Syllabus for Two Years M.Sc. (Applied Physics)

First Semester				Second Semester			
Code	**Subject**	**Contact Hours**	**Credit**	**Code**	**Subject**	**Contact Hours**	**Credit**
MPYC101	Classical Mechanics	40	4	MPYC201	Quantum Mechanics-II	40	4
MPYC102	Mathematical Methods in Physics-I	40	4	MPYC202	Statistical Mechanics	40	4
MPYC103	Quantum Mechanics-I	40	4	MPYC203	Basic Condensed Matter Physics	40	4
MPYC104	Physics of Semiconductor Devices	40	4	MPYC204	Mathematical Method in physics-II	40	4
MPYC105	Fundamentals of computer and Prog. in C	40	4	MPYC205	Electronics	40	4
Practical/Sessional				**Practical/Sessional**			
Code	**Subject**	**Contact Hours**	**Credit**	**Code**	**Subject**	**Contact Hours**	**Credit**
MPYF156	Programming in C Lab	30	2	MPYF256	Computational Physics Lab	30	2
MPYC151	Electromagnetics and Optics lab	30	2	MPYC251	General Physics Lab	30	2
		G. Total	**24**			G. Total	**24**
Third Semester				**Fourth Semester**			
Code	**Subject**	**Contact Hours**	**Credit**	**Code**	**Subject**	**Contact Hours**	**Credit**
MPYC301	Adv. Quantum Mechanics & Quantum Field Theory	40	4	MPYC401	Open elective-I	40	4
MPYC302	Nuclear and Particle Physics	40	4	MPYC402	Nano Science & Technology	40	4
MPYC303	Classical Electrodynamics	40	4	MPYC403	Atomic and Molecular Physics	40	4
MPYE304	Dissertation/ Project	40	8	MPYE405 MPYE406	CoreElective-II (Theory)	40	4
MPYE305 MPYE306	Core Elective-I (Theory) Condensed matter physics Particle Physics	40	4	MPYE404	Seminar	40	2
		G. Total	**24**			G. Total	**18**
Practical/Sessional				**Practical/Sessional**			
Code	**Subject**	**Contact Hours**	**Credit**	**Code**	**Subject**	**Contact Hours**	**Credit**
MPYE352 MPYE353	Core Elective Practical Condensed matter physics Lab Particle Physics Lab		2	MPYE452 MPYE453	Core elective Condensed matter physics Lab Particle Physics Lab		2
MPYC351	Basic Electronics lab		2	MPYC451	Modern Phys. Lab.		2
		G. Total	**28**			G. Total	**22**

Student can offer one of the core electives from below and any one of the core list of Open Elective

List of Core Electives I and II:

1. Advanced Condensed Matter Physics-I &II
2. Particle Physics-I &II

List of Open Elective:

1. Soft condensed matter Physics
2. Advanced characterization Techniques
3. Vacuum science and Technology
4. Material Science

DETAILS

FIRST SEMESTER

MPYC-101 (CLASSICAL MECHANICS) **Marks-100**

UNIT-I: Mechanics of a system of particles:

Inertial and non inertial frames of reference. Lagrangian Formulation, Velocity dependent potentials and Dissipation Function, conservation theorems and symmetry properties, Ho-mogeneity and Isotropy of space and Conservation of linear and Angular momentum, Homogeneity of time and conservation of energy.

Hamiltonian Formulation:

Calculus of variations and Euler Lagranges equation, Brachistochrone problem , Hamiltons principle, extension of Hamiltons principle to nonholonomic systems , Legendre transforma-tion and the Hamilton equations of motion, physical significance of Hamiltonian ,Derivation of Hamiltons equations of motion from a variational principle , Rouths procedure , Principle of least action.(12)

UNIT-II: Canonical transformations:

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

Hamilton -Jacobi Theory:

Hamilton - Jacobi equation for Hamiltons principal function , Harmonic oscillator and Kepler problem by Hamilton - Jacobi method , Action angle variables for completely separable system , Kepler problem in Action angle variables , Geometrical optics and wave mechanics.(15)

UNIT-III: Small oscillation:

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

Rigid body motion:

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

Rigid body dynamics:

Angular Momentum and kinetic energy of motion about a point.: The Inertia Tensor and momentum of Inertia , Eigenvalues of Inertia Tensor and the principal Axis transformation.
The Heavy symmetrical Top with one point Fixed .Elementary idea about non- linearity and chaos. (13)

BOOKS:

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

MPYC-102 (MATHEMATICAL METHOD IN PHYSICS-I)

Full Marks-100

Unit-I

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables.Analyticity and Cauchy-Riemann Conditions.Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable.Cauchy's Inequality.Cauchy’s Integral formula.Simply and multiply connected region.Laurent and Taylor's expansion.Residues and Residue Theorem.Application in solving Definite Integrals.**(10lectures)**

UNIT-II

Integrals Transforms:

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples.Fourier transform of trigonometric, Gaussian, finite wave train & other functions.Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations. **(10 Lectures)**

UNIT-III

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

Groups and Group representation: Definition of groups,Finitegroups,example from solid state physics,sub groups and classes,Group Representation, Characters,Infinite groups and Lie groups,Liealgebra,application, Irreducible representation of SU(2),SU(3)and O(3). Beta, gamma functions, Greens function and its application . Partial differential equations.(20)

BOOKS:

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

MPYC-103(QUANTUM MECHANICS-I)

Marks-100

Unit-I

General principle of Quantum mechanics:

Linear Vector Space Formulation: Linear vector Space(LVS) and its generality. Vectors:Scalar product, metric space, basis vectors,linear independence, linear superposition of general quan-tum states,completeness and orthogonal relation,Schmidtsorthonormalisation procedure, Dual space, Bra and Ket vectors, Hilbert space formalism for quantum mechanics.

Operator:

Linear,Adjoint,hermitian,,unitary,,inverse,,antilinearoperators,Noncommutativity and uncertainty relation, complete set of compatible operators, simultaneous Measurement, Projection operator,eigen value and Eigen vector of linear,hermitian,unitary operators, Matrix representation of vectors and operators, matrix elements,eigen value equation and expectation value, algebraic result on Eigen values, transformation of basis vectors, similarity transformation of vectors and operators,diagonalisation. Vectors of LVS and wave function in co-ordinate, momentum and energy representations .

Unit-II

Quantum Dynamics

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

Rotation and orbital angular momentum:

Rotation matrix, Angular momentum operators as the generation of rotation, components of angular momentum Lx; Ly; Lz and L2 and their commutator relations, Raising and lowering operators (L+ and L), Lx; Ly; Lz and L2 in spherical polar co-ordinates, Eigen value and eigen function of Lz; L2(operator method), Spherical harmonics, matrix representation of L+; L and L2, Spin angular momentum: Spin 1/2 particle,Pauli spin matrices and their prop-erties Eigen values and Eigen function, Spinor transformation under rotation.

UNIT-III

Addition of angular momentum:

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

Motion in Spherical symmetric Field:

Hydrogen atom, Reduction to one dimensional one body problem, radial equation, Energy eigen value and Eigen function, degeneracy, radial probability distribution.

Free particle problem:

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

Books:

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

MPYC-104(PHYSICS OF SEMICONDUCTOR DEVICES)

Mark-100

Unit-I: **Introduction to the quantum theory of solids:**

Formation of energy bands, The k-space diagram (two and three dimensional representation), conductors, semiconductors and insulators. Electrons and Holes in semiconductors: Silicon crystal structure, Donors and acceptors in the band model, electron effective mass, Density of states, Thermal equilibrium, Fermi-Dirac distribution function for electrons and holes, Fermi energy. Equilibrium distribution of electrons & holes: derivation of n and p from D(E) and f(E), Fermi level and carrier concentrations, The np product and the intrinsic carrier concentration. General theory of n and p, Carrier concentrations at extremely high and low temperatures: complete ionization, partial ionization and freeze-out. Energy-band diagram and Fermi-level, Variation of E_F with doping concentration and temperature. Motion and Recombination of Electrons and Holes: Carrier drift: Electron and hole mobilities, Mechanism of carrier scattering, Drift current and conductivity. Motion and Recombination of Electrons and Holes: Carrier di ffusion: diffusion current, Total current density, relation between the energy diagram and potential, electric field. Einstein relationship between diffusion coeffcient and mobility. Electron- hole recombination, Thermal generation.12

Unit-II: PN Junction:

Building blocks of the pn junction theory: Energy band diagram and depletion layer of a pn junction, Built-in potential; Depletion layer model: Field and potential in the depletion layer, depletion-layer width; Reverse-biased PN junction; Capacitance-voltage characteristics; Junction breakdown: peak electric field. Tunneling breakdown and avalanche breakdown; Carrier injection under forward bias-Quasi- equilibrium boundary condition; current continuity equation; Excess carriers in forward- biased pn junction; PN diode I-V characteristic, Charge storage. 13

Unit-III: The Bipolar Transistor:

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

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

MOS Capacitor:

The MOS structure, Energy band diagrams, Flat-band condition and at-band voltage, Sur-face accumulation, surface depletion, Threshold condition and threshold voltage, MOS C-V characteristics, Qinv in MOSFET. 10

MOS Transistor:

Introduction to the MOSFET, Complementary MOS (CMOS) technology, V-I Characteris-tics, Surface mobilities and high-mobility FETs, JFET, MOSFET Vt, Body effect and steep retrograde doping, pinch-o voltage, 5

BOOKS:

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

MPYC-105(FUNDAMENTALS OF COMPUTER AND PROGRAMMING IN 'C')

UNIT-I

Algorithm, flowchart, Structured Programming Approach, structure of C program (header files, C preprocessor, standard library functions, etc.),identifiers, basic data types and sizes, Constants, variables, arithmetic, relational and logical operators, increment and decrement operators, conditional operator, bitwise operators, assignment operators, expressions, type conversions, conditional expressions, precedence and order of evaluation. Input-output statements, statements and blocks, if and switch statements, loops:-while, do-while and for statements, break, continue, goto, programming examples. [12 Hours]

UNIT-II

Designing structured programs: - Functions, parameter passing, storage classes- extern, auto, register, static, scope rules, user defined functions, recursive functions. Arrays- concepts, declaration, definition, accessing elements, and functions, two-dimensional and multi-dimensional arrays, applications of arrays. pointers- concepts, initialization of pointer variables, pointers and function arguments, address arithmetic, Character pointers and functions, pointers to pointers, pointers and multidimensional arrays, dynamic memory management functions, command line arguments[12 Hours]

UNIT – III

Derived types- structures- declaration, definition and initialization of structures, accessing structures, nested structures, arrays of structures, structures and functions, pointers to structures, self referential structures, unions, typedef, bit fields, C program examples. Input and output – concept of a file, text files and binary files, streams, standard I/O, Formatted I/O, file I/O operations, error handling, C program examples. Text Books: 1. Balagurusamy : "C Programming" Tata McGraw-Hill 2. P. Dey& M. Ghosh, "Computer Fundamental & Programming in C"- Oxford University Press 3. Deitel -"C How to programme" PHI publication/ Pearson Publica

Practical/Sessionals

MPYF-156(Programming in C Lab)

(Minimum 10 programs to be done covering 8 Experiments)

Experiment No. 1

a) Write a C program to find the sum of individual digits of a positive integer.

b) A Fibonacci sequence is defined as follows: the first and second terms in the sequence are 0 and 1. Subsequent terms are found by adding the preceding two terms in the sequence. Write a C program to generate the first n terms of the sequence.

c) Write a C program to generate all the prime numbers between 1 and n, where n is a value supplied by the user.

Experiment No. 2

a) Write a C program to calculate the following Sum: Sum=1-x2 /2! +x4 /4!-x6 /6!+x8 /8!-x10/10!

b) Write a C program to find the roots of a quadratic equation.

Experiment No. 3

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

Experiment No. 4

a) Write a C program to find both the larges and smallest number in a list of integers.

b) Write a C program that uses functions to perform the following: i) Addition of Two Matrices ii) Multiplication of Two Matrices

Experiment No. 5

a) Write a C program that uses functions to perform the following operations: i) To insert a sub-string in to given main string from a given position. ii) To delete n Characters from a given position in a given string.

b) Write a C program to determine if the given string is a palindrome or not

Experiment No. 6

a) Write a C program to construct a pyramid of numbers.

b) Write a C program to count the lines, words and characters in a given text.

Experiment No.7

a) Write a C program that uses functions to perform the following operations:

i) Reading a complex number

ii) Writing a complex number

iii) Addition of two complex numbers

iv) Multiplication of two complex numbers (Note: represent complex number using a structure.) 21

Experiment No. 8

a) Write a C program which copies one file to another.

b) Write a C program to reverse the first n characters in a file. (Note: The file name and n are specified on the command line.)

Book:- PVN. Varalakshmi,
Project Using C Scitech Publisher

MPYC-151(Electromagnetism and Optics lab)

1. Michelson's interferometer: determination of wavelength of sodium lines.
2. Magnetic field measurement by search coil
3. Study of polarization using Malus law
4. Specific rotation by sugar solution using polarimeter
5. Brewster'slaw.
6. To study the Hall Effect in semiconductors and determine
    a. Hall coefficient and Hall voltage.
    b. No. of charge carriers / unit volume
    c. Hall mobility and Hall angle.
7. Todetermine the wavelength of (1) sodium and (2) Spectral lines of mercury light using plane diffraction Grating.
8. Determination of magneto resistance of bismuth.
9. Calibration of magnetic field using Hall apparatus.
10. Study of Fabry-perot interferometer.
11. Study of Babinet compensator.
12. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating
13. To study the interference using laser and a double slit and find the wavelength of He-Ne laser source

SECOND SEMESTER

MPYC-201(Quantum Mechanics-II)

Marks-100

Unit-I

Approximation Method for stationary states:

Rayleigh-Schrodinger Method for Time-independent Non degenerate Perturbation theory, First and second order correction, perturbed harmonic oscillator,Anharmonic oscillator, The stark e ect, Quadratic Stark Effect and polarizability of hydrogen atom, Degenerate perturbation theory, Removal of Degerancy,parity selection rule, linear stark effect of hydrogen atom, Spin orbit Coupling, Relativistic correction, ne structure of Hydrogen like atom, normal and anomalous Zeeman effect, The strong- field Zeeman effect, The weak-field Zeeman effect and Landes g-factor.Elementary ideas about field quantizition and particle processes.(10)

Unit-II

Variational Methods:

General formalism, Validity of WKB approximation method, Connection Formulas, Bohrquantisation rule, Application to Harmonic oscillator ,Bound states for potential well with one rigid wall and two rigid walls,Tunneling through potential Barrier, Cold emission, Alpha decay and Geiger-Nutal relation.

Time dependent perturbation Theory:

Transition probability, constant and harmonic perturbation, Fermi golden rule, and electric dipole Radiation and Selection Rule, Spontaneous emission Einsteins A,B- coefficient, Basic principle of laser and Maser.(15)

Unit-III

Scattering Theory:

Scattering amplitude and Cross section.Bornapproximation,Application to Columb and Screened coulmbpotential,Partial wave analysis for elastic and inelastic Scattering.Effective range and Scattering length,Opticaltheorem,Black Disc Scattering,Hard-sphere Scattering,Resonance Scattering from square well potential.(15)

Books:

1. Quantum Mechanics S. Gasiorowicz
2. Quantum Mechanics J. Sukurai
3. Quantum Mechanics R. Shankar
4. Quantum Mechanics S.N. Biswas
5. Quantum Mechanics A. Das

6. Quantum Mechanics A. Ghatak and S. Lokanathan 7. Advanced Quantum Mechanics P.Roman 8. Quantum Mechanics (Non Relativistic theory) L.D. Landau and E.M.Lifshitz

9. Elementary Theory of Angular Momentum M.E. Rose 10.Principles of Quantum Mechanics P.A.M. Dirac
11. Quantum Mechanics, Concept and Applications, N Zettili

MPYC-202 (STATISTICAL MECHANICS)

Marks-100

UNIT-I

Classical Statistical Mechanics:

Classical probabilities: Binomial distribution of probability, variance,
mean value; Poisson's distribution, fluctuation, variance, mean value; Gaussian distribution, variance, mean value and applications. Basic principles and application of classical statistical mechanics,Liouville'stheorem,micro canonical ensemble, Review ofthermodynamics , equipartition theorem , classical ideal gas , Gibb'sparadox,Canonical ensemble and energy fluctuation , grand canonical
Ensemble and density fluctuation , Equivalence of Canonical andgrand canonical ensemble.(14 classes)

UNIT-II

Quantum Statistical Mechanics:

The density matrix, ensembles in quantum mechanics, Ideal gas inmicro canonical and grand canonical ensemble ; equation of state forideal Fermi gas, Theory of white dwarf stars. Ideal Bose gas, photonsand planck's law, statistics of photon and phonon gas, Bose-Einsteincondensation.Distribution function for Fermi-Dirac system, Equation of

states for idealFermi gas, The theory of White Dwarf star; Landau Diamagnetism; Thequantised Hall effect, Pauli Paramgnetism, The De Haas-Van AlphenEffect.
Ising model: Definition of Ising model, One dimensional Ising model,
application to Ferromagnetism.(**20 classes**)

UNIT-III
Phase Transition: Thermodynamics description of Phase Transitions,
Phase Transitions of second kind,Landau theory of phase transitionbeyond mean field, Gaussian fluctuation and Ginzbergcriteria,Discontinuity of specific heat , change in symmetry in Phase atransition of second kind. (10 classes)

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

MPYC-203(BASIC CONDENSED MATTER PHYSICS)

MARKS-100

Unit-I
Crystallography:-
Crystal lattice, crystal structure, symmetry elements in crystal, proper rotation axis,plane of symmetry, inversion center, screw axis, glide plane, types of bravais lattices, crystal structure: simple cubic, body centre cubic face centred cubic, HCP structure, Diamond structure,Zinc blende structure, Fluorite structure ,perovskite structure,,Weigner –Seitz cell, Miller indices, Liquid crystals, quasi crystals, carbon clusters, carbon nano tubes.

Phonons and lattice vibrations Vibrations of monoatomic and diatomic lattices,dispersion,optics& acoustic modes,quantum of lattice vibrations and phonon momentum,Inelastic scat-
tering of neutron and photons by phonons. Thermal properties of insulators Lattice heat capacity,debye& Einstein model,Anharmonic Crystal interactions,Thermal conductivity & thermal expansion.(12)

Unit-II:
Free electron Fermi gas:
Density of state in one dimention,effect of temperature on Fermi-Dirac distribution,Free electron gas in three dimentions,heat capacity of electron gas,electrical and thermal conductivity of metals.
Band theory:
Electrons in periodic potential,Blochstheorem,Kronig Penney model,origin of band gap,

Unit-III:
Superconductivity:
Experimental survey,Meisnerseffect,Type-I & Type-II superconductors,Thermodynamics of superconductors,Londonstheory,Josephsonseffect,Basic concepts of cooper pairing in BCS theory,Ginz-Landau Theory,flux quantization,applications of superconductors.

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

MPYC-204(MATHEMATICAL METHOD IN PHYSICS -II)

Marks-100

Unit-I: Tensor analysis and differential geometry:

Cartesian tensor in three space,Curves in three space and Frenet Formula, General Tensor analysis,Covarient derivative and Christofoel symbol.(10)

Unit-II: Special functions:

Solution of Bessel, Laguerre, hypergeometric and con uent Hyper geometric Equation by generating function method and their properties.(15)

Unit-III:

Functions of complex variable, Ordinary differential equations , differential operations and Sturm Liouville theory, Partial differential equations, Greens function, Solution of inhomogeneous partial differential equation by Green function method.(15)

BOOKS:

1.Mathematical methods of physics J. Mathews & R.L. Walker. 2. Mathematical methods of physics Arfken and Weber.

3.Mathematical methods for physicists Dennery&Krzywicki.

4.Mathematical methods of physics H. K. Das

5.Mathematical methods of physics Dr. Rama verma (S. Chand) 6.Mathematical methods of physics Satyaprakash (S. Chand)

7.Mathematical methods of physics Binoy Bhattacharya. (NCBA Publication) 8.Introduction to Tensor calculus - Goreux S. J.

9.Mathematical methods of physics Dettman J.W.

MPYC-205 (ELECTRONICS) Marks-100

Unit-I

Amplifiers:

Frequency response of linear amplifiers, amplifier pass band, R.C.L.C. and transformer coupled amplifiers, Frequency response, gain band-width product, Feedback amplifiers, e ffects of negative feedback, Boot-strapping the FET, Multistage feedback, stability in amplifiers, noise in amplifiers.

Operational amplifiers:

The differential amplifiers, integral amplifier, rejection of common mode signals. The op-erational amplifier input and output impedances, application of operational amplifiers, unit gala buer, summing, integrating and differentiating amplifiers, comparators and logarithmic amplifiers.(12)

Unit-II

Oscillator Circuits:

Feedback criteria for oscillation, phase shift, Wien bridge oscillator, crystal controlled oscil-lator, klystron oscillator, Principle of multivibrator.(10)

Unit-III

Digital Circuits:

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

Radio Communication:

Ionospheric

propation, Antennas of different types, super heterodyne, receiver (Block dia-gram). Various types of optical fibers and optical communications.(15)

Books :

1.Electronic Fundamental and application J.D. Ryder

2.Int. Digital Electronics Heap and Martin 3.Integrated Electronics Millman and Halkias

3..Foundation of Electronics Chattopadhyay, Rakshit, Saha and Purkalt

MPYF-256 (COMPUTATIONAL PHYSICS LAB)

Marks-100.

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

Programing with fortran:

Programme solving on computers-algorithem and flow charts in FORTAN 77 data types, Exercises for acquaintance:

1. find the largest or smallest of a given set of numbers
2. To generate and print rst hundred prime numbers
3.Sum of an AP series,GPseries,Sine series ,Cosine series
4. Factorial of a number
5. Transpose of a square matrix
6.Matrix multiplication and addition 7.Evaluation of log and exponentials 8.Solution of quadratic equation
9.Division of two complex numbers
10.To find the sum of the digits of a number

NUMERICAL METHODS

1. Interpolation by Lagrange methods
2.Numerical solution of simple algebraic equation by Newton-Raphson Methods
3.Least square fit using rational functions
4.Numerical integration: Trapizoidalmethods,Simsonsmethod,Rombergmethod,Gaussquadra-ture method.
5. Eigen values and eigen vectors of a matrix
6. Solution of linear homogenius equations
7. Trace of a matrix
8. Matrix invertion
9. Solution of ordinary differential equation by Runge-Kutta Method
10.Introduction to Monte carlo techniques

MPYC-251General Physics Lab

Marks-100

1. To calculate the velocity of ultrasonic sound through different liquid media using ultrasonic interferometer.
2. To calculate the adiabatic compressibility of the given liquid using ultrasonic interferometer
3.Stefan's constant measurement.
4. Young's modulus of glass by Coronus method.
5. Determination of magnetic susceptibility of a paramagnetic solution using Quinck's tube method.
6. Determination of magnetic susceptibility of a paramagnetic solution using Gouys method.
7.Measurement of dielectric constant by plate capacitor.
8. To determine the Planck's constant using LEDs of at least 4 different colors.
9. Measurement of Planck's constant using black body radiation and photo-detector
10. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
11.To determine work function of material of filament of directly heated vacuumdiode.

THIRD SEMESTER

MPYC-301 (ADVANCED QUANTUM MECHANICS &QUANTUM FIELD THEORY)

Marks-100

Unit-I

Relativistic Quantum Mechanics:

Klein-Gordon equation and its drawbacks,need for Dirac equation, Properties of Dirac matrices, Non-relativistic reduction of Dirac equation, magnetic moment, Darwins term, Spin-Orbit coupling, Poincare transformation, Lorentz group, Covariant form of Dirac equation, Bilinear covariants, Gordon decomposition.(12)

Unit-II

Free particle solution of Dirac equation, Projection operators for energy and spin, Physi-cal interpretation of free particle solution, Zitterbewegung, Hole theory, Charge conjugation, space reflection and time reversal symmetries of Dirac equation. Continuous systems and fields. Transition from discrete to continuous systems, Lagrangian and Hamiltonian Formulations, Noether's theorem.(13)

Unit-III

Quantization of free fields:

Second quantization, Equal Time Commutators, Normal Ordering, covariant quantization of electromagnetic field, Quantization of scalar, e.m, and Dirac fields, Propagators for scalar, spinor and vector fields(15)

Books:

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

Reference books:

1. Quantum Field Theory - C. Itzykson and J. Zuber Quantum Field Theory - M. E. Peskin and D. V. Schroeder
2. Quantum Field Theory - L. H .Ryder
3. Quantum Field Theory - S. Weinberg

MPYC-302(Nuclear and Particle Physics)

Marks-100

Unit-I

General nuclear properties: Radius, mass, binding energy, nucleon separation energy, angular momentum, parity, electromagnetic moments, excited states.

Two Nucleon Problem:

Central and noncentral forces, deuteron and its magnetic moment and quadrupole moment; Force dependent on isospin, exchange force, charge independence and charge symmetry of nuclear force, mirror nuclei. Nuclear models:

Liquid drop model, fission, magic numbers, shell model, analysis of shell model predic-tions,beta stability line,collective rotations & vibrations, Nuclear Structure: Form factor and charge distribution of the nucleus, Hofstadter form factor.(15)

Unit-II

Nuclear reaction:

Energetics of nuclear reaction, conservation laws, classification of nuclear reaction ,radio active decay,radio active decay law ,production and decay of radioactivity, radioactive dating ,alpha decay:Gamow theory and branching ratios, beta decay: energetic angular momentum and parity selection rules, compound nucleus theory, resonance scattering, Breit- Wigner formula, Fermi's theory of beta decay, Selection rules for allowed transition, parity violation.(10)

Unit-III

Particle Physics:

The Standard model of particle physics, particle classification, fermions and bosons, lepton avors, quark

Flavors, electromagnetic, weak and strong processes, Spin and parity determi-nation, Isospin,strangeness, hypercharge, and baryon number, lepton number, Gell-Mann-Nishijima Scheme, Quarks in hadrons: Meson and baryon octet, Elementary ideas of SU(3) symmetry, charmonium, charmed mesons and B mesons, Quark spin and colour(15)

BOOKS:

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

MPYC-303 (CLASSICAL ELECTRODYNAMICS)

Marks-100

Unit-I

Electrostatics and magnetostatics,Boundary value problems and conservation laws.
Maxwell's Equations:

Maxwells equations in free space; Magnetic charge; Maxwells equations inside matter; Dis-placement current; Vector and scalars potentials; Wave equation for potentials; Lorentz and Coulomb gauge conditions; Wave equation for Electric and Magenticfields in absence of sources.

Covariant Formulation of Maxwells Equation:

Lorentz transformation; Scalars, vectors and Tensors; Maxwells equations and equations of continuity in terms of A and J ; Electromagnetic field tensor and its dual; Covariant form of Maxwells equations; Lagrangian for a charged particle in presence of external electromagnetic eld and Maxwells equation as Euler-Lagrange equations.(15)

Unit-II

Plane Waves in Non-Conducting Media:

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

Plane waves in conduction media; Reflection and transmission at a conducting surface; Cylindrical cavities and wave guides; Modes in rectangular wave guide and resonant cavities.(15)
Diffraction:
Kirchoff 's formulation of diffraction by a circular aperature.(12)

Unit-III

Green's Function Solution for Retarded Potential

Green's function solution of potential form of Maxwell's equations, Retarded and advanced Green's Functions.
Multipole Radiation:

Potential,Fields and radiation due to an oscillating electric dipole; radiation due to a centre -fed linear antenna; angular distribution of power radiated; Rayleigh Scattering. Magnetic dipole and Electric Quadrupole radiation.

Radiation by Point Charge:
Lienard-Weichert potential, Field due to a point charge, Angular distribution of radiation and total power radiated by an accelerated charge, Larmor's formula, Thomson's scattering.(13)

Books:

1. Classical Electrodynamics - J. D. Jackson
2. Classical Theory of Fields - L.LandauLifsitz
3. Introduction to Electrodynamics - D.J.Griths.
4. Principles of Optics-M.Born and E. Wolf

MPYC-304(DISSERTATION/PROJECT) Marks-100

Project evaluation guidelines:

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

Each project will be of 100 marks by internal evaluation.

The project report should be le bound/spiral bound/hard bound and should have fol-lowing format

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

Chapters of Content:

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

Evaluation by Internal examiner will be based on following criteria:

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

Core Electives –A

MPYE-305 Condensed matter Physics-I Mark-100

UNIT –I

Lattice vibration:

Born openheimer Approximation, Hamiltonian for lattice vibration in the harmonic Approximation, Normal modes of system and quantization of lattice vibrations-phonons.

Electron phonon interaction, Second quantized form of Hamiltonian for electrons and phonons in interaction.

Energy Bands:

Wave equation for an electron in a periodic potential, Bloch functions, Brillouin zones E-K diagram under free electron approximation, Nearly free electron approximation-Diffraction of electrons by lattice planes and opening of gap in E-K diagram. Effective mass of electrons in crystals, Holes, Tight binding approximation,

Unit-II

Fermi surface

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

Electron Interaction:

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

UNIT-III

Transport properties:

The Boltzmann equation, Electrical conductivity,General transport coefficients,Thermalconductivity,thermoelectric effect, Hall effect, Elementary ideas about Quantum hall effect, magnetoresistance, Elementary ideas about giant magnetoresistance and colossal magnetoresistance,

Books:

1. D. Pines: Elementary Excitations in Solids S. Raimes: Many Electron Theory
2. O. Madelung: Introduction to Solid State Theory
3. N.H. March and M. Parrinello: Collective E ects in Solids and Liquids
4. H. Ibach and H. Luth: Solid State Physics: An Introduction to Theory and Experiments J.M. Ziman: Principles of the Theory of Solids
5. C. Kittel: Quantum Theory of Solids

Core Electives –B
MPYE-306 Particle Physics -I

Mark-100

Unit-I

Lorentz Group:

Continuous and discrete transformations, Group structure, Proper and improper Lorentz Transformations, SL(2,C) representations, Poincare group.

Interacting fields:

Interaction picture, Covariant perturbation theory, S-matrix, Wicks theorem, Feynman dia-grams.(12)

Unit-II

QED:

Feynman rules, Example of actual calculations: Rutherford, Bhabha, Moeller, Compton, $e^+ e^- \rightarrow \mu+ \mu-$. Decay and scattering kinematics. Mandelstam variables and use of crossing symmetry.

Higher order corrections:

One-loop diagrams. Basic idea of regularization and renormalization.Degree of divergence.Calculation of self-energy of scalar in Φ^4-theory using cut-of or dimensional regularization. Elementary discussions on running couplings and renormalization group.(13)

Unit-III

Gauge theories:

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

Electroweak Theory:

Gauge boson and fermion masses, Neutral current, Experimental tests. Calculation of FB asymmetry in $e^+e^- \rightarrow \mu+ \mu-$ and decay widths of W and Z (only at tree-level). Higgs physics.(13)

BOOKS:

1. M. Peskin and F. Schroeder: Quantum Field Theory
2. J.D. Bjorken and S.D. Drell: Relativistic Quantum Fields
3. D. Bailin and A. Love: Introduction to Gauge Field Theory
4. A. Lahiri and P.B. Pal: A First Book of Quantum Field Theory
5. F. Mandl and G. Shaw: Quantum Field Theory
6. P. Ramond: Field Theory: A Modern Primer
7. C. Itzykson and J.B. Zuber: Quantum Field Theory

MPYC-351(BASIC ELECTRONICS LAB.) Marks-100

1. Frequency response of transistor amplifier with the without feedback .
2. Characteristics of Hartleyoscillator.
3. Determination of different parameters of transistor.
4. Study of multivibratorAstable..
5. Study of multivibratorBistable.
6. Study of multivibratorMonostable.
7. To measure the divergence of a laser beam.
8. To find the band gap in a semiconductor using pn junction diode.
9. 10.To show the tunneling effect in tunnel diode using I-V characteristics.
10. To design a Wien bridge oscillator for given frequency using an op-amp.
11. To design a phase shift oscillator of given specifications using BJT.
12. 14.To add two dc voltages using Op-amp in inverting and non-inverting mode
13. 15. To design a precision Differential amplifier of given I/O specification using Op- amp.
14. To investigate the use of an op-amp as an Integrator.
15. To investigate the use of an op-amp as a Differentiator.

CORE ELECTIVE-PRACTICAL
MPYE-352 Core Elective-A
Condensed Matter Physics-I Lab

Marks-100

1. Study of energy gap of Germanium by four probe method.
2. Study of Laue's spot of mica sheet using X-ray diffraction technique.
3. Determination of magneto resistance of bismuth.
4. To study the PE Hysteresis loop of a Ferroelectric Crystal.
5. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
6. To measure the Magnetic susceptibility of Solids.
7. To determine the Coupling Coefficient Piezoelectric crystal.
8. e/m measurement by Thomson Method .
9. Verification of Richardson's T 3/2 law.
10. Calibration of Oscilloscope.
11. Determination of Plank's constant by reverse photoelectric effect method.

MPYE-353 Core Elective-B
Particle Physics-I

Mark-100

1. Study of surface barrier detector.
2. Determination of value for DPPH using ESR.
3. Study of counter technique.
4. Study of single channel analyzer.
5. Study of photo detector and photo multiplier.
6. Study of wide-band amplifier.
7. Emulsion photograph studies.

FOURTH SEMESTER

MPYC-401 (Open Electives) Marks-100

MPYC-401 Advanced Characterization Techniques (Open elective-A)

Mark-100

Unit-I

X-ray diffraction and reciprocal lattices

Choice of x ray ,electron and Neutron for crystal structure determination, Bragg diffraction,Reciprocallattices,Thebragg‘s condition and ewald construction, Brillouinzones,Brillouin zones of SC,BCC,FCC lattices, Atomic scattering factor,Geometrical Structure factor,Lauemethod,Rotating crystal method, powder method,Electron diffraction, Geometrical nature of electron diffraction patterns,Indexing of electron diffraction spot pattern,electron microscope ,transmission electron microscopy,scanning electron microscopy,DebyeScherrer Technique,-Analysis of the powder photograph,The determination of lattice type and space group,crystal structure determination.(20)

Unit-II

Microscope techniques:

Electron Microscope:SEM,TEM,FESEM,HRTEM

Scanning probe microscopy:Atomic Force microscopy,Scanning tunneling microscopy.(10)

Unit-III

Spectroscopic Techniques:

UV-visible spectroscopy,Ramanspectroscopy,electronspectroscopy,Neutronscattering,X-ray scattering,x-ray photoelectron spectroscopy (10)

MPYC-401 Material Science (Open Elective-B)

Mark-100

Unit-I

Mechanical,Thermal and elecetrical properties of materials, Mechanical properties:TensileStrength,stress-strain behavior,Ductile and brittle material,Toughnes,hardness,fatigue,creep and fracture.

Thermal properties:Thermalconductivity,thermoelectric effects, Electrica properties: electricalconductivity, energy band structure of conductors, semiconductors and insulators, type-I and Type-II superconductors and their application,dielectric,ferroelectric and piezoelectric materiala and their application.(13)

Unit-II

Laser Physics:

Basic elements of a laser; Threshold condition; Four-level laser system, CW operation of laser; Critical pumping rate; Population inversion and photon number in the cavity around threshold; Output coupling of laser power. Optical resonators; Cavity modes; Mode selection; Pulsed operation of laser: Q-switching and Mode locking; Experimental technique of Q-switching and mode locking Different laser systems: Ruby, CO_2 , Dye and Semiconductor diode laser;

Optical materials:optical properties-scattering,refraction,reflection,transmission and absorption,opticalfibres-principle and application.(12)

Unit-III

Soft condensed matter:

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

Conducting polymers:

Composite Materials: Microcomposites&Macrocomposites, fibre reinforced composites, Continuousfibre composites, Short fibre composites, Polymer matrix composites, Metal-matrix composites:

Ceramic-matrix composites, Carbon-carbon Composites, Hybrid composites.

Ceramics: Types, structure, properties and application of ceramic materials
Other materials: Brief description of other materials such as Corrosion resistant materials, Nanophase materials, Shape memory alloy, SMART materials(15)

MPYC-401Vacuum Science and Cryogenics (Open elective-C)

Mark-100

Unit-I
Behavior of gases; Gas Transport phenomenon,Viscous ,molecular and transition flow regimes, measurement of pressure, Residual gas analyses.(10)
Unit-II
Production of vacuum-mechanical pumps,Diffusionpump,Getter and ion pumps,cryopumps,material in vacuum;high Vacuum and ultra high vacuum systems;Leak detection.(10)
Unit-III
Properties of engineering material at low temperature;cryogenic fluids-Hydrogen,Helium3,Helium4,superfuidity,experimentalmethod at low temperature:closedcycle,Refrigerators,single and double cycle He 3 refrigerator,He4 refrigerator,He3-He4 dilution refrigerator,pomeranchunkcooling,pulsed refrigerator system,magneticrefrigerators,Thermoelectriccoolers;CryostatDesign: Cryogenic level sensors,Handling of cryogenic liquids,Cryogenic thermometry**.(20)**

MPYC-402NANO SCIENCE AND TECHNOLOGYMark-100

Properties of individual Nanoparticles:
Magic numbers, Theoretical modeling of nanoparticles,Geometric structure, Electronic structures, relativity, fluctuations, magic clusters, Bulk to nanostriction
Semiconducting Nanoparticles:
Optical properties,photofragmentation, Coulombic explosion.
Carbon nanostructures
Carbon molecules:Nature of the carbon Bond,New carbon structures
Small Carbon Clusters, Discovery of C_{60}, Structure of C_{60} and its crystal, Alkali doped C_{60} ,Larger and Smaller Fullerenes, Other Bucky balls,
Carbon Nanotubes
Fabrication,Structure,Electricalproperties,Vibrationalproperties,Mechanical properties
Applications of carbon nanotubes: Field emission and shielding, computers,Fuel cells, Chemical Sensors,Catalysis, Mechanical Renforcement.
Bulk Nanostructured materials:
Solid Disordered Nanostructures: Methods of synthesis,Failure mechanism of Conventional Grain-Sized Materials, Mechanical properties, Nanostructured Multilayers, Electrical properties, Other properties, Metal Nanocluster Composite Glasses, Porous Silicon
Nanostructured Crystals: Natural Nanocrystals, Computational Prediction of Cluster Lattices, Arrays of nanoparticles in Zeolites, Crystals of Metal Nanoparticles, Nanoparticle Lattices in Colloidal suspensions, Photonic Crystals
Nanostructured Ferromagnetism: Basics of ferromagnetism, Effect of bulk Nanostructuring of magnetic properties, Dynamics ofnanomagnets, Nanopore Containment of magnetic properties, Nanocarbonferromagnets, Giant and colossal Magneto resistance, Ferro fluids
Optical and vibrational spectroscopy:
Infrared frequency range: Spectroscopy of semiconductors; Excitons , Infrared surface spectroscopy, Raman spectroscopy, Brillouin spectroscopy,
Luminescence: Photoluminescence, Surface states, thermo luminescence nanostructures in Zeolite Cages**.**
Quantum wells ,Wires and Dots : Preparation of quantum nanostructures ,size and Dimensionally effects: Size effects, Conduction electron and dimensionality, Fermi gas and density of states, potential

wells, partial confinement Properties dependent on Density of states, Excitons, Single electron tunneling, Applications: infrared detectors, Quantum Dot Lasers, Superconductivity.

References:

Introduction to Nanotechnology: Charles P. Poole, Jr., Frank J. Owens

MPYC-403 (ATOMIC AND MOLECULAR PHYSICS) Marks-100

Unit-I

One Electron Atom:

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

Hyperfine structure:

Review of Fine structure and relativistic correction, Lamb shift. Hyper ne interaction and isotope shift; Hyper fine splitting of spectral lines; selection rules.

Many electron atom:

Independent particle model; He atom as an example of central field approximation; Central field approximation for many electron atom; Slater determinant; L-S and j-j coupling; Equiva-lent and nonequivalent electrons; Energy levels and spectra; Spectroscopic terms; Hunds rule; Lande interval rule; Alkali spectra.(13)

Unit-II

Molecular Electronic States:

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

Rotation and Vibration of Molecules:

Solution of nuclear equation; Molecular rotation: Non-rigid rotator, Centrifugal distortion, Symmetric top molecules, Molecular vibrations: Harmonic oscillator and the anharmonic oscillator approximation, Morse potential.(12)

Unit-III

Spectra of Diatomic Molecules:

Transition matrix elements, Vibration-rotation spectra: Pure vibrational transitions, Pure ro-tational transitions, Vibration-rotation transitions, Electronic transitions: Structure, Franck-Condon principle, Rotational structure of electronic transitions, Fortrat diagram, Dissocia-tion energy of molecules, Continuous spectra, Raman transitions and Raman spectra.

Vibration of Polyatomic Molecules:

Application of Group Theory Molecular symmetry; Matrix representation of the symmetry elements of a point group; Reducible and irreducible representations; Character tables for C 2v and C 3v point groups; Normal coordinates and normal modes; Application of group theory to molecular vibration.(15)

BOOKS:

B.H. Bransden and C.J. Joachain: Physics of Atoms and Molecules

- C. Cohen-Tannoudji, B. Dier, and F. Laloe: Quantum Mechanics vol. 1 and 2
- R. Shankar: Principles of Quantum Mechanics
- C.B. Banwell: Fundamentals of Molecular Spectroscopy
- G.M. Barrow: Molecular Spectroscopy
- K. Thyagarajan and A.K. Ghatak: Lasers, Theory and Applications
- O. Svelto: Principles of Lasers
- B.H. Eyring, J. Walter and G.E. Kimball: Quantum Chemistry
- W. Demtroder: Molecular Physics
- H. Herzberg: Spectra of Diatomic Molecules

- J.D. Graybeal: Molecular Spectroscopy
- M.C. Gupta: Atomic and Molecular Spectroscopy
- B.B. Laud: Lasers and Non-linear Optics

  A. Thorne, U. Litzen and J. Johnson: Spectrophysics

MPYC-404 (SEMINAR) Marks-100

Each student has to give a seminar on any advanced topic from its core electives of 30minutes presentation before the faculty members who shall give marks out of 100 on the following criteria:

1.Preliminary Seminar-30
2.Final seminar-70

MPYE-405 Core Elective-A (Theory)

Condensed Matter Physics-II

Mark-100

Unit-I
Magnetism:
Landau diamagnetism and Pauli paramagnetism,Weiss theory of ferromagnetism,Currywiss law for suscsptibility,Heisenberg model- condition for ferro and anti ferromagnetic order, spin waves and magnons,Bloch $T^{3/2}$Law,Antiferro magnetic order,Neeltemperature.Diluted magnetic Semiconductors.
Ferroelectricity:
Ferroelectric crystals,classification of Ferroelectric crystals,Polarisationcatastrophe,Soft optical phonons,Landau theory of phase transition-second and first order transition,
Multiferroics-Elementary concept

UNIT-II
Electronic and lattice defects:
Lattice defects,Frenkel and schottkydefects,Linedefects,Edge and screw dislocations-Burger's Vector,planner(stacking) Faults- twin planes and grain boundaries Color centers-mechanism of coloration of a solid, F-center, other color centers.
Excitons: Loosely bound, tightly bound, ExcitonicWaves,Electron –hole droplets.
Exotic Solids
Amorphous materials,Quasi-crystals,Nano structured materials-Classification based on spatial extention(0-D,1-D,2-D). 0-D nanostructures-quantum dots,Widening of band gap in quantum dots,1-D nano structures-Quantum wells-superlattices.

Unit-III
Electron-phonon interaction,Second quantized form of Hamiltonian for electrons and phonons interaction,electron-electron attractive interaction due to virtual phonon exchange,Cooper pairs and BCS Hamiltonian,Solution of BCS Hamiltonian- spin analog method.
Josephson effect: Microscopic quantum mechanical effect, Dc Josephson effect, Effect of electric field Ac/Inverse Ac Josephson effect, Effect of magnetic field, SQUID.
Books:
1. M. Tinkham: Group Theory and Quantum Mechanics
2. M. Sachs: Solid State Theory
3, A.O.E. Animalu: Intermediate Quantum Theory of Crystalline Solids
4. N.W. Ashcroft and N.D. Mermin: Solid State Physics
5. J.M. Ziman: Principles of the Theory of Solids
6. C. Kittel: Introduction to Solid State Physics

MPYE-406 Core Elective-B (Theory)
Particle Physics-II

Marks-100

Unit-I
Symmetry:
Different types of symmetries and conservation laws. Noethers theorem.

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

Hadron structure:
Elastic e-p scattering, electromagnetic form factors, electron-hadron Deep Inelastic Scatter-ing, structure functions, scaling, sum rules, neutrino production.(12)

Unit-II
Strong interactions:
QCD, asymptotic freedom, gluons and jets in $e^+e \rightarrow$ hadrons, Scaling violation.

Low energy weak interactions:
Fermi theory, calculation of decay widths of muon and π^+.

Neutrino physics:
Theory of two- flavour oscillation. Solar and atmospheric neutrino anomalies.Neutrino ex-periments. The Indian Neutrino Observatory.(13)

Unit-III
Flavour physics:
Quark mixing, absence of tree-level FCNC in the Standard Model, the CKM matrix, oscillation in K and B systems, CP violation.

HEP experiments:
Relative merits and demerits of e^+e^- andhadronic colliders, LEP, LHC, B-factories.(15)

Books
1. F. Halzen and A.D. Martin: Quarks and Leptons
2. J. Donoghue, E. Golowich and B. Holstein: Dynamics of the Standard Model
3. T.-P. Cheng and L.-F. Li: Gauge Theories in Particle Physics
4. E. Leader and E. Predazzi: An Introduction to Gauge Theories and Modern Particle Physics
5. F.E. Close: An Introduction to Quarks and Partons

MPYC-451 (MODERN PHYSICS LAB.)

Marks-100

1. Measurement of Rydberg constant.
2. e/m measurement by Braun tube .
3. e/m measurement by Magnetron Valve Method .
4. To setup the Millikan oil drop apparatus and determine the charge of an electron.
5. To show the tunneling effect in tunnel diode using I-V characteristics.
6. Magnetic field measurement by search coil .
7. Ferroelectric transition point by Dielectric Constant Measurement.
8. Rectification by junction Diode using various filters .
9. Dielectric constant of solid (wax) by Lecher Wire .
10. Existence of discrete energy level by Frank Hertz experiment

MPYE-452 Core Elective-A
Condensed matter Physics-II Lab

1.Characterization of Solar cell .
2.Synthesis of thin films samples by thermal evaporation method and determination of its resistance.
3.Determination of precise lattice parameter and grain size of crystalline materials by X-Ray powder diffractometer.
4. Study of Laues spot of mica sheet using X-ray diffraction technique.
5. Study of the dispersion relation for the monoatomic and lattices using the given electrical transmission line.
6. Find the Youngs modulus for the given metal using composite piezoelectric oscillator technique.
7. Determination of magnetic susceptibility by Guoy-balance.
8. Velocity of ultrasonic waves in a given medium at different temperatures.
9. Measurement of Lande's g factor of DPPII by ESR at Microwave frequency.
10.Study of thermoluminescence of F-centre in alkali halide crystals.
11. Study of phase transition using feedback amplifier circuit.

MPYC-453 Core Elective-B,
Particle Physics-II Lab

1. Calibration of the x-ray spectrometer and determination of x-ray energy of unknown sources.
2. Determination of resolving poser of x-ray spectrometers.
3. Study of β spectrum.
4. Determination of absorption co-efficient of Aluminum using G.M Counter.
5. X-test and operating point determination using G-N tube.
6. Characteristics of G.M. counter.