Syllabus Scheme

for

Master of Science (Physics)

NEW SCHEME of M. Sc. PHYSICS
JULY-2015

Course Code	Title of the Paper	L	P	CONTACT HOURS/ WEEK
	Semester - I			
PHYS 411	Mathematical Physics	4	0	4
PHYS 412	Classical Mechanics	4	0	4
PHYS 413	Electronics	4	0	4
PHYS 414	Computational Techniques	4	0	4
PHYS 415	Physics Laboratory-I	0	2	6
COMP 101	Computer Laboratory	0	2	2
	Semester - II			
PHYS 421	Quantum Mechanics-1	4	0	4
PHYS 422	Condensed Matter Physics	4	0	4
PHYS 423	Electrodynamics-I	4	0	4
PHYS 424	Atomic and Molecular Spectroscopy	4	0	4
PHYS 425	Physics Laboratory-II	0	2	6
PHYS 501	Seminar & Project	0	0	1
	Semester - III			
PHYS 431	Quantum Mechanics-II	4	0	4
PHYS 432	Condensed Matter Physics-II	4	0	4
PHYS 433	Electrodynamics-II	4	0	4
PHYS 434	Nuclear and Particle Physics	4	0	4
PHYS 435	Physics Laboratory-III	0	2	6
PHYS 501	Seminar & Project	0	0	2
	Semester - IV			
PHYS 441	Statistical Mechanics	4	0	4
PHYS 442	Nano Technology	4	0	4
PHYS 443	(a) Plasma Physics (E)	4	0	4
	(b) Physics of Materials (E)	4	0	4
	(c) Advanced Nuclear Physics (E)	4	0	4
	(d) Advanced Quantum Mechanics (E)	4	0	4
PHYS 501	Seminar & Project	0	0	6

Course Structure

SEMESTER – I

PHYS 411 (MATHEMATICAL PHYSICS)

L	T	P	Credit
4	0	0	4

Module– I

COMPLEX VARIABLES:

Analyticity of the function of a complex variable, Cauchy integral theorem and formula, Expansion of an analytic function; Taylor and Laurent series, Residue theorem, contour integration, Applications in evaluation of definite integrals.

VECTOR SPACES:

Vector Spaces and Matrices; linear independence, Bases; dimensionality; inner product; linear transformations, Matrice, Inverse; Orthogonal and Unitary matrices, Independent elements of a matrix; Eigen-values and eigen-vectors, Diagonalization, Complete ortho-normal set of functions.

Module– II

SPECIAL AND ORTHOGONAL FUNCTIONS:

Partial differential equations, separation of variable technique in Cartesian, Spherical, Cylindrical Coordinates, Special functions related to these equations (Laguerre, Bessel's, Legendre and Hermite) and their applications to boundary value problems, Sturm-Liouville theory and orthonormal eigen-functions. Beta and Gamma functions, Fourier and Laplace transforms and their properties, Applications of Laplace Transforms to solve differential equations.

Module - III

GREEN'S FUNCTION:

Non homogeneous boundary value problems and Green's functions in one dimension. Eigen-function expansion of Green's function. Fourier transform method of constructing the Green's function, Green's function in 3-dimensions, application to scattering problem.

GROUP THEORY:

Postulates, multiplication tables, subgroup, direct product group, isomorphism and homomorphism. Representation of a group, Schur's Lemma and orthogonality theorem (Statement only), reducible and irreducible representation, Permutation group C42 group (group of the symmetry of a square), Lie group, Lie algebra, orthogonal groups and unitary group.

***Books Recommended Recommended*:**

1. G. Arfken: Mathematical Methods for Physicist 4th edition (Academic Press).
2. J. Mathews and R. L. Walker: Mathematical Methods of Physics (I. B. House Pvt. Ltd.).
3. C. Harper: Introduction to Mathematical Physics (Prentice Hall of India).
4. A. W. Joshi: Vectors & Tensors (Wiley Eastern Limited).
5. A. W. Joshi: Elements of Group Theory (Wiley Eastern).
6. Riley, Hobson & Bence: Mathematical Methods for Physics and Engineering (Cambridge University Press)

PHYS 412 (CLASSICAL MECHANICS)

L	T	P	Credit
4	0	0	4

Module– I

VARIATIONAL PRINCIPLES AND LAGRANGIAN FORMULATION OF MECHANICS:
D'Alembert's Principle and Lagrange's equations, Constraints and generalize coordinates, Calculus of variations, Hamilton's principle and derivation of Lagrange's equation from it, Extension to non-holonomic and non-conservative systems.Symmetry properties of space and time and the corresponding theorems (with reference to cyclic coordinates), Simple applications of Lagrangian formulation for a single particle and a systems of particles, Lagrangian formulation of relativistic mechanics.

CENTRAL FORCE PROBLEM:
Equations of motion and first integrals, Equivalent one dimensional problem and classification of orbits, The virial theorem, Differential equation for a orbit with a general power law potential, Applications: Kepler problem; scattering in c.m. and lab coordinates.

Module- II

KINEMATICS AND DYNAMICS OF RIGID BODIES:
Generalized coordinates of a rigid body, orthogonal transformations and the transformation matrix, The Euler's angles and Euler's theorem on motion of rigid bodies, infinitesimal rotations, motion in a rotating frame of reference, Coriolis force on (i) air flow on the surface of earth (ii) projectile motion (iii)atomic nuclei, Angular momentum and Kinetic energy of motion about a point, Moment of inertia tensor, the principle axis transformation, Euler's equation of motion, Torque free motion of a rigid body, Heavy symmetric top with one point fixed.

Module– III

HAMILTONIAN FORMULATION OF MECHANICS:
Legendre's transformations and Hamilton's equations of motion, Derivation of Hamilton's equations from variational principle, The principle of least action, Canonical transformations; Poisson's and Lagrangian brackets, their invariance under a canonical transformation, equations of motion in the Poisson's bracket notation; infinitesimal canonical transformations, constants of motion and symmetry properties.

Books Recommended Recommended:

1. H. Goldstein, Classical Mechanics 2nd ed. (Indian Student Edition, Addison-Wesley/Narosa).
2. J. B. Marion, Classical Mechanics (Academic Press).
3. L. D. Landau and E. M. Lifshitz, Mechanics 3rd ed. (Pergamon).
4. R. G. Takwale& P. S. Puranik, Introduction to Classical Mechanics (Tata McGraw – Hill)
5. Kiran C. Gupta, Classical Mechanics of Particles and Rigid Bodies (Wiley Eastern).
6. N. C. Rana and P. S. Joag, Classical mechanics (TMH).

PHYS 413 (ELECTRONICS)

L	T	P	Credit
4	0	0	4

Module– I

Electronic Devices: MESFETs and MOSFETs, Charge Coupled(CCDs) devices, Unijunction transistor (UJT), four layer (PNPN) devices, construction and working of PNPN diode, Semiconductor controlled rectifier (SCR) and Thyristor.

Electronic Circuits: Multivibrators (Bistable Monostable and Astable), Differential amplifier, Operational amplifier (OP-AMP), OP-AMP as inverting and non-inverting, scalar, summer, integrator, differentiator. Schmitt trigger and logarithmic amplifier, Electronic analog computation circuits.

Module- II

Digital Principles: Binary and Hexadecimal number system,Binary arithmetic, Logic gates, Boolean equation of logic circuits, Karnaugh map simplifications for digital circuit analysis, and design, Encoders & Decoders, Multiplexers and Demultiplexers, Parity generators and checkers, Adder-Subtraction circuits.

Sequential Circuits: Flip Flops, Registers, Up/Down counters, Basics of semiconductor memories: ROM, PROM, EPROM, and RAM,D/A conversion using binary weighted resistor network, Ladder, D/A converter, A/D converter using counter, Successive approximation A/D converter.

Module- III

Microprocessors: Basic architecture of INTEL 8085 Microprocessor, Assembly language(AL), Machine language(ML), Programming of 8085 Microprocessor, Instructions for simple mathematical operations : Addition , Substraction, Multiplication and Division.

Books Recommended :

1. Electronic Devices and Circuits- Millman and Halkias-Tata Mc Graw Hill, 1983.
2. Solid State Electronic Devices - Ben G Streetman-Prentice Hall, New Delhi, 1995.
3. Digital Principles and Applications- A.P.Malvino and D.P.Leach-Tata McGraw Hill, New Delhi, 1986.
4. Digital Computer Electronics- A P Malvino-Tata Mc Graw Hill, New Delhi, 1986
5. Microelectronics – Millman-Tata Mc Graw Hill, London, 1979.
6. Digital Electronics - W.H. Gothmann-Prentice Hall, New Delhi, 1980.

PHYS 414 COMPUTATIONAL TECHNIQUES

L	T	P	Credit
4	0	0	4

Module– I

Programming (in C):

Basics of C Programming, Structure of C Program, Variables and Constants: character set, identifiers and keywords, declaring a Variable, initialization Variables, integer Constants, floating point Constant, String Constants, Symbolic Constants, Data types, Operators.

Module-2

Control Statements: Design Control Statements: If statement, Switch statement

Loop Control Statements: While loop, Do While, for loop, Nested loop, Go to statement, Break and Continue.

Array: Declaration of Array, Initialization of Array, size, Character array initialization, processing the array, types of array.

Module-3

Interpolation:

Interpolation, Newton's formula for forward and backward interpolation, divided differences, Symmetry of divided differences, Newton's general interpolation formula, Lagrange's interpolation formula.

Module– 4

Numerical Integration:

Numerical integration, A general quadrature formula for equidistant ordinates, Simpson rules, Weddle and Trapezoidal rules, Monte- Carlo Method.

Module– 5

Roots of Equation:

Approximate values of roots: Bisection Method, Regula-Falsi Method, Newton-Raphson method, Bairstow method. Solution of Simultaneous Linear equations, Gauss elimination method, Gauss-Jordon method, Matrix inversion. Solution of Ordinary Differential Equation: Euler's method, Modified Euler's method, Runge-Kutta Method.

Books Recommended:

1. Ram Kumar-Programming with Fortran-77 (Tata McGraw Hill), 1995.
2. R.S. Dhaliwal - Programming with Fortran-77 (Wiley-Eastern Ltd)
3. James Scarborough-Numerical Mathematical Analysis (Oxford and IBH), 1966.
4. S.D. Conte - Elementary Numerical Analysis (McGraw Hill), 1965.
5. John. H. Methews, Numerical Methods for Mathematics, Science and Engineering (Prentice Hall of India).

PHYS 415 (LABORATORY-I)

L	T	P	Credit
0	0	2	3

1. To determine Planck's constant using photocell.
2. Kelvin double bridge: Determination of low resistance.
3. Anderson Bridge: determination of self-inductance.
4. To study SR and JK flip flop circuits using logic gates.
5. Study of characteristics of BJT
6. Study of characteristics of SCR
7. Study of characteristics of UJT
8. Study of characteristics of FET
9. Study of Op-Amplifier
10. Millikan's oil drop experiment.
11. To study quantized excitation energy in argon using Frank Hertz experiment.
12. To Measure reverse saturation current in pn junction diode at various temperatures and to find the approximate value of energy gap.

COMP -101 COMPUTER APPLICATIONS IN PHYSICS

L	T	P	Credit
0	0	2	1

1. Determination of Roots:
(a) Bisection Method
(b) Newton Raphson Method
(c) Secant Method
2. Matrix Manipulation
(a) Matrix Multiplication
(b) Determinant
(c) Gauss Elimination
(d) Matrix Inversion
(e) Gauss Jordan
3. Integration
(a) Trapezoidal rule
(b) Simpson 1/3 and Simpson 3/8 rules
(c) Gaussian Quardrature
4. Differential Equations
(a) Euler's method
(b) Runge Kutta Method
5. Interpolation
(a) Forward interpolation, Backward interpolation
(b) Lagrange's interpolation
6. Applications
(a) Chaotic Dynamics, logistic map
(b) One dimensional Schrondinger Equation
(c) Time period calculation for a potential
(d) Luminous intensity of a perfectly black body vs. temperature

SEMESTER-II

PHYS 421 (QUANTUM MECHANICS-I)

L	T	P	Credit
4	0	0	4

Module– I

MATRIX FORMULATION OF QUANTUM MECHANICS:
Matrix Algebra: Matrix addition and multiplication, Null unit and Constant Matrices, Trace, Determinant and Inverse of a Matrix, Hermitian and unitary Matrices, Transformation and diagonalization of Matrics, Function of Matrices and matrices of infinite rank. Vector representation of states, transformation of Hamiltonian with unitary matrix, representation of an operator, Hilbert space. Dirac bra and ket notation, projection operators, Schrodinger, Heisenberg and interaction pictures. Relationship between Poisson brackets and commutation relations. Matrix theory of Harmonic oscillator.

Module– II

SYMMETRY IN QUANTUM MECHANICS:
Unitary operators for space and time translations. Symmetry and degeneracy. Rotation and angular momentum; Commutation relations, eigenvalue spectrum, angular momentum matrices of J+, J-, Jz, J2. Concept of spin, Pauli spin matrices. Addition of angular momenta, Clebsch-Gordon coefficients and their properties, recurssion relations. Matrix elements for rotated state, irreducible tensor operator, Wigner-Eckart theorem.Rotation matrices and group aspects. Space inversion and time reversal: parity operator and anti-linear operator. Dynamical symmetry of harmonic oscillator.

APPLICATIONS: non-relativistic Hamiltonian for an electron with spin included. C. G. coefficients of addition for j =1/2, 1/2; 1/2, 1; 1, 1.

Module- III

APPROXIMATION METHODS FOR BOUND STATE:
Time independent perturbation theory for non-degenerate and degenerate systems upto second order perturbation. Application to a harmonic oscillator, first order Stark effect in hydrogen atom, Zeeman effect without electron spin. Variation principle, application to ground state of helium atom, electron interaction energy and extension of variational principle to excited states. WKB approximation: energy levels of a potential well, quantization rules. Time-dependent perturbation theory; transition probability (Fermi Golden Rule), application to constant perturbation and harmonic perturbation.Semi-classical treatment of radiation.Einstein coefficients; radiative transitions.

Books Recommended:

1. L. I. Schiff, Quantum Mechanics (McGraw Hill).
2. Eugan Merzbacher, Quantum Mechanics Johan Wiley & Sons Inc.
3. P. M. Mathews and K. Venkatesan, A Text-Book of Quantum Mechanics (TMH)
4. C. Cohen-Tannoudji, Bernard Diu, Franck Loloe, Quantum Mechanics Vols-I & II (John Wiley).
5. J. J. Sakurai, Modern Quantum Mechanics (Addison-Wesley).
6. A. K. Ghatakh and S. Lokanathan, Quantum Mechanics 3rd ed. (MacMillan).

PHYS 422 CONDENSED MATTER PHYSICS

L	T	P	Credit
4	0	0	4

Module– I

Dia-Para and Ferromagnetism:

Classification of magnetic materials, the origin of permanent magnetic dipoles, diamagnetic susceptibility, classical theory of para magnetism, Quantum theory of paramagnetism, Quenching of orbital angular momentum, cooling by adiabatic demagnetization. Paramagnetic susceptibility of conduction electrons. Ferromagnetism, the Weiss molecular field, the interpretation of the Weiss field. Ferromagnetic domains, Spin waves, quantization of spin waves, Thermal excitations of magnons.

Module– II

Antiferro-Ferrimagnetism and Superconductivity:

The two sublattice model, superexchange interaction, the structure of ferrites, saturation magnetization, Neel's theory of ferrimagnetism, Curie temperature and susceptibility of ferrimagnets. Superconductivity, zero resistivity, critical temperature, Meissner effect, Type I and Type II superconductors, specific heat and thermal conductivity, BCS theory, Ginzsburg-Landou theory, Josephson effect: dc Josephson effect, ac Josephson effect, macroscopic quantum interference, high temperature superconductivity .

Module– III

Defects and Diffusion in Solids:

Point defects: Impurities, Vacancies- Schottky and Frankel vacancies, Color centers and coloration of crystals, F-centres, Line defects (dislocations), Edge and screw dislocations, Berger Vector, Planar (stacking) Faults, Grain boundaries, Low angle grain boundaries, the Hydration energy of ions, Activation energy for formation of defects in ionic crystals, Ionic conductivity in pure alkali halides.

Module– IV

Lattice Vibrations and Phonons:

Vibrations of one dimensional linear monoatomic lattice, Normal modes of vibrations in a finite length of the lattice, The linear diatomic lattice, Excitation of optical branch in ionic crystals –the infra red absorption, Quantization of lattice vibrations – concept of phonons, Phonon momentum, Inelastic scattering of photons by phonons, Inelastic scattering of neutrons by phonons.

Books Recommended Recommended:

1. An Introduction to Solid State Physics: C. Kittel-Wiely Estem Ltd., New Delhi, 1979.
2. Solid State Physics-A.J. Dekkar- Maemillan India Ltd., New Delhi, 2004.
3. Principles of Solid State Physics-R.A. Levy-New York Academy, 1968.
4. Introduction to Solids-Azaroff-Tata Mc Graw Hill, New Delhi, 1992.
5. Elementary Solid State Physics-Omar, Addison Wesly, 1975.
6. Solid State Physics-Aschroft and Mermin-New York Holt, 1976

PHYS 423 (ELECTRODYNAMICS-I)

L	T	P	Credit
4	0	0	4

Module– I

Electrostatics: Coulomb's law, Guass's law, Poisson's equation, Laplace equation. Solution of boundary value problem: Green's function, method of images and calculation of Green's function for the image charge problem in the case of a sphere, Laplace equation, uniqueness theorem. Electrostatics of dielectric media, multipole expansion. Boundary value problems in dielectrics; molecular polarisability, electrostatic energy in dielectric media.

Module– II

Magnetostatics: Biot and Savart's law, the differential equation of Magnetostatics and Ampere's law, vector potential and magnetic fields of a localised current distribution. Magnetic moment, force and torque on a magnetic dipole in an external field. Megnetic materials, Magnetisation and microscopic equations.

Module– III

Time-varying fields: Time varying fields, Maxwell's equations, conservation laws: Faraday's law of induction, Energy in a magnetic field. Maxwell's displacement current, vector and scalar potential, Gauge transformations; Lorentz gauge and Coulomb gauge. Poynting theorem, conservation laws for a system of charged particles and electromagnetic field, continuity equation.

Module– IV

Electromagnetic Waves: Plane wave like solutions of the Maxwell equations, polarization, linear and circular polarization. Superposition of waves in one dimension. Group velocity, Illustration of propagation of a pulse in dispersive medium. Reflection and refraction of electromagnetic waves at a plane surface between dielectrics, polarization by reflection and total internal reflection. Waves in conductive medium, simple model for conductivity.

Books Recommended:

1. Classical Electrodynamics - J.D. Jackson-John & Wiley Sons Pvt. Ltd. New York, 2004.
2. Introduction to Electrodynamics - D.J. Griffiths-Pearson Education Ltd., New Delhi, 1991.
3. Classical Electromagnetic Radiation - J.B. Marion-Academic Press, New Delhi, 1995.

PHYS 424 (ATOMIC AND MOLECULAR SPECTROSCOPY)

L	T	P	Credit
4	0	0	4

Module –I

Spectra of one and two valance electron systems:

Magnetic dipole moments; Larmor's theorem; Space quantization of orbital, spin and total angular momenta; Vector model for one and two valance electron atoms; Spin-orbit interaction and fine structure of hydrogen, Lamb shift, Spectroscopic terminology; Spectroscopic notations for L-S and J-J couplings; Spectra of alkali and alkaline earth metals; Interaction energy in L-S and J-J coupling for two electron systems; Selection and Intensity rules for doublets and triplets

Module -II

Breadth of spectral line and effects of external fields:

The Doppler effect; Natural breadth from classical theory; natural breadth and quantum mechanics; External effects like collision damping, asymmetry and pressure shift and stark broadening; The Zeeman Effect for two electron systems; Intensity rules for the Zeeman effect; The calculations of Zeeman patterns; Paschen-Back effect; LS coupling and Paschen –Back effect; Lande's factor in LS coupling; Stark effect.

Module-III

Microwave and Infra-Red Spectroscopy:

Types of molecules, Rotational spectra of diatomic molecules as a rigid and non-rigid rotator, Intensity of rotational lines, Effect of isotopic substitution, Microwave spectrum of polyatomic molecules, Microwave oven, The vibrating diatomic molecule as a simple harmonic and an harmonic oscillator, Diatomic vibrating rotator, The vibration-rotation spectrum of carbon monoxide, The interaction of rotation and vibrations, Outline of technique and instrumentation, Fourier transform spectroscopy.

Raman and Electronic Spectroscopy:

Quantum and classical theories of Raman Effect, Pure rotational Raman spectra for linear and polyatomic molecules, Vibrarional Raman spectra, Structure determination from Raman and infra-red spectroscopy, Electronic structure of diatomic molecule, Electronic spectra of diatomic molecules, Born Oppenheimer approximation- The Franck-Condon principle, Dissociation and pre-dissociation energy, The Fortrat diagram, example of spectrum of molecular hydrogen.

Books Recommended:

1. *Introduction to Atomic Spectra: H.E. White-Auckland Mc Graw Hill, 1934*
2. *Fundamentals of Molecular spectroscopy: C.B. Banwell-Tata Mc Graw Hill, 1986.*
3. *Spectroscopy Vol. I, II & III: Walker & Straughen*
4. *Introduction to Molecular Spectroscopy: G.M.Barrow-Tokyo Mc Graw Hill, 1962.*
5. *Spectra of Diatomic Molecules: Herzberg-New York, 1944.*
6. *Molecular Spectroscopy: Jeanne L McHale-NewJersy Prentice Hall, 1999.*
7. *Molecular Spectroscopy: J.M. Brown-Oxford University Press, 1998.*
8. *Spectra of Atoms and Molecules: P.F. Bermath-New York, Oxford University Press, 1995.*
9. *Modern Spectroscopy: J.M. Holias*

PHYS 425 (LABORATORY –II)

L	T	P	Credit
0	0	2	3

1. Determination of wavelength and difference in wavelengths of sodium lines, and thickness of mica sheet using Michelson Interferometer.
2. ESR Spectrum of DPPH and calculation of g factor.
3. To trace B-H curve for different materials using CRO and to find the magnetic parameters from these. Also calculate the energy loss per cycle.
4. To find the susceptibility of a given salt by Quinck's Method.
5. Stefan's constant.
6. Solar cell Characteristics.
7. Measurement of Hall coefficient of given semiconductor. Identification of type of semiconductor and estimation of charge carrier concentration
8. Measurement of resistivity of a semiconductor by four probe method at different temperatures and determination of band gap.
9. To study uncertainty principle using Laser.
10. To determine crystal structure of different material using X ray diffraction.
11. To determine the wavelength of given source light using diffraction grating on spectrometer.
12. To determine the charge to mass ratio (e/m) of an electron with normal Zeeman Effect
13. To determine the velocity of ultrasonic waves in a liquid using ultrasonic interferometer

SEMESTER-III

PHYS 431 (QUANTUM MECHANICS – II)

L	T	P	Credit
4	0	0	4

Module – I

SCATTERING THEORY: General considerations; kinematics, wave mechanical picture, scattering amplitude, differential and total cross-section. Green's function for scattering. Partial wave analysis: asymptotic behavior of partial waves, phase shifts, scattering amplitude in terms of phase shifts, cross-sections, Optical theorem. Phase shifts and its relation to potential, effective range theory. Application to low energy scattering; resonant scattering, Breit-Wigner formula for one level and two levels, non-resonant scattering. s-wave and p-wave resonances. Exactly soluble problems; Square-well, Hard sphere, coulomb potential. Born approximation; its validity, Born series.

Module – II

Relativistic Quantum Mechanics*:* Klein Gordon equation. Dirac Equation, Lorentz covariance of Dirac equation. Positive and negative energy solutions of Dirac equation, positrons. Properties of gamma matrices, Parity operator and its action on states. Magnetic moments and spin orbit energy.

Identical Particles*:* Brief introduction to identical particles in quantum mechanics symmetrisation postulates. Application to 2-electron systems, Pauli exclusion principle. Bose Einstein and Fermi Dirac Statistics.

Module – III

Relativistic Dirac Equations:

Dirac equation; relativistic Hamiltonian, probability density, expectation values, Dirac gamma matrices and their properties, non-relativistic limit of Dirac equation, Covariance of Dirac equation and bilinear covariance, plane wave solution, energy spectrum of hydrogen atom, electron spin and magnetic moment, negative energy sea, hole interpretation and the concept of positron, Spin –orbit coupling, hyperfine structure of hydrogen atom.

Quantization of Wave Fields: The procedure for quantization of wave fields, quantization of non-relativistic Schrodinger equation, second quantization, N-representation creation and annihilation operators.

Books Recommended:

1. Modern Quantum Mechnics: J.J. Sakurai-Pearson Educaton Pvt. Ltd., New Delhi, 2002.
2. Quantum Mechanics: L I Schiff-Tokyo Mc Graw Hill, 1968.
3. Feynmann lectures in Physics Vol. III-Addison Wesly, 1975.
4. Quantum Mechanics: Powel and Craseman-Narosa Pub. New Delhi, 1961.
5. Quantum Mechanics: Merzbacher-John Wiley & Sons, New York, 1970.
6. P. M. Mathews and K. Venkatesan, A Text book of Quantum Mechanics (TMH)
7. A. S. Davydov, Quantum Mechanics (Pergamon).
8. L. I. Schiff, Quantum Mechanics (McGraw Hill).
9. J. D. Bjorken and S. D. Drell, Relativistic Quantum Mechanics (McGraw Hill).
10 J. J. Sakurai, Advanced Quantum Mechanics (Addison Wesley).

PHYS 432 (CONDENSED MATTER PHYSICS-II)

L	T	P	Credit
4	0	0	4

Module – I

Lattice Specific Heat and Elastic Constants:

The various theories of lattice specific heat of solids, Einstein model of the Lattice Specific heat. Density of modes of vibration, Debye model of Lattice specific heat, Born cut-off procedure, Specific heat of metals, Elastic strain and stress components, Elastic compliance and stiffness constants, Elastic constants of cubic crystals, Elastic waves in cubic crystals.

Module – II

Physics of Semiconductors:

Semiconductors, Chemical bonds in semiconductors, Mechanism of current flow, Forbidden, valence and conduction bands, Band structure of silicon and germanium, Mobility, drift velocity and conductivity of intrinsic semiconductors, Carrier concentration in intrinsic semiconductors, Impurity semiconductors, Thermal ionization of impurities, Impurity states and band model, Impurity states, energy band diagram and Fermi level.

Module – III

The conductivity of Metals and Luminescence:

Electrical conductivity of metals, Drift velocity and relaxation time, The Boltzmann transport equation, The Sommerfield theory of conductivity, Mean free path in metals, Qualitative discussion of the features of the resistivity, Mathiesson's rule. Luminescence, excitation and emission, Decay mechanisms, Thallium activated alkali halides. Electro Luminescence.

Dielectrics and Ferro Electrics:

Macroscopic field, The local field, Lorentz field. The Claussius-Mossotti relations, Different contribution to polarization: dipolar, electronic and ionic polarizabilities, General properties of ferroelectric materials, The dipole theory of ferroelectricity, objection against dipole theory, Thermodynamics of ferroelectric transitions.

Books Recommended:

1. An Introduction to Solid State Physics: C. Kittle-Wiley, 1958
2. Solid State Physics: A.J. Dekker-Prentice Hall, 1965.
3. Principles of Solid State Physics: R.A. Levey-Academic Press, 1968
4. Introduction of Solid State Physics: Ashroft-Cengage Learning, 1999.

M.Sc. (Physics) (For Colleges) (Semester-III)

PHYS 433 (ELECTRODYNAMICS – II)

L	T	P	Credit
4	0	0	4

Module – I

Wave Guides: Field at the surface of and within a conductor. Cylindrical cavities and waveguides, modes in a rectangular wave guide, energy flow and attenuation in wave guides. Perturbation of boundary conditions, resonant cavities, power loss in cavity and quality factor.

Module – II

Relativistic formulation of electrodynamics: Special theory of relativity, simultaneity, length, contraction, time dilation and Lorenz's transformations, Structure of space-time, four scalars, four vectors and tensors, relativistic mechanics, Relativistic electrodynamics, Magnetism as a relativistic phenomena and field transformations, Recasting Maxwell equations in the language of special relativity, covariance and manifest covariance, field tensor, Lagrangian formulation for the covariant Maxwell equations.

Module – III

Radiation Systems: Fields of radiation of localized oscillating sources, electric dipole fields and radiation, magnetic dipole and electric quadrupole fields, central fed antenna, brief introduction to radiation damping and radiation reaction.
Fields of moving charges: Lienard Wiechert potential, field of a moving charge. Radiated power from an accelerated charge at low velocities, Larmor's power formula and its relativistic generalization; Angular distribution of radiation emitted by an accelerated charge.

Books Recommended:

1. *Classical Electrodynamics: J.D. Jackson-Wiley, 1967*
2. *Electricity and Magnetics: D.J. Griffiths-Prentice hall, 1996*
3. *Classical Electromagnetic Radiation: J.B. Marian-Academic Press, 1965*

PHYS 434 (NUCLEAR & PARTICLE PHYSICS)

L	T	P	Credit
4	0	0	4

Module – I

Nuclear Interactions and Nuclear Reactions

Nuclear Forces: Two nuclear system, deutron problem, binding energy, nuclear potential well, pp and pn scattering experiments at low energy, meson theory of nuclear forces, e.g. Bartlett, Heisenberg, Majorans forces and potentials, exchanges forces and tensor forces, effective range theory-spin dependence of nuclear forces-Charge independence and charge symmetry of nuclear forces-Isospin formalisim- Yukawa interaction.

Nuclear Reactions

Direct and compound nuclear reaction mechanisms, cross sections in terms of partial wave amplitudes, Compound nucleus, scattering matrix, Reciprocity theorem, Breit Winger one level formula, Resonance scattering.

Module – II

Elementary Particles and Their Properties: Historical survey of elementary particles and their classification, determination of mass, life time, decay mode, spin and parity of muons, pions, kaons and hyperons. Experimental evidence for two types of neutrinos, production and detection of some important resonances and antiparticles.

Symmetries and Conservation Laws: Conserved quantities and symmetries, the electric charge, baryon number, leptons and muon number, particles and antiparticles, hypercharge (strangeness), the nucleon isospin, isospin invariance, isospin of particles, parity operation, charge conservation, time reversal invariance, CP violation and CPT theorem, the KO – KO doublet unitary symmetry SU(2), SU (3) and the quark model.

Module – III

Nuclear Models

Liquid drop model, Bohr-Wheeler theory of fission, Experimental evidence for shell effects, Shell Model, Spin-Orbit coupling, Magic-Applications of Shell model like Angular momenta and parities of nuclear ground states, Quantitative discussion and estimates of transition ratesmagnetic moments and Schmidt lines, Collective model, Nuclear vibrations spectra and rotational spectra, applications, Nilsson model.

Module – IV

Nuclear Decay

Beta decay, Fermi theory of beta decay, shape of the beta spectrum, Total decay rate, Angular momentum and parity selection rules, Comparative half-lives, Allowed and forbidden transitions, selection rules, parity violation, Two component theory of neutrino decay, Detection and properties of neutrino, Gamma decay, Multipole transitions in nuclei, Angular momentum and parity selection rules, Internal conversion, Nuclear isomerism.

Books Recommended:

1. *A. Bohr and B.R. Mottelson: Nuclear Structure, Vol.1(1969) and Vol.2 Benjamin, Reading, A.1975.*
2. *Kenneth S. Krane: Introductory Nuclear Physics, Wiley, New York, 1988*
3. *G.N. Ghoshal: Atomic and Nuclear Physics Vol.2, S. Chand and Co., 1997*
4. *P. H. Perkins, introduction to High Energy Physics, Addison-Wiley, London, 1982.*
5. *Introduction to Elementary particle physics by D. Grifiths.*

PHYS 435 (LABORATORY-III)

L	T	P	Credit
0	0	3	1.5

1. To study the energy resolution of Cs 137.
2. To identify the unknown gamma source using the energy calibration.
3. To study G.M. counter (a) characteristics (b) dead time (c) statistical distribution of counting rates.
4. Study of Proportional counter and low energy gamma ray measurements.
5. To determine the absorption coefficient of Pb and Fe for gamma rays using G.M. Counter.
6. To determine the energy of a pure Beta-emitter using G.M. Counter and Al absorbers.
7. Use of Microwaves to study Micheleson's interferometer.
8. Use of Microwaves to study Brewster's angle for polarization
9. Use of Microwaves to study Braggs diffraction from crystal model
10. Calibration of Scintillation Spectrometer
11. Pulse-Height Analysis of Gamma Ray Spectra.
12. Study of absorption of gamma rays in matter.

SEMESTER-IV

PHYS 441 (STATISTICAL MECHANICS)

L	T	P	Credit
4	0	0	4

Module – I

Classical Stat. Mech. I: Foundation of statistical mechanics; specification of states in a system, contact between statistics and thermodynamics, the classical ideal state, the entropy of mixing and Gibbs paradox. The phase space of classical systems, Liouville's theorem and its consequences.

Classical Stat. Mech. II: The microcanonical ensemble with examples. The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations in the canonical ensemble. A system of harmonic oscillators. The statistics of paramagnetism. The grand canononical ensemble, the physical significance of the statistical quantities, examples, fluctuation of energy and density. Cluster expansion of classical gas, the virial equation of state.

Module – II

Quantum Stat. Mech.I : Quantum states and phase space, the density matrix, statistics of various ensembles. Example of electrons in a magnetic field, a free particle in a box and a linear harmonic oscillator. Significance of Boltzamann formula in classical and quantum statistical mechanics.

Quantum Stat. Mech. II : An ideal gas in quantum mechanical microcanonical ensemble. Statistics of occupation numbers, concepts and thermodynamical behaviour of an ideal gas. Bose Einstein condensation, Discussion of a gas of photons and phonons, Thermodynamical behaviour of an ideal fermi gas, electron gas in metals, Pauli paramagnetism, statistical equilibrium of white dwarf stars.

Books Recommended:

1. Statistical Mechanics: R.K. Patharia-Butten Worth Heinemann, 1996
2. Statistical and Termal Physics: F. Reif-Mc-Graw Hill, 1965
3. Statistical Mechanics: Kerson Huang-Wiley, 1963.

PHYS 442 (NANOTECHNOLOGY)

L	T	P	Credit
4	0	0	4

Module– I

Introduction and Synthesis of Nano Materials:

Introduction, Basic idea of nanotechnology, nanoparticles, metal Nanoclusters, Semiconductor nanoparticles, Physical Techniques of Fabrication, inert gas condensation, Arc Discharge, RF plasma, Ball milling, Molecular Beam Epitaxy, Chemical Vapour deposition, Electrodeposition, Chemical Methods-Metal nanocrystals by reduction, Photochemical synthesis, Electrochemical synthesis, Sol-gel, micelles and microemulsions, Cluster compounds. Lithographic Techniques-AFM based nanolithography and nanomanipulation, E-beam lithography and SEM based nanolithography, X ray based lithography.

Module– II

Characterization Techniques:

X-ray diffraction, data manipulation of diffracted X-rays for structure determination, Scanning Probe microscopy, Scanning Electron microscopy, Transmission Electron Microscopy, Scanning Tunneling Microscopy, Optical microscopy, FTIR Spectroscopy, Raman Spectroscopy, DTA, TGA and DSC measurements, PL, Band Gap; optical transmission and absorption, Transport properties measurements; two probe and four probe methods and Vander Pauw techniques.

Module– III

Carbon Nanotubes and other Carbon based materials:

Preparation of Carbon nano tubes, CVD and other methods of preparation of CNT, Properties of CNT; Electrical, Optical, Mechanical, Vibrational properties etc. Application of CNT; Field emission, Fuel Cells, Display devices. Other important Carbon based materials; Preparation and Characterization of Fullerenes and other associated carbon clusters/molecules, Graphenepreparation, characterization and properties, DLC and nano diamonds.

Nanosemiconductors and Nano sensors:

Semiconductor nanoparticles-applications; optical luminescence and fluorescence from direct band gap semiconductor nanoparticles, carrier injection, polymers-nanoparticles, LED and solar cells, electroluminescence. Micro and nanosensors; fundamentals of sensors, biosensor, microfluids, MEMS and NEMS, packaging and characterization of sensors, Quantum dots; their special properties, synthesis and applications.

Books Recommended:

1. *Solid State Physics: J.P. Srivastva-Prentice Hall, 2007.*
2. *Introduction to nanoscience and Nanotechnology: K.K. Chattopadhyay and A.N. Banerjee- PHI Learning Pvt. Ltd. 2009*
3. *Nanotechnology Fundamentals and Applications: Manasi Karkare, I.K.- International Publishing House, 2008.*
4. *Nanomaterials: B. Viswanathan- Narosa, 2009.*
5. *Encyclopedia of Nanotechnology: H.S. Nalwa-American Scientific Publishers, 2004.*
6. *Introduction to Nanotechnology: Charles P. Poole Jr. and Franks J. Qwens,-John Wiley & Sons, 2003.*
7. *Nanostructures and Nanomaterials, Synthesis, Properties and Applications: Guoahong Cao- Imperial College Press, 2004.*
8. *Springer Handbook of Nanotechnology: Bharat Bhushan-Springer, 2004.*
9. *Science of Engineering Materials: C.M. Srivastva and C. Srinivasan-New Age International, 2005.*
10. *The Principles and Practice of electron Microcopy: Ian. M. Watt-Cambridge University Press, 1997.*

PHYS 443 a (PLASMA PHYSICS) E

L	T	P	Credit
4	0	0	4

Module– I

Basics of Plasmas: Occurence of plasma in nature, definition of plasma, concept of temperature, Debye shielding and plasma parameter. Single particle motion in uniform E and B, nonuniform magnetic field, grid B and curvature drifts, invariance of magnetic moment and magnetic mirror. Simple application of plasmas.

Module– II

Plasma Waves: Plasma oscillations electron plasma waves, ion waves, electrostatic electron and ion oscillations perpendicular to magnetic field upper hybrid waves, lower hybrid waves, ion cyclotron waves. Light waves in plasma.

Module– III

Boltzmann and Vlasov Equations: The fokker plank equation, integral expression for collision lern zeroth and first order moments, the single equation relaxation model for collision lern. Application kinetic theory to electron plasma waves, the physics of landau damping, elementary magnetic and inertial fusion concepts.

Non-linear Plasma Theories: Non-linear Electrostatic Waves, K dV Equations, Non-linear Schrodinger Equation, Solitons, Shocks, Non-linear Landou Damping.

Books Recommended:

1. *Introduction to Plasma Physics and Controlled Fusion: F. F. Chen-Springer, 1984*
2. *Plasma Physics: R. O. Dendy-Cfambridge University Press, 1995.*
3. *Ideal Magnetohydrodynamics: J. P. Friedberg-Springer edition, 1987*
4. *Fundamental of Plasma Physics: S. R. Seshadri-American Elsevier Pub. Co.,1973.*

PHYS 443 b (PHYSICS OF MATERIALS) E

L	T	P	Credit
4	0	0	4

Module– I

Materials Science and Vacuum Technology: Structure property relation, classification of engineering materials, semiconductor materials, Quantum dots; their special properties, synthesis and applications, Basic ideas about vacuum, Throughput, Conductance, Vacuum pumps : rotary pump, diffusion pump, ion pump, molecular pump, cryopump, Vacuum gauges : pirani gauge, penning gauge, ionization gauge (hot cathode ionization gauge, cold cathode ionization gauge), Epitaxy and its benefits, Grain boundaries as a defect and material engineering.

Thin Film

Thin Film and growth process, Influence of nature of substrate and growth parameters (substrate temperature, thickness, deposition rate), Thin film deposition, techniques: thermal evaporation, chemical vapor deposition, spray pyrolysis, sputtering. Epitaxial growth, Thin film thickness measurement techniques: film resistance method, optical method, microbalance method.

Module–II

Polymers, Ceramics, Liquid Crystals and Nanophase Materials: Characteristics, Application and Processing of polymers: Polymerization, Polymer types, Stress- Strain behaviour, melting and glass transition, thermosets and thermoplasts, Characteristics, Application and Processing of Ceramics, glasses and refectories, Liquid Crystals : classification and applications, Nanophase materials: synthesis and applications, Plasticity and elasticity, nanocomposites; synthesis and their applications, latest's trends and challenges in nanofield materials.

Module– III

Characterization of Materials

Powder and single crystal X-ray diffraction, Transmission electron microscopy, Scanning electron microscopy, Low Energy Electron Diffraction (LEED), Auger electron microscopy, Atomic force microscopy, SPM, Raman Spectroscopy, PL, FTIR, UV-Vis Spectroscopy, Transport properties characterization.

Books Recommended:

1. *Vacuum Technology: A. Roth-North Holland Pub. Co., 1976*
2. *Thin Film Phernomeon: K.L. Chopra-R E Kriegn Pub. Co., 1979.*
3. *High Temperature Superconductors: E.S.R. Gopal & SV. Subramanyam-Wiley, 1989*
4. *Material Scienceand Engg: W.D. Callister-.Wiley, 1994*
5. *Nanostructured Materials: J.C. Ying-Wiley-. Academic Press, 2001*
6. *Methods of Surface Analysis: J.M. Walls- CUP Archive, 1990.*
7. *Introduction to Nanotechnology - Charles P.Pooler, Frank J. Owens- IEEE, 2003*

PHYS 443 (ADVANCED NUCLEAR PHYSICS)

L	T	P	Credit
4	0	0	4

Modul e– I

Angular Momentum Theory:

Angular momentum coupling: coupling of two angular momenta, coupling of three angular momenta, coupling of four angular momenta Racah coefficients. Tensors and reduced matrix elements of irreducible operators, Product of tensor operators. Application: Spherical harmonics between orbital angular momentum states, Spin operator between spin states, Angular momentum J between momentum states, Matrix elements element of compounded states and Matrix elements between angular momentum coupled state.

Nuclear decays:

Decay widths and lifetimes. Alpha Decay: General Properties and theory of alpha decay, Barrier penetration of alpha decay, alpha decay spectroscopy Spontaneous fission decay Beta Decay: General Properties, Neutrinos and Antineutrinos, the Fermi theory of beta decay, Angular momentum and selection rules of beta decay, electron capture, beta spectroscopy. Gamma decay, reduced transition probabilities for gamma decay, Weisskopf units for gamma decay.

Module – II

The Fermi gas model, The one body potential General properties, The harmonic oscillator potential separation of intrinsic and centre-of-mass motion, the kinetic energy and the harmonic oscillator. Conserved quantum numbers, angular momentum, parity and isospin, Quantum number for the two nucleon system, two proton or two neutron, and proton and neutron. *The Hartree Fock Approximation* Properties of single Slater determinants, Derivation of the Hartree-Fock equations, examples of single particle energies, Results with Skyrme Hamiltonian: Binding energy, single particle energies, Rms charge radii and charge densities.

Module – III

The Shell Model:

Ground state spin of nuclei, Static electromagnetic moments of nuclei, Electromagnetic transition probability on shell model, Exact treatment of two-nucleons by shall model, two-nucleon wave function, matrix elements of one-body operator and two-body potential, Shell model digonalization, Configuration mixing, relationship between hole state and particle state, State of hole-particle excitation and core polarization, Seniority and fractional percentage by second-quantization technique.

Books Recommended:

1. M.K. Pal Theory of Nuclear Structure, Affiliated East-West, Madras-1992.
2. Y. R. Waghmare, Introductory Nuclear Physics, Oxford-IBH, Bombay, 1981.
3. K. L. G. Heyde, The Nuclear Shell Model, (Springer-Verlag, 1994)
4. R. D. Lawson, Theory of the Nuclear Shell Model, (Clarendon Press, 1980).
5. A. R. Edmonds, Angular Momentum in Quantum Mechanics, (Princeton University Press, 1957
6. D. M. Brink and G. R. Satchler, Angular Momentum, (Clarendon Press, Oxford, 1968).
7. R. D. Lawson, Theory of the Nuclear Shell Model, (Clarendon Press, 1980)
8. D. Vautherin and D. M. Brink, Phys. Rev. C 5, 626 (1972)
9. T. R. H. Skyrme. Philos. Mag. 1, 1043 (1956); Nucl. Phys. 9, 615 (1959);9, 635 (1959)
10. W. Kohn and L. J. Sham, Phys. Rev. 140 A1133 (1965).
11. P. J. Brussaard and P. W. M. Glaudemans, Shell Model Applications in Nuclear Spectroscopy, (North Holland, 1977).
12. A. de Shalit and I. Talmi, Nuclear Shell Theory, (Academic Press, 1963).

PHYS 443 d (ADVANCED QUANTUM MECHANICS) E

L	T	P	Credit
4	0	0	4

Module– I

Quantization Of Fields:

Quantization of neutral and complex scalar fields, U (1) gauge invariance Quantization of Dirac field covariant anti commutation relations, Quantization of electromagnetic field. Interaction Lagrangion for the fields, QED lagrangian.

Module– II

Scattering Matrix and Feynman Rules:

The S-Matrix reduction of S- Matrix chronological product, Wicks theorem Furry's theorem Covariant perturbation theory interaction lagrangian for QED, Feynman Diagrams and Feynman rules for QED in configuration and momentum space, Electron- Positron scattering, Coulomb scattering of Electrons, electron – positron annihilation , Compton scattering.

Module– III

Renormalization of Qed:

Self-energy correction, vacuum polarization and vertex correction, classification of Divergences, Renormalization of mass and charge, wave function renormalization.

Recommended Books

1. *Theory of photons and electrons, J.M. Jauch and E.Rohrlich*
2. *Relativistic Quantum field, J.D. Bjorkern and S.D.Drett.*
3. *Quantum electrodynamics , A.I. Akhiezer and Berestetskl*

PHYS 501 (SEMINAR & PROJECT)

All the M.Sc. Physics Students will do a supervised Physics Project in IV Semester. Department considers it an important culmination of training in Physics learning and research. This project shall be a supervised collaborative work in Condensed Matter Physics, Electronics, Atmospheric Physics and Space sciences, Microwaves, Material Science, Nano Science or any interdisciplinary project based on Physics Principles. Physics The project will aim to introduce student to the basics and methodology of research in physics, which is done via theory, computation and experiments either all together or separately by one of these approaches. It is intended to give research exposure to students at M.Sc. level itself.

Format of Dissertation:

Title Page

M.SC. PROJECT REPORT ON TITLE OF THE PROJECT

Supervised by:
Submitted by:
Name of the Group Name 1
Name 2
Name 3
Department of Applied Science
Sri Sai University, Palampur
Session
Month Year

Page 2

(Preferably on (Guide's) letter head)

CERTIFICATE

This is to certify that the project entitled "**Title of Project**" aimed at " Project purpose" was worked upon by the following students under my supervision at Physics Laboratory in Department of Applied Science, Sri Sai University, Palampur.

Name 1 with signatures
Name 2 with signatures
Name 3 with signatures

It is certified that this is a live project done by the team and has not been submitted for any degree.

Chairman Name of Guide

Page 3

ACKNOWLEDGEMENTS

Page 4

PREFACE

Page 5

CONTENTS

Page 6

ABBREVIATIONS USED

Page 7
LIST OF TABLES
Page 8
LIST OF GRAPH AND FIGURES

Page 9
INTRODUCTION
Chapter 1
Chapter 2
Chapter 3
…………..
Concluding remarks
END OF REPORT
Appendices
Source code and other relevant appendices

Bibliography /References.

INSTRUCTIONS FOR THE FORMATTING AND PRESENTATION OF PROJECT REPORT

The following instructions be strictly adhered to while formatting the Project Report.
Top margin = 2.54 cm
Bottom margin = 2.54 cm
Left margin = 3.17 cm
Header and Footer = 3.17 cm
Page Size = 1.25 cm (from edge)
Font = Times new Roman
- Body test size………… 12pt
- Chapter headings ……… 18 pt Bold
- Section heading …………16 pt Bold
- Sub Section heading ……14 pt Bold

Header and footers
- Header ……………… Chapter Name
- Footer……………….. Page number

Spacing before and after body text paragraph 6 pt uniform
Spacing before section headings Zero
Spacing after section headings 12
Line spacing 1.5 lines
Tables………………………………Centered, captions must.
Diagrams……………Centered, captions must, No text around Diagrams
Page Numbering scheme for entailing chapters…. Roman Numbers
Page Numbering scheme for entailing pages of chapters ….. Arabic
The pages starting from Certificate to list of graph and figures must be enlisted in chronological sequence using Roman Numbers.
Final Project report must be - Hard Bound

-Rexene Covered
- Golden text to be used on cover
- Print details on side strip also in text book format.
- Paper to be used Bond paper

TOTAL NUMBER OF COPIES TO BE SUBMITTED ALONG WITH SOFT COPY ON A CD 4 COPIES

LAST DATE FOR SUBMISSION OF PROJECT REPORT

Last date for submission of project report shall be one month after the last theory paper examination of IV Semester for regular students.