M.Sc Physics (Semester Pattern)

CURRICULUM

(With effect from the academic year 2017-2018)

SEMESTER I

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1411	Mathematical Physics	5	3 hrs	40	60	100
PH1712	Classical Mechanics & Statistical Mechanics	5	3	40	60	100
PH1713	Laser and Spectroscopy	5	3	40	60	100
PH142L1	Practical – I –General	5*	To be continued in Semester II			
PH142L2	Practical - II - Electronics	5*	To be continued in Semester II			
SEMESTER II						
PH1721	Electromagnetic Theory	5	3	40	60	100
PH1422	Quantum Mechanics - I	5	3	40	60	100
PH1423	Solid State Physics – I	5	3	40	60	100
PH1724	Electronics	5	3	40	60	100
PH142L1	Practical – I –General	-	6	40	60	100
PH142L2	Practical - II - Electronics	-	6	40	60	100
SEMESTER III						
PH1731	Digital electronics and microprocessors	5	3	40	60	100
PH1432	Quantum Mechanics – II	5	3	40	60	100
PH1433	Solid State Physics – II	5	3	40	60	100
PH1734	Nuclear and Particle Physics	5	3	40	60	100
PH143L3	Practical – III (Advanced Physics)	5	4	40	60	100

* total credits for one year

SEMESTER IV

PH1441	Nano Physics	5	3	40	60	100
PH1442	Numerical methods and C Programing (Elective)	5	3	40	60	100
PH1443	Energy Physics (Elective)					
PH1444	Ultrasonics & Applications (Elective)					
PH1445	Crystal Growth (Elective)					
PH1446	Advanced Instrumentation (Elective)					
PH144P1	Project	20	-	80	80	160
	Viva		-	-	40	40
Total		100				1800

Syllabus

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1411	Mathematical Physics	5	3	40	60	100

UNIT I: VECTOR FIELDS

Concept of vector and scalar fields – Gradient, divergence, curl and Laplacian – Vector identities – Line integral, surface integral and volume integral – Gauss theorem, Green's Theorem, Stoke's theorem and applications – Orthogonal curvilinear coordinates – Expression for gradient, divergence, curl and Laplacian in cylindrical and spherical
co-ordinates

UNIT 2 : MATRIX THEORY

Solution of linear algebraic equations – rank of a matrix – Characteristic equation of a matrix – Eigen values and eigen vectors – Trace of a matrix – Cayley – Hamilton theorem-diagonalization of matrices – Hermitian and Unitary matrices – Direct sum and products of matrices – Sylvester's theorem.

UNIT 3: COMPLEX ANALYSIS

Functions of complex variables – Differentiability -- Cauchy-Riemann conditions – Complex integration – Cauchy's integral theorem and integral formula – Taylor's and Laurent's series – Residues and singularities - Cauchy's residue theorem – Evaluation of definite integrals.

UNIT 4: SPECIAL FUNCTIONS

Gamma and Beta functions – Sterm-Liouville problem – Legendre, Associated Legendre, Bessel, Laugerre and Hermite differential equations : series solution – Rodriguez formula – Generating functions – Orthogonality relations – Important recurrence relations.

UNIT 5: GROUP THEORY

Basic definitions – Multiplication table – Subgroups, Co-sets and Classes – Direct Product groups – Point groups - Space groups – Representation theory – Homomorphism and isomorphism– Reducible and irreducible representations – Schur's lemma – The great Orthogonality theorem – Character table -- C3v and D3h as examples – Elementary ideas of rotation groups.

Books For Study and Reference :

1. A.K. Ghatak, I.C. Goyal and A.J. Chua, Mathematical Physics (McMillan, New Delhi1995).

2. P.K. Chattopadhyay, Mathematical Physics (Wiley, Eastern, New Delhi, 1990)

3. W.W.Bell, Special Functions for Scientists and Engineers (Van Nostrand, New York, 1968) .

4. A.W. Joshi, Elements of Group Theory for Physicists (Wiley Eastern, New Delhi, 1971).

5. F.A. Cotton, Chemical Applications of Group Theory (Wiley Eastern, New Delhi, 1987).

6. Monte Carlo : Basics, K.P.N. Murthy, ISRP, Kalpakkam, 2000.

7. Sathyaprakash, Mathematical Physics

8. H.K.Dass – Mathematical Physics

9. B.D.Guptha – Mathematical Physics

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1712	Classical Mechanics & Statistical Mechanics	5	3	40	60	100

UNIT - I CANONICAL TRANSFORMATION

Lagrangian and Hamiltonian functions, Poisson's Brackets Invariance - Equation of Motion in Poisson Bracket Notation.
Equations of Canonical Transformations, Hamilton-Jacobi equation for Hamilton's Principle Function- Separation of Variables-Harmonic Oscillator Problem in H-J Method.

UNIT - II RIGID BODY DYNAMICS

Generalized coordinates for Rigid Body Motion - Euler Angles-Angular Velocity, Angular Momentum of rigid body-Moments and Products of Inertia - Rotational Kinetic Energy-Moment of Inertia of a Rigid Body-Equation of Motion of a Rigid Body - Euler's Equations.

UNIT -III MECHANICS OF SMALL OSCILLATIONS

Stable and Unstable Equilibrium - Two Coupled Oscillators - Formulation of the Problem - Properties of T,V and ω - Normal Coordinates and Normal Frequencies of Vibration - Systems few Degrees of Freedom - Parallel Pendulum - Double Pendulum - Triple Pendulum (degenerate system) - Linear Triatomic Molecule.

UNIT - IV KINETIC THEORY

Distribution function and its evolution -- Boltzmann transport equation and its validity – Maxwell-Boltzmann distribution law of velocity of molecules – Transport phenomena – Mean free path – Conservation laws.

UNIT - V QUANTUM STATISTICAL MECHANICS

Basic concepts – Partition function and properties – Quantum ideal gas – Bose-Einstein and Fermi - Dirac statistics –Distribution laws – Equations of state -- Bose-Einstein condensation.

Books for Study and Reference

1. Classical Mechanics- S.L.Gupta, V. Kumar &H.V.Sharma –Pragati Prakashan Meerut (1987).
2. Classical Mechanics- H. Goldstein-Addison Wesley, London (2001).
3. Classical Mechanics of Particles & Rigid Bodies-KiranC.Gupta-Wiley Eastern Ltd (1988).
4. Classical Mechanics-S.N. Gupta (1970).
5. Mathematical Physics- SathyaPrakash-Sultan Chand & Sons (2014).
6. Mathematical Physics-B.S. Rajput- Pragati Prakashan- Meerut
7. Mathematical physics by P.K. Chattopadhayay-New Age International-NewDelhi – (2015).
8. Mathematical Physics-P.P. Gupta, Yadav & Malik-KedarnathRamnath-Meerut (1984).
9. Numerical Methods in Science & Engineering- M.K.Venkataraman - National Publishing, Chennai (1977).
10. Numerical Methods-A. Singaravelu-Meenakshi Publishing (2008).
11. Statistical Mechanics – Guptha, Kumar and Sharma (2013).

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1713	Laser and Spectroscopy	5	3	40	60	100

UNIT – I INTRODUCTION TO LASER PHYSICS

Laser principles - Principles —Einstein Theory – derivation of Einstein coefficients - Gas Laser – He-Ne laser, CO_2 laser - Solid state Laser –Nd- YAG laser – Dye Lasers – Tunable Lasers - Operation principle and design - Output characteristics -, Applications of Lasers in Medicine, Communication and Holography.

UNIT - II ATOMIC & MICROWAVE SPECTROSCOPY

Spectra of Atoms - Normal Zeeman Effect - Anomalous Zeeman Effect - Magnetic Moment of Atom and the G Factor - Lande's 'g' Formula - Paschen Back Effect - Hyperfine Structure of Spectral Lines.

Microwave Spectroscopy - Theory of Microwave Spectra of Linear, Symmetric Top Molecules – Techniques and Instrumentation - Hyperfine Structure.

UNIT – III INFRARED & RAMAN SPECTROSCOPY

IR Spectroscopy: Basic principles of FTIR Spectroscopy- Theory of IR Rotation-Vibration Spectra of Gaseous Diatomic Molecules –Anharmonic oscillator – Instrumentation and Techniques – Applications

Raman Spectroscopy: Classical and Quantum Theory of Raman Effect - Rotation Vibration Raman Spectra of Diatomic and Polyatomic Molecules– Instrumentation and Techniques – Applications.

UNIT – IV UV & NQR SPECTROSCOPY

UV-Visible spectroscopy **:** Principle, Theory and instrumentation - sampling techniques-applications in industries.

NQR Spectroscopy: General Principle - instrumentation -Interpretation of NQR Spectroscopy.

UNIT – V NMR & ESR SPECTROSCOPY

NMR Spectroscopy: Basic Principles – Bloch Equation - Relaxation Processes - Experimental Technique - Principle and Working of High Resolution NMR Spectrometer - Chemical Shift

ESR Spectroscopy : Basic Principles – Experiments -ESR Spectrometer - Reflection Cavity and Microwave Bridge - ESR Spectrum - Hyperfine Structure.

Text Books

1. C.N. Banwell and E.M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4th Edition, Tata McGraw-Hill Publications, New Delhi (1994).
2. G. Aruldas, Molecular Structure and Spectroscopy, Prentice - Hall of India Pvt.Ltd., New Delhi (2001).
3. D.N. Satyanarayana, Vibrational Spectroscopy and Applications, New Age International Publications, New Delhi (2004).
4. Raymond Chang, 1980, Basic Principles of Spectroscopy, McGraw-Hill Kogakusha Laser and Non Linear optics – B.B.Laud, New Age International,3rd edition (2011).

Reference Books

1. Straughn and Walker, Spectroscopy, Vol I &II Chapman and Hall (1967).
2. Atta Ur Rahman, Nuclear Magnetic Resonance, SpingerVerlag, New York (1986).
3. Towne and Schawlow, Microwave Spectroscopy, McGraw-Hill (1995).
4. Raymond Chang, Basic Principles of Spectroscopy, McGraw-Hill, Kogakusha, Tokyo (1980).
5. D.A. Lang, Raman Spectroscopy, McGraw-Hill International, N.Y. 6. John Ferraro, Introductory Raman Spectroscopy, Academic Press (2008).

Subject Code	Subject	Credit/ Hrs. per week	Duration of Universit y Exam	Marks		Total Marks
				CIA	External Exam	
PH1721	Electromagnetic Theory	5	3	40	60	100

UNIT I: ELECTROSTATICS

Potential and Field due to an Electric Dipole-Dielectric Polarization-External Field of a Dielectric Medium-Guass' Theorem in a Dielectric-Electric Displacement Vector D-Linear Dielectrics - Relations connecting Electric Susceptibility χe, Polarization P, Displacement D and Dielectric Constant-Boundary Conditions of Field Vectors.

Molecular Field-ClausiusMosotti Relation for Non-Polar Molecules-Langevin Debye Formula for Polar Molecules, Electrostatic Energy and Energy Density -Molecular polarizability and electric susceptibility –Electrostatic energy in dielectric media.

UNIT II: MAGNETOSTATICS

Biot and Savart law – Force between current carrying conductors – Differential equations of magnetostatics and Ampere's law – Vector potential – Magnetic field of a localized current distribution, magnetic moment – Force and torque and energy of a localized current distribution - Macroscopic equations – Boundary conditions on B and H– Uniformly magnetized sphere.

UNIT III: ELECTROMAGNETICS

Faraday's law of induction – Maxwell's displacement current – Maxwell equations - Maxwell equations in terms of vector and scalar potentials – Gauge transformations – Lorentz gauge, Coulomb gauge – Poynting's theorem.

UNIT IV: ELECTROMAGNETIC WAVES

Electromagnetic waves in vacuum – Energy and momentum of EMW – EMW in matter – Propagation in linear media – Reflection and transmission at Normal incidence – Reflection and Transmission at Oblique incidence – Implications: Laws of incidence and reflectance, snell's law, Brewster law – Fresnel's equations.

UNIT V: PLANE ELECTROMAGNETIC WAVES AND WAVE PROPAGATION

Plane waves in a non-conducting medium – Linear and circular polarization, Stokes parameters – Reflection and refraction of electromagnetic waves at a plane interface between dielectrics – Fields at the surface of and within a conductor – Propagation of electromagnetic waves in hollow metallic cylinders: Cylindrical wave guides -- TM and TE modes – Wave propagation in optical fibers.

Books For Study and Reference

1. J. D. Jackson, Classical Electrodynamics, Wiley Eastern Ltd., New Delhi, (1999).
2. D. Griffiths, Introduction to Electrodynamics, Prentice-Hall, New Delhi, (1999).
3. R. P. Feynman et al, The Feynman Lectures on Physics, Vol.II, Narosa, New Delhi, (1989).
4. Sathyaprakash , Electro Magnetic Theory, Kedarnath, (2012).
5. Electromagnetic theory – Chopra and Agarwal, KNath & Co, (2012).
6. Electromagnetic theory – B.B.Laud, Wiley-Blackwell; 2nd Edition edition, (1987).

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1422	Quantum Mechanics - I	5	3	40	60	100

UNIT 1: FUNDAMENTALS OF WAVE MECHANICS

Dual nature of light and matter waves – Experimental evidence for matter waves – Davison - Germer experiment – de Broglie wavelength associated with electron – Wave velocity & group velocity – Relation between phase velocity and group velocity – Equation of motion of matter waves – Schrodinger's time independent and time dependent equation.

UNIT 2 : GENERAL FORMULATION IN WAVE MECHANICS

Physical Interpretation of wave function – Orthogonal & normalized wave functions – Expectation values – Conditions satisfied by wave function – Operators associated with observables – Energy, momentum and position operators – Uncertainty relations – Bra & Ket vectors – Schrodinger, Heisenberg & Interaction pictures.

UNIT 3: APPROXIMATE METHODS

Time Independent Perturbation Theory in Non - Degenerate Case – First and Second order Perturbation - Ground State of Helium Atom-Degenerate Case - Stark Effect in Hydrogen-Variation Method & its Application to Hydrogen Molecule-WKB Approximation.

UNIT 4: SCATTERING THEORY & MATRICES IN QUANTUM MECHANICS

Scattering theory: Scattering cross section – Green's function approach - Born Approximation – Partial wave analysis.

Direct sum & direct product – Null, Unit and constant Matrices – Spur determinant and inverse of a matrix – Transpose & Conjugate of matrix – The conjugate transpose of a matrix – Symmetric & Antisymmetric matrices – Hermitian and skew hermitian – Hilbert space – Matrix form of wave function – Operators & matrices – Eigen value problem.

UNIT 5: THEORY OF RADIATION (SEMI CLASSICAL TREATMENT)

Einstein's Coefficients - Spontaneous and Induced Emission of Radiation from Semi Classical Theory - Radiation Field as an Assembly of Oscillators - Interaction with Atoms-Emission and Absorption Rates - Density Matrix and its Applications.

Books for Study and References:

1. Quantum Mechanics-Gupta, Kumar & Sharma
2. Quantum Mechanics-Satyaprakash
3. Quantum Mechanics-L.I. Schiff- McGraw Hill
4. Quantum Mechanics-E. Merzbacher-Wiley and Sons
5. A Text Book of Quantum Mechanics-P.M. Mathews & K.Venkatesan-Tata McGraw Hill
6. Introduction to Quantum Mechanics-A.K. Chandra-Tata McGraw Hill
7. Quantum Mechanics-A.K. Ghatak and S. Loganathan-McMillan India
8. Quantum Mechanics-Messiah (North Holland), K.Venkatesan-Tata McGraw Hill

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1423	Solid State Physics – I	5	3	40	60	100

Credits : 5

UNIT 1 : X-RAY AND ITS APPLICATION

Interaction of X-ray with matter - Absorption of X-rays – Lattice,Crystal,Direction,Miller indices - Elastic Scattering from a perfect lattice - The reciprocal lattice and its application to diffraction Techniques - the Laue, powder and rotating crystal methods - Crystal structure factor and intensity diffraction maxima - Extinction due to lattice centering - Point defects, line defects and planar (stacking) faults.

UNIT 2: FREE ELECTRON THEORY

Free electron Fermi gas - Energy levels of orbital in one and three dimensions - Electrons in a periodic lattice - Bloch theorem -–Kronig –Penney Model- Band theory of solids Classification of solids effective mass - Tight binding - Cellular and pseudo potential methods - Fermi surface - De Hass Von Alfen effect.

UNIT 3 : DIELECTRIC PROPERTIES

Atomic and molecular Polariziblity - Claussius-Mossotti relation - Types of polarzibility - Dipolar polarizibility - Frequency dependence of dipolar polarizibility, ionic and electronic polarizibilty - Hall effect - Quantum Hall Effect – Magneto Resistance.

UNIT 4 : MAGNETIC PROPERTIES

Weiss Theory of Ferromagnetism - Heisenberg model and molecular field theory - Spin waves and magnons - Curie-weiss law of susceptibility - Ferri and anti-Ferro-magnetic order - Domains and Bloch-wall energy.

UNIT 5 : SUPERCONDUCTIVITY

Concept of superconducting state - Thermo-dynamical properties of Superconductors - London’s equation and penetration depth - Magnetic properties and critical magnetic fields - Meissner effect - Flux quantization.

Books for Study and References:

1. Solid State Physics : Kittle
2. Solid State Physics : Aschroft & Mermin
3. Introduction to Solid State Physics : L.V. Azaroff
4. Crystellographic Solid State Physics. : Verma & Srivastava
5. Solid State Physics : A.J. Dekker
6. Principles of Condense Matter Physics : P.M. Chaiken& T.C. Lubensky
7.Solid State Physics – Guptha ,Kumar and Sharma
8. Solid State Physics – Asokamani

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1724	Electronics	5	3	40	60	100

UNIT – I SEMICONDUCTOR DEVICES

FET as a Voltage Variable Resistor-Common Source Amplifier at High Frequencies - Common Drain Amplifier at High Frequencies-Silicon Controlled Rectifier (SCR)-Characteristics-SCR Power Control-Tunnel Diode Optoelectronics: Photo Resistor-Photo Diode-Photo Transistor-LED-Photo Voltaic Effect-Solar Cells.

UNIT -II OPERATIONAL AMPLIFIER

Operational amplifier characteristics – Inverting and non-inverting amplifier – Instrumentation amplifier – Voltage follower – Integrating and differential circuits – Log & antilog amplifiers – Op-amp as comparator – Voltage to current and current to voltage conversions-active filters: low-pass, high pass, band pass & band rejection filters-Solving simultaneous and differential equations.

UNIT – III OP-AMP APPLICATIONS (OSCILLATORS AND CONVERTORS)

Twin-T oscillators – triangular, saw-tooth and square wave generators-Schmitt's trigger – Multiplexer and demultiplexers- sample and hold circuits – Voltage control oscillator – phase locked loops. Basic D to A conversion: weighted resistor DAC – Binary R-2R ladder DAC – Basic A to D conversion: counter type ADC – Successive approximation converter – dual slope ADC.

UNIT – IV IC FABRICATION AND IC TIMER

Basic monolithic Ics – epitaxial growth – masking –etching impurity diffusion fabricating monolithic resistors, diodes, transistors, inductors and capacitors – Circuit layout contacts and inter connections – Charge coupled device – Applications of CCDs.555 timer description of the functional diagram – monostable operation – applications of mono shots – Astable operation-Pulse generation.

UNIT – V MICROWAVES AND POWER AMPLIFIERS

Microwaves : Klystron – Magnetron – Travelling wave tubes – Microwave propagation through wave guides – Attenuators – Crystal detection – Measurement of SWR – Transmitters and receivers

Voltage regulation:- IC 723 voltage regulator- Low /High Voltage regulator-current limit protection-current Fold back- current boosting - Swtiching regulator –SMPS.

Books for References

1. T.F.Schubert and E.M.Kim, Active and Nonlinear Electronics, John Wiley Sons, New York (1996).
2. L.Floyd, Electronic Devices, Pearson Education, New York (2004).
3. Dennis Le Crissitte, Transitors, Printice Hall India Pvt. Ltd (1963).
4. J.Milman and C.C. Halkias, Integrated Electronics, McGraw Hill (1972).
5. A. Mottershed, Semiconductor Devices and Applications, New Age Int Pub.
6. M.Goodge, Semiconductor Device Technology McMillan (1983).
7. S.M.Sze, Physices of Semiconductor Devices, Wiley-Eastern Ltd (1981).
8. Milman and Taub, Pulse, digital and switching waveforms, McGraw Hill (1965).
9. Ben.G.Streetman, Solid state electronic devices, Prentice Hall, Engle wood cliffs, NJ (1999).
10. R.A.Gayakwad, Op-Amps&Linear integrated circuits, Printice Hall India Pvt Ltd (1999).
11. Atwatts, Introduction to Microwave theory (McGraw Hill Ltd, Singapore, (1980).

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH142L1	Practical – I –General	5	6	40	60	100

Any Ten Experiments

1. Young's Modulus-Elliptical Fringes
2. Young's Modulus - Hyperbolic Fringes (Cornu's Method)
3. Rydberg's Constant-Solar Spectrum
4. Determination of Audio Frequencies-Bridge Method
5. Thermal Conductivity-Forbe's Method
6. Thermistor-Temperature Coefficient and Band Gap Energy Determination
7. Biprism on Optical Bench-Determination of Wavelength
8. Measurement of rotation of plane of polarization - Polorimeter
9. Fabry-Perot Interferometer-Study of Fine Structure
10. Plateau Characteristics – verification of inverse square law G.M.Counter
11. Aluminium absorption co-efficient - GM Counter
12. Viscosity of a Liquid-Mayer's Oscillating Disc
13. Polarizability of Liquids
14. Stefan's constant
15. Determine the wavelength of the Laser source using a diffraction grating and then use it to determine the grating constant of a different grating.

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH142L2	Practical - II - Electronics	5	6	40	60	100

Any Ten Experiments

1. IC Regulated - Dual Power Supply Construction
2. Universal Building blocks, De Morgan's theorems
3. Half Adder, Full Adder
4. Wien's Bridge Oscillator- Op-Amp
5. Wave Form Generators- Op-Amp
6. Differential Amplifier- Op-Amp
7. Sign Changer, Scale Changer, Adder and Subtractor- Op-Amp
8. CRO-Differentiating, Integrating, Clipping and Clamping Circuits, Square Wave testing
9. Electronic Switch-IC 555
10. Measurement of Hall Coefficient of given Semiconductor-Estimation of Charge Carrier Concentration
11. Shift Register-Digital IC's
12. Schmitt Trigger
13. Phase-Shift Oscillator- Op-Amp
14. UJT Relaxation Oscillator
15. SCR-Characteristics and an Application

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1731	Digital Electronics And Microprocessors	5	3	40	60	100

UNIT I : DIGITAL CIRCUITS & DEVICES

Logic Families - Combinational Logic - Function of Combinational Logic - Flip Flops and other Multivibrators – Counters - Shift Registers - Memories RAM, ROM, PROM, EPROM - Charge Coupled Devices (CCD).

UNIT II : MICROPROCESSOR ARCHITECTURE AND INSTRUCTION SET

8085 microprocessor architectures – Various registers – Central processing unit of micro computers – Timing and control unit – Instruction and data flow – System timings – Examples – Instruction set -- Data transfer group – Logical group – Branch group – Stack and I/O control instructions – Addressing modes.

UNIT III : SOFTWARE PROGRAMS (8085 ONLY)

Addition – Subtraction – Multiplication – Division – BCD arithmetic – Searching an array of a given number – Choosing the biggest and smallest numbers from a list – Ascending and descending orders – Square root of a number – Time delay – Square wave generator.

UNITI IV : INTERFACING MEMORY AND I/O DEVICES

Interfacing memory and devices - I/O and Memory mapped I/O - Type of Interfacing devices - Data transfer schemes - Programmed and DMA data transfer Schemes Programmable Peripheral Interface (8255A) - 8253 Timer Interface - DMA controller(8257) - Programmable Interrupt controller (8259) – Programmable Communication Interface (8251).

UNIT V: MICROCONTROLLER

Architecture of Microcontroller 8051 Introduction - comparison between microcontroller and microprocessors - Architecture of 8051 - Key features of 8051 - memory organization – Data memory and prograrn memory - internal RAM organization – Special function registers - control registers – I/O ports - counters and timers - interrupt structure

Books for Study and Reference

1. R. Goankar, Micropressor Architecture, Programming and Applications (Wiley Eastern, New Delhi, (1985).
2. B. Ram, Fundamentals of Microprocessors and Microcomputers, Dhanapet Rai & Sons, New Delhi, (1995).
3. Integrated Electronics -Millman&Halkias-Tata McGraw Hill (2001).
4. Digital Fundamentals-Floyd-UBS – (2011).
5. Digital Principles and Applications-Malvino- McGraw Hill (2011).
6. Electronic Communication Systems-George Kennedy & Davis -Tata McGraw Hill – (1993).
7. Principles of Communication Systems-Taub Schilling-TMH8. Interfacing Peripherals 825 – Douglass V. Hall (2007).
8. A. NagoorKani, Microprocessors & Microcontrollers,1st edition, RBA Publications, Chennai, (2006).

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1432	Quantum Mechanics – II	5	3	40	60	100

UNIT 1: EXACTLY SOLVABLE SYSTEMS

Linear harmonic oscillator - Solving the one dimensional Schrödinger equation - Abstract operator method – Particle in a box – Square well potential - Rectangular barrier potential – Rigid rotator – Hydrogen atom.

UNIT 2: TIME DEPENDENT PERTURBATION THEORY

Time Dependent Perturbation Theory - First and Second Order Transitions - Transition to continuum of States - Fermi Golden Rule - Constant and Harmonic Perturbation –Transition Probabilities - Selection Rules for Dipole Radiation - Adiabatic Approximation.

UNIT 3: ANGULAR MOMENTUM

Orbital Angular Momentum - Spin Angular Momentum - Total Angular Momentum Operators - Commutation Relations of Total Angular Momentum with Components – Ladder Operators - Commutation Relation of J_z with J_+ and J_- - Eigen Values of J^2, J_z - Matrix Representation of J^2, J_z, J_+ and J_- - Addition of Angular momenta - Clebsch - Gordon Coefficients and its properties.

UNIT 4: APPLICATION TO ATOMIC STRUCTURE

Central Field Approximation - Thomas Fermi Model - Hartree's Self Consistent Model - Hartree Fock equation - Alkali Atoms - Doublet Separation – Intensities - Complex Atoms – Coupling Schemes.

UNIT 5: RELATIVISTIC QUANTUM MECHANICS

Klein-Gordon equation for a free particle and in an electromagnetic field – Dirac equation for a free particle - Charge and current densities - Dirac matrices – Plane wave solution – Negative energy states – Zitterbewegung – Spin angular momentum – Spin-orbit coupling.

Books for Study and References:

1. Quantum Mechanics - Gupta, Kumar & Sharma
2. Quantum Mechanics - Sathya prakash
3. Quantum Mechanics - L.I. Schiff- McGraw Hill
4. Quantum Mechanics - E. Merzbacher-Wiley and Sons
5. A Text Book of Quantum Mechanics-P.M. Mathews & K.Venkatesan - Tata McGraw Hill
6. Introduction to Quantum Mechanics-A.K. Chandra-Tata McGraw Hill
7. Quantum Mechanics-A.K. Ghatak and S. Loganathan-McMillan India
8. Quantum Mechanics-Messiah (North Holland)

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1433	Solid State Physics – II	5	3	40	60	100

UNIT 1 : CRYSTALLOGRAPHY

Elements of crystallography – Different features of crystals – Symmetry operations – Primitive and Non primitive unit cell – Symmetry elements – Rotation axes of symmetry planes – Space lattice – Packing fraction – Lattice constants – Crystal structure.

Voids in closest packing – Rules governing packing of atoms – Polymorphism – Isomorphism – Cubic structure – (ZnS, Perovskite –Spinel structures). Bragg's law – Uses – Phase problem – Heavy atom – Isomorphous replacement – Anomalous scattering methods.

UNIT 2 : LATTICE VIBRATIONS

Elastic vibrations of continuous media – Group velocity of thermodynamic wave – Wave motion of one dimensional atomic lattice – Lattice with two atoms – Classical theory of specific heat – Dulong-Petit's law – Einstein's model – Debye model – Modification of Debye's theory – Born Karman cut off – Anharmonic crystal interactions – Free electron theory - Heat capacity of metallic elements – Electrical and thermal conductivity.

UNIT 3 : BAND THEORY OF SOLIDS

Calculation of electron and hole concentration in extrinsic semi conductor – Hall effect in semi conductors – Impurity states – Thermal ionization of impurities – Band structure of Si and Ge – Constant energy surface and the effective gap - Life time and diffusion of minority charge carriers.

UNIT 4 : TRANSPORT PROPERTIES

Boltzman transport equation for electrons and Lorentz equation – Sommerfield theory of electrical conductivity – Thermal conductivity of metals – Criticism of Sommerfield theory – Relaxation time – Mean free path in metals – The additive nature of resistivity – Mathiessen's rule – Thermoelectric effect – Magneto resistance.

UNIT 5 : OPTICAL PHENOMENA IN INSULATORS

Photo conductivity – Excitation across a gap – Simple model of a photo conductor – Traps - Excitons – Luminescensce – Activators – Thallium activated KCl – Maser – Principle.

Books for Study and Reference:

1. Solid State Physics : C. Kittel
2. Solid State Physics : A.J. Dekker
3. Solid State Physics : S.O.Pillai
4. Solid State Physics : Gupta Kumar
5. Solid State Physics – Asokamani

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1734	Nuclear And Particle Physics	5	3	40	60	100

UNIT I: Basic Nuclear Properties

Nuclear size, mass, Charge, Spin, Binding energy –Weizacker's Semi empirical mass formula – Nuclear stability – Mass parabola -- Nature of nuclear forces, Simple theory of Ground state of deuteron – Proton-neutron scattering at low energies – Scattering length, Spin dependence and Charge independence– Exchange forces – Meson theory.

UNIT II : Radioactive Decays

Alpha emission – Geiger-Nuttal law – Gamow theory – Neutrino hypothesis – Fermi theory of beta decay – Selection rules– Gamma emission – Selection rules– Internal conversion – Nuclear isomerism - Basic principles of particle detectors – Ionization chamber – Proportional counter and G.M counters – Solid state detectors – Scintillation and semiconductor detectors.

UNIT III : Nuclear Models

Liquid Drop Model: Bohr Wheeler Theory of Fission-Condition for Spontaneous Fission - Activation Energy

Shell Model: Explanation of Magic Numbers-Prediction of Shell Model-Prediction of Nuclear Spin and Parity-Nuclear Statistics-Magnetic Moment of Nuclei-Schmidt Lines

Collective Model: Explanation of Quadrupole Moments-Prediction of Sign of Electric Quadrupole Moments.

UNIT IV: Accelerators and Reactors

Cyclotron – Synchrocyclotron – Betaron – Synchrotron – Linear accelerators - Characteristics of fission – Mass distribution of fragments – Radioactive decay processes – Fission cross section – Energy in fission –Fission reactors – Thermal reactors – Homogeneous reactors – Heterogeneous reactors – Basic fusion processes - Characteristics of fusion – Solar fusion – Controlled fusion reactors.

UNIT V: Elementary Particles

Building blocks of nucleus – Nucleons, leptons, mesons, baryons, hyperons, hadrons, strange particles - Classification of fundamental forces and elementary particles – Basic Conservation laws – Additional Conservation laws : Baryonic, leptonic, strangeness and isospin charges/quantum numbers –Multiplets -- Invariance under time reversal (T) charge conjugation (C) and parity (P) – TCP theorem -- SU(3) symmetry and quark model - Basic ideas on the theories of weak and strong interactions.

Books for Study and Reference

1. K. S. Krane, Introductory Nuclear Physics, John-Wiley, New York, (1987).
2. S. B. Patel, Nuclear Physics: An Introduction, Wiley-Eastern, New Delhi, (1991).
3. B. L. Cohen, Concepts of Nuclear Physics, Tata McGraw Hill, New Delhi, (1988).
4. H. S. Hans, Nuclear Physics: Experimental and Theoretical, New Age International Publishers, New Delhi, (2001).
5. D. C. Cheng and G. K. O'Neill, Elementary Particle Physics: An Introduction, Addison- Wesley, (1979).
6. Nuclear Physics – M.L Pandya and R.P.S Yadav (1994).

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH143L3	Practical – III (Advanced Physics)	5	3	40	60	100

Any Ten Experiments

1. Magnetic susceptibility of liquids – Guoy method

2. Magnetic susceptibility of liquids – Quincke's method

3. Velocity and Compressibility of liquids – Ultrasonic interferometer

4. Michelson interferometer

5. Hg – Cu Spectrum – Hartmann's constant using spectrometer

6. Cauchy's dispersion constant

7. Molecular Constants – CN band

8. Logical operation – 8085

10. Temperature conversion - 8085

11. Code conversion - 8085

12. Decimal counter - 8085

13. Display, flash and relay of message - 8085

14. Digital to analog conversion - 8085

15. ADC interfacing - 8085

16. A/D Converters

17. D/A Converters

18. Synthesis of Nanoparticles

19. Nano thin film coating

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1441	Nano Physics	5	3	40	60	100

UNIT – I : INTRODUCTION TO NANOMATERIALS

Classification of Nanomaterials – Reason for the development of Nanomaterials – Surface energy – Surface charge density — Vander vaals attraction potential – DLVO theory.

UNIT – II : BASIC PROPERTIES OF NANOPARTICLES

Size effect and properties of Nanoparticles – Particle size – Particle shape – Particle density – Melting point, Surface tension, wettability – Specific surface area and pore – Composite structure – Crystal structure – Surface Characteristics – Mechanical property – Electrical properties – Magnetic properties – Optical property of Nanoparticles.

UNIT – III SYNTHESIS AND PROCESSING OF NANOPARTICLES

Top-down and Bottom-up approaches – Synthesis of metallic and semiconductor Nanoparticles – Physical and chemical techniques – Ball milling - laser ablation – Molecular beam epitaxy (MBE) – Inert gas condensation – Physical vapour deposition (PVD) – Plasma arching – Chemical vapour deposition (CVD) – Sol-gel techniques.

UNIT – IV : FABRICATION AND CHARACTERIZATION OF NANOSTRUCTURED MATERIALS

Zero-D, One-D and Two-D structures: Nanoparticles dispersed in various matrixes – Nanowires – Nanorods – Nanotubes – Formation and growth techniques – Carbon Nanotubes – Types and Structures –Types of Nano lithography - Microprinting – Nano print - XRD,SEM and TEM.

UNIT – V : PROPERTIES AND APPLICATIONS OF NANOMATERIALS

Melting point and lattice constant – Estimation of Particles size – XRD, Quantum size effect – Surface Plasmon resonance – Electrical conductivity – Excitons – Scattering – Quantum transport – Magnetic behavior of Nanoparticles – Dilute magnetic semiconductor – Super Para magnetism – Application in molecular and nano devices: Nanodots – Molecular recognition – Quantum dot wells.

Books for Reference:

1. Nano – The essentials, T.Pradeep, Mc Graw Hill Education, Chennai.
2. Nanosystems, Drexler E, John Wiley, CNY.
3. Nanotechnology, AIP Press, Springer – Verlag, Gregory Timp, Editor, 1999, New York, (ISBN 0 – 387 – 98334 – 1).
4. Nanoscale charterization of surfaces & Interfaces, N.JohnDinardo, Weinheim Cambridge: Wiley – VCH, 2000 2nd Ed.
5. Semiconductors for Micro and Nanotechnology – An introduction for engineers, Jan Korvink & Andreas Greiner, Weinheim Cambridge: Wiley – VCH, 2001.
6. Nanomaterials and machines, W.Kamliu et al John Wiley.
7. Hand book of Nanoscience, Engineering and Technology – The Electrical Engineering hand Book series.

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1442	Numerical methods and C Programming (Elective)	5	3	40	60	100

Numerical methods and C Programming

UNIT-I : Numerical methods

Solutions of equations - Simple iterative methods - Newton - Raphson method - Numerical Integration - Simpson's 3/8 rule - Runge Kutta method II order - Solution of Simultaneous equation .

UNIT-II : Programming in C

Introduction –Importance of C language - Basic structure of C Programming - Character set - constants - Keywords - Identifiers - Variables - declaration of variables - Assigning values to variables - defining symbolic constants – Types of Operators - Arithmetic, relational, logical, assignment, increment, decrement conditional and special type conversion in Expressions.

UNIT-III : Operators, Arrays and Strings

Arrays:Introduction - one, two and multi-dimensional arrays - Initializing two dimensional arrays - Declaring and Initialising string variables - Reading and Writing Strings on the screen - Arithmetic operations on strings.

UNIT-IV : Simple Programmes

Multiplication programme - Return values and their types - Calling Functions - Categories of functions - Matrix multiplication - Diagonalisation and inversion - Solution to simultaneous equations - differential and integral equations.

UNIT- V: Principles of Scientific Research

Identification of the problem - Literature survey - Reference collection - Familiarity with ideas and concept of investigation - Internet Browsing - Drawing Inferences from data - Qualitative and Quantitative analysis - Results - Seminar - Synopsis writing - Art of writing a Research paper and Thesis - OHP Presentation- Power point presentation

Books for Study

1. J. Anderson B.H. Burston and M. Poole, 1977, Thesis and Assignment writing, Wiley Eastern, London.

2. Rajammal.P. Devadas, 1976, A hand book of methodology of research, RMM Vidyalaya Press.

3. E. Balagurusamy, Numerical methods, Tata McGraw-Hill

4. V. Rajaraman, 1993,Computer oriented Numerical Methods, 3rd Edition, PHI, New Delhi.

5. S.S. Sastry, Introductory Methods of Numerical analysis, PHI, N.Delhi

6. V. Rajaraman, Programming in C, PHI, New Delhi.

Books for Reference

1. S.D. Conte and C.de Boor, 1981, Elementary Numerical analysis-an algorithmic approach, 3rd Edition, McGraw Hill.

2. B.F. Gerald, and P.O. Wheatley, 1994, Applied Numerical analysis, 5th Edition, Addison-Wesley, M.A.

3. B. Carnagan, H.A. Luther and J.O. Wilkes, 1969, Applied Numerical Methods, Wiley, New York.

4. S.S. Kuo, 1996, Numerical Methods, and Computer, Addison-Wesley.

5. W.H. Press, 1992, Numerical Recipes in C, 2nd Edition, Cambridge University Press.

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1443	Energy Physics (Elective)	5	3	40	60	100

UNIT I : CONVENTIONAL AND NON – CONVENTIONAL ENERGY SOURCES

Man and Energy, world production and reserves of commercial energy sources – fossil fuel, hydroelectric power, Nuclear energy, Indian energy scenario – fossil fuel, hydroelectric power, Nuclear energy power plants, Non-conventional Energy Sources – Scope and potential, Concept of Solar constant, Solar intensity on earth's surface, Direct and diffused radiation, Measurements of solar radiations.

UNIT II : PHOTOVOLTAIC CONVERSION TECHNOLOGIES

Crystalline Solar Cell Technology – Purification of Silicon, conversion of metallurgical grade silicon to semiconductor grade – Czochralski crystalline silicon formation process, Process involved in the conversion of silicon wafer to solar cell, Modular design of solar cell, Power generation through satellite solar power station, Advantages and disadvantages of solar cell.

UNIT III : PHOTO THERMAL CONVERSION TECHNOLOGIES

Basic principles of flat plate collector (FPC), elements of flat plate collector, selective coatings and ideal characteristics of absorber plate of flat plate collector, Solar cooker, Hot water system, Solar dryer, Solar pond, Design of central tower receiving system for power generation, Essential elements of Solar concentrators, Parameters and efficiency of solar concentrators, Cylindrical parabolid concentrators (PTC), Compound parabolid concentrators (CPC), Applications of solar concentrators.

UNIT IV : BIOGAS

Principles of biogas production, The anaerobic digestion process, Types of systems (Standard and high rate system) Proportion of gases in biogas, Design of the plant, process control consideration (Temperature and pH), gas production, gas collection, gas utilization, Advantages and disadvantages of biogas plant.

UNIT V : FUEL CELLS

Hydrogen as source of energy, photo electrochemical cell, source of hydrogen, solar hydrogen through electrolysis and photo catalytic process, hydrogen storage, brief discussion of various process, concept of fuel cell, thermodynamics of fuel cell, merits and demerits of fuel cell.

Books for Reference:

1. Solar Energy – S.P.Sukhatme (TMH)
2. Solar Energy – Garg and Prakash (PHI)
3. Solar Cells – M.A. Green (PHI)
4. Biogas Technology – B.R.Veena (Ashish Pub. House)
5. Non Conventional Energy Sources – G D Rai

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1444	Ultrasonics & Applications (Elective)	5	3	40	60	100

UNIT – I : GENERATION OF ULTRASONIC WAVES

Production of Ultrasonic waves – Low and High Frequency waves – Longitudinal and Transverse Modes – Piezoelectric and Magnetosriction Transducers.

UNIT – II : PROPAGATION OF ULTRASONIC WAVES IN LIQUIDS AND SOLIDS

Adiabatic Compressibility – Intermolecular Free length, Internal Pressure and their excess properties – complex formation – detection of Hydrogen bonding using ultrasonic method - Stress, strain, and displacement relations – Elastic constants – Propagation of elastic waves in ferromagnetic, ferroelectric materials.

UNIT – III : VELOCITY AND ATTENUATION MEASUREMENTS

Velocity and attenuation measurement in solids and liquids – stationary and continuous wave method – Pulse-echo method (Direct and interference technique)

UNIT – IV : ULTRASONIC INSTRUMENTATION

Ultrasonic instrumentation - low intensity devices, pulse echo overlap and swing around technique - flaw detection, scanning methods - A, B and C scan techniques.

Low intensity methods for characterizing structure and interaction - high intensity waves - cavitations, emulsification and cleaning.

UNIT – V : ULTRASONIC APPLICATIONS

NDT- Medical applications – Ultrasonography – Scanning modes - A Scan –B Scan - Industrial applications

Books for Reference:

1. Fundamental of Ultrasonics – Jack Blitz – Butterworths – London.
2. Introduction to chemical Ultrasonics – M.J.Blandamer – Academic Press – London.
3. Ultrasonics – Bemsomcarlin – McGraw Hill.
4. Ultrasonic methods in Solid State Physics – John Truell and others – Academic Press.
5. Physical Acoustics – W.P.Mason – Academic Press.
6. Science and Technology of Ultrasonics – Baldev Raj and Others – Narosa.

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1445	Crystal Growth and Characterization (Elective)	5	3	40	60	100

UNIT – I : CRYSTAL GROWTH FROM SOLUTION

Main categories of crystal growth methods – The chemical Physics of Crystal growth – Solid growth techniques – Melt growth techniques – Solution growth methods – Vapour phase growth - Choosing crystal growth methods.

Basic requirements – Crystallization apparatus – Saturation and seeding – Factors that influence the perfection of the final crystal – Control of crystal morphology.

UNIT – II : CRYSTAL GROWTH IN GEL MEDIA

Various methods of gel growth – Growth mechanism – Morphologies of various gel grown crystals.

UNIT – III : METHODS OF CRYSTAL GROWTH

Material considerations – Crystal growth – Solid solutions and impurities – Growth control – Special techniques –Crystal pulling, Czochralski method

UNIT – IV : STRUCTURAL CHARACTERIZATION OF CRYSTALS

Different probes for structure analysis – Principles of X-ray diffraction – Experimental methods in structure analysis – Steps in crystal structure analysis – Structure determination – Structure refinement.

UNIT–V : CRYSTALLINE PERFECTION AND ELECTRICAL CHARACTERIZATION

Volume, Area, Line and point defects – Threshold concentration of defects in crystals – Methods of detecting imperfections.

Two probe method to determine dielectric constant, electrical conductivity and thermo electric power.

Books for reference:

1. Crystal Growth Edited by Brain R. Pamplin (2^{nd} Edn. Pergamon Press, Oxford, 1980)

2. Crystal in Gels and Liecegand Rings by Heinz K. Henisch (Cambridge University Press, Cambridge, 1988).

3. Crystal Structure Analysis by C.Mahadevan in Horizons of physics (Vol. II) edited by Narendra Nath and A.W.Joshi. (New Age International Publishers, New Delhi, 1996).

Articles for Study :

1. Crystal Growth in Gel media by *C.Mahadevan* (Bulletin of IAPI, 5(9), 1988, 243 – 245).

2. Crystal Growth in Gel media by *A.R.Patel and A.Venkateswara Rao* (Bulletin of Materials Science, 4(5), 1982, 527 – 528).

3. A Versatile setup for determination of Dielectric Constant, Electrical Conductivity and Thermo electric power by *A.T.Seshadri, V.K.Vijayaraghavan and G.Balakrishnan* (Bulletin of IPAT, 10(5), 1993, 146 – 148).

Subject Code	Subject	Credit/ Hrs. per week	Duration of University Exam	Marks		Total Marks
				CIA	External Exam	
PH1446	ADVANCED INSTRUMENTATION TECHNIQUES (Elective)	5	3	40	60	100

ADVANCED INSTRUMENTATION TECHNIQUES

UNIT-I: TRANSDUCERS :

Classification of Transducers - Principle, construction and working of Thermistor, capacitive transducers. Measurement of non-electrical quantities - Strain, Displacement, temperature, Pressure and Force.

UNIT – II: DIGITAL INSTRUMENTATION:

Principle, block diagram and working of: Digital Multimeter, Digital Frequency counter, Digital PH meter, Digital conductivity meter, Digital storage Oscilloscope and Q-meter.

UNIT – III: SPECTROPHOTOMETER (INSTRUMENTATION ONLY) :

UV-VIS, FTIR, AFM, SEM, TEM, Spectrophotometer – X-ray – X-ray diffractometer - X-ray fluorescence – Basic Principles of NMR, ESR and AAS

UNIT – IV: MEASURING INSTRUMENTS:

Calorimeters, PH meters – principle of measurement – electrodes – buffer solution and types of PH meters – Water pollution monitoring instruments.

UNIT – V: MEDICAL IMAGING INSTRUMENTATION:

Magnetic Resonance Imaging : Principle-Magnetic resonance phenomena-Magnetic resonance imaging-Imaging process- Instrumentation. Ultrasonic Imaging System: Principle-Construction of an ultrasonic transducer-Ultrasonic propagation through tissues-Display-A mode- B mode-M mode-TM mode-Doppler mode- Recording devices. Computed Tomography: Principle-CAT scanning-Instrumentation- Contrast scale-Scanning components.

Text Books and References:

1. A.K.Sawhney-Electrical and Electronics measurement and Instrumentation-Dhanpath Rai and Co. (Pvt. Ltd) New Delhi,2000
2. S. Ramambhadran, Electronic Measurements and Instrumentation Khanna Publications.
3. Dr.Rajendra Prasad -Electronic measurements and Instrumentation-Khanna Publishers , New Delhi,2002
4.S.M. Dhir, Electronics and Instrumentation, Khanna Publishers. Khandpur,
5. Willard.D. Merrit et.al., -Instrumental methods of analysis- CBS Publishers, New Delhi,2004
6. Gurdeep Chatwal and Sham Anand-Instrumental methods of analysis-Himalaya Publishers,New Delhi,2003.
7. M.Arumugam-Biomedical Instrumentation- Anuradha Publishers, Kumbakonam, 2001.
8. R.S.Khandpur – Hand Book of Biomedical Instrumentation –TMH-New Delhi,2004.
9. B.C.Nakra and K.K.Chawdry-Instrumentation –Measurement and Analysis- TMH, New Delhi,2004.
10. Albert D.Helfrock and William D Cooper-Modern Electronic Instrumentation and Measurement Techniques- Printice Hall of India-New Delhi, 2000
11. V.Ramasamy-Instrumentation- Swami Publications,Tamilnadu, 2005
12. S.K.Venkata Ram- Bio Medical Electronics and Instrumentation- Galgotia Publications Pvt. Ltd., New Delhi,2001