavan and P. Ramasamy, KRU Publications.
Crystal Growth in Gel, Heinz K Henish, Dover Publication

PH3MP3 COMPUTATIONAL AND ADVANCED ELECTRONICS PRACTICALS
(Experiments from 1 to 15 are C++ programs)

Motion of a spherical body in a viscous medium
Projectile motion and motion of a satellite
SHM – damped and forced
Formation of standing waves
Young’s double slit – interference
Diffraction due to a grating

253
Polarisation and birefringence
Electric field due to a point charge and equipotential surface
Motion in electric and magnetic fields – cyclotron
Circuit analysis using Kirchoff’s laws – LCR circuit with AC & DC sources
Solution of Schrodinger equation for harmonic and anharmonic potential
Finding the roots of a non-linear equation by bisection method
Solving an ordinary differential equation
Numerical integration of a function
Integration by using Monte Carlo method
RF oscillator above 1 MHz – frequency measurement
Pulse width modulator
Microprocessor – multiplication of two 8 bit binary numbers
Microprocessor – Sorting of data in ascending and descending order
Microprocessor – measurement of analogue voltage
Microprocessor – stepper motor control
Fullwave controlled rectifier
Frequency modulation and demodulation
OPAMP – Inverting amplifier
OPAMP – Low distortion sine wave generator
OPAMP – Difference amplifier
JK flip flop – four bit binary counter
JK flip flop – shift register
Amplitude modulation
PH4MC1 QUANTUM MECHANICS -II

Unit I
Methods for Time-dependent Problems (18 Hrs)

Unit II
Relativistic Quantum Mechanics (20Hrs)
The Dirac’s relativistic equation - free particle equation - Dirac matrices for α and β - free particle solutions – charge and current densities – Electromagnetic potentials. Dirac’s equation for a central field - Spin angular momentum - spin orbit energy - Zitterbewegung - Separation of the equation
The Hydrogen atom - Classification of energy levels - Negative energy states- electron hole theory - Weyl equation for neutrino and non conservation of parity – the tau matrices - bilinear covariants.

**Unit III**

**Identical particles and Spin (16Hrs)**


Unit IV
The Quantization of Wave Fields (18Hrs)
Classical and Quantum field equations - Coordinates of the field - Time derivatives – Classical Lagrangian and Hamiltonian equations - Quantum equations for the field - Fields with more than one component - Complex field - Quantization of non-relativistic Schrodinger equation - Classical Lagrangian and Hamiltonian equations - Quantum equations - creation annihilation and number operators – Connection with the many particle Schrodinger equation - anti commutation relations - physical implication of anti commutation - representation of the anti commuting a_k operators .
Electromagnetic field in vacuum - Lagrangian equations - Hamiltonian equations - Quantum equations - Commutation relations for E and H - Plane wave representation - Quantized field energy - Quantized field momentum - Commutation relations at different times - Interaction between charged particles and Electromagnetic field - Lagrangian and Hamiltonian equations - Elimination of φ - Quantization of the fields - Perturbation theory of the interparticle interaction- Einstein-Bose case - Fermi-Dirac case - radiation theory - Transition probability for absorption and emission.

Reference Books:
Quantum Mechanics, L.I. Schiff, 3rd Edn. MGH
Quantum Mechanics, B.K. Agarwal , Hari Prakash, PHI
A text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan, TMGH.
Advanced Quantum Mechanics, J.J. Sakurai, Pearson Education
Advanced Quantum Mechanics, Stya Prakash, Kedar Nath Ramnath Company.
Quantum Field theory, Claude Itzykson, McGraw Hill
Quantum Field theory, Lewis H. Ryder, Cambridge University Press.
Introduction to Quantum Mechanics, R.H. Dicke & J.P. Wittke, Addison Wesley.
Quantum Mechanics, A Messiah, Dover Publication.
Quantum Mechanics, R.K. Srivastava, PHI.

PH4MC2 STATISTICAL PHYSICS AND ASTROPHYSICS

Unit I

Quantum Statistical Mechanics and Ideal Gas Systems (18 Hrs)
Unit II
The Canonical and Grand Canonical Ensemble (18 Hrs)
Equilibrium between a system and heat reservoir – a system in the canonical ensemble – thermo dynamical relations in a canonical ensemble – the classical systems – energy fluctuations in the canonical ensemble: correspondence with micro canonical ensemble – equilibrium between a system and a particle energy reservoir – a system in the grand canonical ensemble – physical significance of statistical quantities – density and energy fluctuations in the grand canonical ensemble: correspondence with other ensembles.

Unit III
Fluctuations and Phase Transitions (18 Hrs)

Unit IV Astrophysics
(18 Hrs)
Stellar spectrum - stellar types - electromagnetic radiation from stars - measuring temperature and distances - excitation and ionization -
application of Saha's Equation - Hertz Sprung Russell diagram - star formation - life of a star - Virial theorem - stellar energy and nuclear reactions - stellar structure - final stages of stellar evolution - white dwarfs - neutron stars - black hole - pulsars.

**Reference Books:**

- Fundamentals of Statistical Mechanics, B. B. Laud, New Age International.
- Elements of Statistical Mechanic, Kamal Singh, S P. Singh, S. Chand & Co.
- Statistical mechanics, Kerson Huang, John Wiley and Sons.
- Statistical mechanics, R..K. Pathria, Butterworth-Heinemann
- Statistical Mechanics, Tung Tsang, Rinton Press.
- Statistical Mechanics, Gupta, Kumar, Pragati Prakasan.
- Introduction to Astrophysics, Baidyanath Basu, PHI.
PH4ME3 NANOSTRUCTURES AND CHARACTERIZATION

Unit I

Low Dimensional Structures (18hrs)


Unit II

Carbon Nanostructures (18hrs)
Unit III

Thermal, Microscopic and Infrared Analysis (18 Hrs)

Thermal analysis – DTA, DSC and TGA – methodology of DTA, DSC and TGA and Instrumentation.


Unit IV

Mass Spectrometry, Resonance Spectroscopy (18 Hrs)


Reference Books:


Instrumental methods of Chemical Analysis, G. Chatwal & Sham Anand, Himalaya

Introduction to Infrared and Raman spectroscopy, Norman D Colthup, Lawrence H Daly and Stephen E Wiberley, Academic press, NY.


Principles of Instrumental analysis, Skoog and West – Hall – Sanders Int.

Instrumental methods of chemical analysis, G W Ewing, MGH

8. Scanning Tunnelling Microscopy, R. Wiesendanger & H.J. Guntherodt, Springer


PH4ME4 THIN FILM AND NANO SCIENCE

Unit I

Thin Film (18 Hrs)

Unit II
Deposition of Films (18 Hrs)
Production of Vacuum, Different types of vacuum pumps, Measurement of Vacuum Gauges, Working principle, Deposition of thin films, Various
deposition techniques, Thickness measurement – optical methods, thickness monitors - Thin film applications.

Unit III

Nano materials and Applications (18 hours)
Synthesis and purification of carbon nanotubes, Single-walled carbon nanotubes and multiwalled carbon nanotubes, Structure-property relationships, physical properties, applications.
Overview of different nano materials available, Potential uses of nano materials in electronics, robotics, computers, sensors in textiles, sports equipment, mobile electronic devices, vehicles and transportation. Medical applications of nano materials.

Unit IV

Synthesis of Nano materials (18hrs)
Top-down techniques: photolithography, other optical lithography (EUV, X-Ray, LIL), particle-beam lithographies (e-beam, focused ion beam, shadow mask evaporation), probe lithographies, Bottom-up techniques: self-assembly, self-assembled mono layers, directed assembly, layer-by-layer assembly. Combination of Top-Down and Bottom-up techniques: current state-of-the-art.
Pattern replication techniques: soft lithography, nano imprint lithography. Pattern transfer and enhancement techniques: dry etching, wet etching, pattern growth techniques (polymerization, directed assembly).
**Reference Books:**

- Thin film fundamentals, A. Goswami, New Age International
- Vacuum deposition of Thin films, L. Holland, Chapman Hall, London
- Optical Properties of Thin Films, O. S. Heaven, Dover Publications
- Nano: the essentials, T. Pradeep, TMH, 2007
- Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley


PH4MP4 MATERIAL SCIENCE PRACTICALS

Ultrasonic Interferometer – ultrasonic velocity in liquids
Ultrasonic Interferometer – Young’s modulus and elastic constant of solids
Determination of dielectric constant
Determination of forbidden energy gap
Determination of Stephan’s constant
Determination of Fermi energy of copper
Study of ionic conductivity in KCl / NaCl crystals
Thermo-emf of bulk samples of metals (aluminium or copper)
Study of physical properties of crystals (specific heat, thermal expansion, thermal conductivity, dielectric constant)
Study of variation of dielectric constant of a ferro electric material with temperature (barium titanate)
Study of variation of magnetic properties with composition of a ferrite specimen
Four probe method – energy gap
Energy gap of Ge or Si
Hall effect – Hall constant
Thin film coating by polimerisation
Measurement of thickness of a thin film
Study of dielectric properties of a thin film
Study of electrical properties of a thin film (sheet resistance)
Growth of single crystal from solution and the determination of
  its structural, electrical and optical properties (NaCl, KBr, KCl, NH₄Cl etc.)
Determination of lattice constant of a cubic crystal with accuracy and indexing the
  Bragg reflections in a powder X-ray photograph of a crystal
Observation of dislocation – etch pit method
Michelson Interferometer – Thickness of transparent film
X-ray diffraction – lattice constant
Optical absorption coefficient of thin films by filterphotometry
Temperature measurement with sensor interfaced to a PC or a microprocessor
ESR spectrometer – g factor
Beam profile of diode laser
Track width of a CD using laser beam
He – Ne laser- verification of Malus law, measurement of Brewster angle, refractive
  index of a material