Revised Syllabus to be implemented from 2012-2013 Semester Pattern

Scheme of teaching and examination under credit based semester pattern
Semester I-III

S.No.	Semester	Theory Paper/ Practical	Teaching Scheme (Hrs/ week)			Credits	Examination Scheme					
			Th	Pr.	Total		Duration (Hrs)	Max. Marks		Total Marks	Min. Passing Marks	
								External Marks	Internal Marks		Th	Pr.
1	I	I	4		4	4	3	100		100	40	
2	I	II	4		4	4	3	100		100	40	
3	I	III	4		4	4	3	100		100	40	
4	I	IV	4		4	4	3	100		100	40	
5	I	Practical I		8	8	4	3-8*	80	20	100		40
6	I	Practical II		8	8	4	3-8*	80	20	100		40
7	I	Seminar	2		2	1	---		25	25	10	
		Total	**18**	**16**	**34**	**25**				**625**	**170**	**80**

Semester IV

S.No.	Semester	Theory Paper/ Practical	Teaching Scheme (Hrs/ week)			Credits	Examination Scheme					
			Th	Pr.	Total		Duration (Hrs)	Max. Marks		Total Marks	Min. Passing Marks	
								External Marks	Internal Marks		Th	Pr.
1	IV	I	4		4	4	3	100		100	40	
2	IV	II	4		4	4	3	100		100	40	
3	IV	III	4		4	4	3	100		100	40	
4	IV	IV	4		4	4	3	100		100	40	
5	IV	Practical I		8	8	4	3-8*	80	20	100		40
6	IV	Project		8	8	4	3-8*	80	20	100		40
7	IV	Seminar	2		2	1	---		25	25	10	
		Total	**18**	**16**	**34**	**25**				**625**	**170**	**80**

Note: Th = Theory; Pr = Practical/lab, * = If required, for two days.

Minimum Passing marks for each paper will be 40 % (minimum 40 in theory papers, 40 in each practical, 10 in seminar).

A) Pattern of Question Paper

1. Four units in each paper
2. One question on each unit
3. Q. 5 will be short answer covering all four units.
4. Duration of question paper is of 3 hours

B) Internal assessment

For the purpose of internal assessment the department will conduct three tests (with equal weight of marks). Best two scores of a student in these three tests will be considered to obtain the internal assessment score of that student.

C) Absorption Scheme

1. While switching over to semester system, failure students should get three chances to clear yearly pattern.
2. Students passing First year annual pattern shall get admission to third semester directly.
3. To get admission to the third semester, students should clear first semester including theory as well as practical. While appearing for fourth semester exam, a student must have cleared second semester.

D) Grade Point Average (GPA) and Course Grade Point Average (CGPA)

On clearing a paper, based on the cumulative score (out of 100) in that paper, a student will be given **Grade Point Average (GPA)** (Maximum of 10, and minimum of 4) for that paper on the following basis.

Score (out of 100)	**Grade Point Average** (out of 10)
90 to 100	10
80 to 89	09
70 to 79	08
60 to 69	07
55 to 59	06
50 to 54	05
40 to 49	04
Below 40	00 or fail

On clearing all the five papers in a semester, a student will be allotted a **Semester Grade Point Average (SGPA**) for that particular semester. As the pattern given above does not have differential weights for papers, the SGPA of a student for a particular semester will be the simple average of the GPA’s for all the five papers.

A student will be allotted a **Course Grade Point Average (CGPA)** after clearing all the four semesters. Again as there is no differential weight system for semesters, the CGPA of a student will simply be the average of the four SGPA's of that student.

The CGPA can be converted to the usual/ conventional divisions in the following way.

CGPA	**Equivalent class/division**
9.00- 10.00	First Class (Outstanding)
8.00 to 8.99	First Class (Excellent)
7.00 to 7.99	First Class with distinction
6.0 to 6.99	First Class
5.50 to 5.99	Higher Second Class
5.00 to 5.49	Second Class
4 to 4.99	Pass class

Revised Syllabus 2012-2013 Semester Pattern

Syllabus for Each theory paper is based on 60 clock hours of teaching.
Each lab will involve 16 clock hours per week.

M.Sc. Part I Semester I
1. Paper I: Mathematical Physics
2. Paper II: Classical Mechanics
3. Paper III: Solid State Physics I
4. Paper IV: Electrodynamics I

M.Sc. Part I Semester II
1. Paper I: Quantum Mechanics-I
2. Paper II: Numerical Methods
3. Paper III: Statistical Physics
4. Paper IV: Electrodynamics II

M.Sc. Part II Semester III
Compulsory Papers
1. Paper I: Quantum Mechanics-II
2. Paper II: Nuclear and Particle Physics-I

3. Any one of the Optional Papers from the following List

1. Materials science I
2. Atomic and Molecular Physics (Spectroscopy) I
3. Applied Electronics I
4. X-rays I
5. Nanoscience and Nanotechnology I

4. Any one of the following electives. Each one of Marks
Note: Subject of Elective paper will be different from that of optional.

1. X-Rays
2. Materials Science
3. Numerical Methods and Programming
4. Spectroscopy elective I
5. Lasers, Fibre Optics and Applications elective I
6. Digital Electronics and Microprocessors.

M.Sc. Part II Semester IV
Compulsory Papers
1. Paper I: Solid State Physics II
2. Paper II: Nuclear and Particle Physics II
3. One of the Optional paper 2 for the subject same as that chosen in Semester III

1. Materials science II
2. Atomic and Molecular Physics (Spectroscopy) II
3. Applied Electronics II
4. X-rays II
5. Nanoscience and Nanotechnology II

4. Any of the following electives. Each one of Marks
Note: Subject of Elective paper will be different from that of optional.

1. Nanoscience
2. Nonlinear Dynamics with Applications to Physics and other Sciences
3. Condensed Matter Physics
4. Electroacoustics
5. Spectroscopy elective and II
6. Lasers, Fibre Optics and Applications elective II

Semester I Paper I. Mathematical Physics;

Unit I

Curvilinear co-ordinate Systems, Physical ideas about gradient, divergence and Curl, Expressions for▼, divergence, Curl and Laplacian in curvilinear co-ordinate Systems. (Vector analysis – Newell)

Unit II

Elementary ideas about tensors, Cartesian tensors, differential of Cartesian tensors, gradient, divergence and curl , Laplacian of Cartesian tensors. Non-Cartesian tensors. Tensor densities and capacities. Differentiation of Non-Cartesian tensors, Chrisoffel symbols. gradient, divergence and curl , Laplacian of Non-Cartesian tensors

Unit III

Linear vector spaces - linear independent bases, Dimensionality, inner product, matrices, linear transformation, Matrices- Inverse, Orthogonal and Unitary matrices, Cayley Hamilton theorem, eigen vectors and eigen value problem, Diagonalization, Complete orthonormal sets of function.

Unit-IV

Linear differential equations, Special Function- Laguerre, Hermite, Legendre polynomials, Special Bessel’s function, Spherical harmonics, Generating Function and recursion relations, differential and integral forms, Fourier series, Fourier and Laplace Transform.

1.Matrices and Tensor in Physics: A.W.Joshi
2. Mathematical Physics: H.K.Dass
3. Tensors in Mechanics and Elasticity Brillouin.
4. Vector analysis – Newell

Semester I Paper II . Classical Mechanics

Unit-I

Survey of elementary principles of mechanics of a particle, constraints & their classifications, D'Alemberts Principle, Variational Principle, Lagrange's equation, Hamilton's Principle

Unit-II

Conservation theorems and symmetry properties, Hamiltonian formalism, Hamiltons equations, Routh's procedure for cyclic coordinates

Canonical transformations, Poisson brackets and Poisson theorems, Hamilton-Jacobi Theory

Unit-III

Central force motion, reduction to one body problem, equations of motions and first integrals , classification of orbits for inverse square central forces. Two body collisions, Rutherford scattering in laboratory and centre-of-mass frames;

Unit-IV

Rigid body dynamics, Euler's angles, Euler's theorem, moment of inertia tensor, eigen values and principal axis transformation, non-inertial frames and Pseudo forces,

Text and Reference books:

1. Classical Mechanics: H. Goldstein
2. Classical Mechanics: N.C.Rana and P.S.Joag

Semester I Paper III. *Solid State Physics*

Unit I: Crystallography: External symmetry elements of crystals, crystal systems, Bravais lattices, Concept of point group, stereograms for 32 point groups, Space groups, derivation of equivalent point positions (with examples from triclinic systems), Miller and Bravais indices, unit cell, Wigner-Seitz unit cell, Reciprocal lattice, Principle of powder diffraction method, Elementary ideas about Interpretation of Powder photographs, Analytical indexing

Unit II: Free Electron Theory: Electrons moving in one and three dimensional potential wells, quantum state and degeneracy, density of states, electrical and thermal conductivity of metals, relaxation time and mean free path, the electrical resistivity of metals, thermonic emission.

Semiconductors: Free carrier concentration in semiconductors, Fermi level and carrier concentration in semiconductors, effect of temperature on mobility, electrical conductivity of semiconductors, Hall effect in semiconductors, p-n junction.

Unit III : Band Theory: Bloch theorem, the Kronig- Penney model, construction of Brillouin zones, extended and reduced zone schemes, effective mass of an electron, tight binding approximation,

Empty lattice approximation, Band structure for f.c.c. and b.c.c. metals, Fermi surface, effect of electrical field and magnetic fields on Fermi surface. Basic Principles and outline of Experimental methods for studying Fermi surface.

Unit IV

Lattice Dynamics: Energy of atomic motions, adiabatic principle, harmonic approximation, cyclic boundary condition. Lattice vibrations of linear monoatomic and diatomic chains. Dispersion relations, acoustic and optical phonons.

Theories of lattice specific heat, Dulong and Petit'slaw, Einstein and Debye models, T^3 law, Born procedure, anharmonicity and thermal expansion.

Text and Reference books:

1 Solid State Physics, A.J. Dekker, Macmillan India Ltd. (2005)

2. Solid State Physics, Charles Kittel, John Willey & Sons

3 .Physics of Semiconductor Devices – Physics and Technology: M.S. Sze,John Willey & Sons

4. Introduction to Solids – Azaroff

5. Solid State Physics- A.J. Blackmore

6. Fermi Surface Cracknell and Wang

7. Lattice Dynamics- Ghatak and Loknathan

8. Solid State Physics Kubo and Nagamiya

Semester I. **Paper IV**

Electrodynamics-I

Unit I

Electrostatics: Coloumb's law, Electric field, Charge distribution, Dirac delta function, Field lines, Gauss's law and applications, Differential form of Gauss's law, Electric potential, Poisson and Laplace's equations, Electrostatic potential energy.

Unit II

Electrostatics: Boundary value problems, Uniqueness theorems, Green's theorem, Method of images, Method of separation of variables (Cartesian Coordinates, Spherical and Cylindrical Coordinates), Multipole expansion.

Unit III

Magnetostatics: Biot-Savart law, Ampere's law, Differential form of Ampere's law, Vector potential, Magnetic field of a localized current distribution, magnetic moment, Magnetostatics boundary conditions, Magnetic Shielding.

Unit IV

Time varying fields: Faraday's law, Maxwell's displacement current, Maxwell's equations, Maxwell's equations in matter, Scalar and vector potentials, Gauge Transformation, Wave equations, Poynting's theorem, Conservation laws.

Text Books:

1. Introduction to Electrodynamics, David J. Griffith, Prentice Hall of India Private Limited.
2. Classical Electrodynamics, John D. Jackson, Wiley Eastern Limited.
3. Classical Electrodynamics, Tung Tsang, World Scientific Publishing Private Limited.

Semester II Paper I. **Quantum Mechanics-I**

Unit- I

Why Quantum Mechanics? Revision, inadequacy of classical mechanics, development of Schrodinger equation, time dependent and time-independent Schrodinger equation, continuity equation, wave packet, admissible wave functions, stationary states.

Formalism of wave mechanics, expectation values, quantum mechanical operators for position and momentum in the coordinate representation, Construction of quantum mechanical operators for other dynamical variables from those of position and momentum, Ehrenfest's theorem, momentum eigen functions in the coordinate representation, box normalization and Dirac delta function.

Coordinate and momentum representations, Schrodinger equation in momentum representation,

Unit-II

Brief revision of linear vector spaces, inner or scalar product, Schwarz inequality, state vectors, general formalism of operator mechanics vector, operator algebra, commutation relations, eigen values and eigen vectors, hermitian operators degeneracy, orthogonality eigenvectors of Hermitian operators, noncommutativity of two operators and uncertainty in the simultaneous measurements of the corresponding dynamical variables, the fundamental expansion postulate, representation of state vector, Dirac's bra-ket notations.

Matrix representation of operators, change of basis, unitary transformations,

quantum dynamics, Schrodinger, Heisenberg and interaction picture.

Unit-III

Solution of Schrodinger equation for simple problems, 1-D Square well, step and barrier potentials, 1-D harmonic oscillator, zero point energy. harmonic oscillator problem by operator method.

Angular momentum operator, commutation relations, expression for L^2 operator in spherical polar coordinates, Role of L^2 operators in central force problem, eigen value problem for L^2 , separation of Schrodinger equation in radial and angular parts, solution of radial equation for hydrogen atom, 3-d square well potential, parity of wave function, parity operator.

Unit-IV

Generalized angular momentum, raising and lowering operators, matrices for J^2, Jx, Jy, Jz operators,

Pauli spin matrices, Addition of angular momenta, Clebich-Gordon Co-efficient, spin angular momentum, spin momentum functions.

Text and Reference Books:

1. Quantum mechanics: E. Merzbacher
2. Quantum mechanics: L.I.Schiff
3. Quantum mechanics: Mathews and Venkatesan
4. Quantum mechanics : Ghatak and Loknathan
5. Quantum mechanics: B.Craseman and J.D.Powell
6. Modern quantum mechanics: J.J.Sakurai
7. Quantum Theory D. Bohm, (Asia Publishing House)

Semester II Paper II Numerical Methods

Unit 1

Methods for determination of zeros and linear and non-linear single variable algebraic and transcendental equations, (Bisection method, false position method, iteration method, Newton-Raphson method, secant method) convergence of solutions. Solution of Linear systems using Gaussian elimination,

Unit 2

Finite differences, interpolation with equally spaced and unevenly spaced points. Newton's formulae, Central difference interpolation formula Gauss , Stirling, Bessel and Everett, Lagrange's interpolation, Divided differences.

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Unit 3

Numerical differentiation. Numerical integration, trapezoid rule, simpson's 1/3rd rule, Simpson's 3/8th rule, Romberg integration, Polynomial least squares and cubic spline fitting,

Iterative methods for Linear systems, Jacobi and Gauss-Seidel methods

Unit-iV

Numerical solution of ordinary differential equations, Euler and Runge Kutta methods (2nd and 4th order), Predictor- corrector methods by Adams-Moulton and Milne, Classification of Partial differential equations. Solving Laplace's equation by finite difference scheme.

References:

1. Introductory Methods of Numerical Analysis: S S Sastry
2. Computer Oriented Numerical Methods: V Rajaraman
3. Computer oriented Numerical Methods: R.S.Salaria

Semester II Paper III **Statistical Physics**

Unit I

Fundamentals of classical statistical mechanics, microstate and macrostate, distribution function, Liouville's theorem, Gibbs Paradox, ensembles (micro-canonical, canonical and grand-canonical), partition function, free energy and connection with thermodynamic quantities, energy and density fluctuations

Unit II

Fundamentals of quantum statistical mechanics, BE and FD Statistics, Symmetry of wave functions, Boltzmann limit of Bosons and Fermions, Ideal Bose system: Bose-Einstein condensation, Behaviour of ideal Bose gas below and above Bose temperature, Photons and liquid helium as bosons.

Unit III

Ideal Fermi system: Weak and strong degeneracy, Fermi function, Fermi energy, Behaviour of ideal Fermi gas at absolute zero and below Fermi temperature, Fermionic condensation, Free electrons in metals as fermions, Electronic specific heat,
Cluster expansion for classical gas, Virial equations of states.

Unit IV

Phase transition: Phase transition of first and second order, Landau theory of phase transition, Ising model, Order parameter, Critical exponents, Scaling hypothesis, Random walk, Brownian motion, Langevin theory, Correlation function and fluctuation-dissipation theorem, Fokker-Planck equation.

Text and Reference Books:

1. Fundamentals of Statistical Physics: B. B. Laud
2. Statistical Mechanics: R. K. Pathria
3. Statistical Mechanics: S. K. Sinha
4. Statistical and Thermal Physics: F. Reif
5. Statistical Mechanics: K. Huang
6. Statistical Mechanics: Loknathan and Gambhir
7. Statistical mechanics: R. Kubo
8. Statistical Physics: Landau and Lifshitz

Semester II Paper **IV**

Electrodynamics-II

Unit I

Electromagnetic Waves:

Maxwell's equations, Boundary conditions, Wave equation and its complex notation, Electromagnetic waves in vacuum, Electromagnetic waves in non-conducting and linear media, Electromagnetic waves in linear conducting media. Poynting theorem, Reflection, refraction and polarization of electromagnetic waves,

Unit II

Waveguides and Cavities:

Metallic boundary conditions, Electromagnetic waves confined to hallow metallic pipe, TE, TM and TEM modes, TE and TM modes in rectangular waveguides, Bessel's function, TE and TM modes in cylindrical waveguides, Dielectric waveguides, TE and TM modes in rectangular and cylindrical Resonant cavities.

Unit III

Potential, Fields and Radiations:

Scalar and vector potentials, Gauge transformation, Coulomb and Lorentz gauge, Retarded potential, Lienard-Wiechert potentials, Fields due to moving charge, Power radiated by an accelerated charge and angular distribution, Bremstrahlung Cerenkov and Synchrotron radiations.

Unit IV

Relativistic Electrodynamics:

Four vectors, Lorentz transformation in terms of Four vectors, Lorentz transformation matrix, Transformation of electromagnetic fields, Field Tensor, Dual field strength tensor, Maxwell's equations in terms of strength tensors, Motion of a charged particle in Uniform, Static Magnetic field, Motion in combined Uniform, Static Electric and Magnetic field, Particle drifts in Non uniform, Static, Magnetic field, Adiabatic invariance of flux through orbit of particle.

Text Books:

4. Introduction to Electrodynamics, David J. Griffith, Prentice Hall of India Private Limited.
5. Classical Electrodynamics, John D. Jackson, Wiley Eastern Limited.
6. Classical Electrodynamics, Tung Tsang, World Scientific Publishing Private Limited.
7. Electromagnetic Waves and Radiating Systems, Edward C. Jordan and Heith G. Balmain, Prentice Hall of India Private Limited.

(List of Recommended Experiments) for Semesters I and II

Lab – I:

1. Measurement of resistivity of a semiconductor by four probe method at
2. different temperatures and determination of band gap energy.
3. Determination of Lande's factor of DPPH using ESR spectrometer.
4. Measurement of Hall coefficient of given semiconductor: identification of type of semiconductor and estimation of charge carrier concentration.
5. To study Faraday effect using He-Ne laser.
6. Determination of Hall life of 'In".
7. Determination of range of Beta-rays from Ra and Cs.
8. X-ray diffraction by TELEXOMETER.
9. Determination of ionization potential of lithium.
10. Determination of e/m of electron by normal Zeeman effect using Febry Perot Etalon.
12. Determination of Dissociation Energy of Iodine (Molecule by photography of the absorption band of Iodine in the visible region.
14. Determination of wavelength of monochromatic source using MICHELSON Interferometer.
16. Study of fiber optics.
17. Study of waveguide.
18. Study of emission spectra of iron (Iron arc).
19. Study of B-H Curve.
20. (a) Measurement of wavelength of He-ne laser light using ruler.
21. (b) Measurement of thickness of thin wire with laser.

Lab –II:

1. Design of a regulated power supply.
2. Characteristics and applications of silicon controlled rectifier.
3. Design of common emitter Power transistor amplifier.
4. Experiments on bias stability.
5. Negative feedback (Voltage series / shunt and current series / shunt).
6. Astable, Monostable and Bistable multivibrator.
7. Experiment on FET and MOSFET characterization and application as an
8. amplifier.
9. Experiment on Uni-junction transistor and its application.
10. Digital – I: Basic, TTL, NAND and NOR.
11. Digital – II: Combinational logic.
12. Flip-Flops.
13. Study of modulation (FM, AM, etc.).
14. Operational Amplifier.
15. Differential Amplifier.
16. Microprocessor.

Semster III Paper I (Compulsory) Quantum Mechanics-II

Unit- I

Time independent perturbation theory, First order perturbation theory applied to non-degenerate states, second order perturbation extension to degenerate state, Application of perturbation theory to the ground state energy, He atom (calculation given in Pauling and Wilson), Normal and anomalous Zeeman effect, First order Stark effect in the ground and first excited states of H atom and second order Stark effect of H atom, an-harmonic oscillator.

Unit II

Time dependent perturbation theory, transition rate, Fermi Golden rule, constant perturbation harmonic in time, radiative transitions, absorption and induced emission, atomic radiation, dipole approximation, Einstein's atomic radiation, Einstein's A and b coefficients and their calculations.

Approximation methods: W. K. B. method and its application to barrier penetration.

Variational principle and its application to simple cases like ground state of He atom and deuteron in Yukawa potential.

Unit III

System of identical particles, exchange and transposition operators, totally symmetric and antisymmetric wave function and their expressions for a system of non-interacting particles, statistics of systems of identical particles, Relation of statistics with spin, Ortho and para states of the helium atom and their perturbation by Coulomb repulsion.

Hamiltonian of a molecule, Born-Oppenheimer approximation, outline of Heitler-London theory of the hydrogen molecule.

Scattering theory, scattering cross-section in laboratory and centre of mass system, scattering by a central potential , Partial wave method, phase shifts and their importance, scattering by a square well; potential and a perfectly rigid sphere, resonance scattering.

Unit IV

Relativistic wave equation, the Klein-Gordon equation and initial difficulties in interpreting its solutions, Dirac's relativistic equation, Dirac's matrices, explanation of the spin of the electron, equation for an electron in an electromagnetic field and explanation of the magnetic moment due to the electron spin, spin-orbit interaction, solution for hydrogen atom in Dirac's theory, negative energy states and their qualitative explanations.

Text and References Books:

1. E. Merzbacher, Quantum Mechanics (Wiley and Sons-Toppon)
2. J. L. Powell and B. Crazemann, uantum mechanics (B I Publications)
3. L. I. Schiff, Quantum Mechanics (McGraw-Hill)
4. Quantum Mechanmics Aruldhas
5. Pauling and Wilson, Introduction to Quantum Mechanics
6. A.K. Ghatak and Lokanathan, Quantum Mechanics (Macmillan, India)

Semster III Paper II (Compulsory) Nuclear and Particle Physics-I

Unit-I

Basic nuclear properties: size, shape, charge distribution, spin and parity, nuclear mass, and binding energy, semi-empirical mass formula, Angular momentum, magnetic moment and electric quadrupole moment, Molecular beam resonance, and NMR Methods, Mossbaur effect and its applications.

The nucleon-nucleon interaction: Nucleon-nucleon interaction and hadron structure, phenomenological nucleon – nucleon potentials, Meson theory, derivation of Yukawa interaction, Electromagnetic properties of deuteron-polarization in nucleon- nucleon scattering, cross- sections in terms of partial wave amplitude, Effective range theory, spin dependence of Nuclear forces, charge independence and charge symmetry of nuclear forces, Isospin formalism, reciprocity theorem, optical model, Exchange forces.

Unit-II

Nuclear Models : Evidence of Shell structure, Magic numbers, Single particle shell model, it's validity and limitations, Spin- orbit coupling, Angular momenta and parities of nuclear ground states, Magnetic moments and Schmidt lines, Determinantal wave functions of the nucleus – single particle operator and their expectation values.

Collective Models of Nucleus: Deformable liquid drop and nuclear fission, Shell effects on liquid drop energy, Collective vibrations and exited states, Permanent deformation and collective rotations, Energy levels, Electromagnetic properties of even – even, odd-A deformed nuclei, Nilsson model and equilibrium deformation, Behaviour of nuclei at high energy liquid drop model, Collective model of Bohr-Mottelson.

Unit-III

Nuclear Reactions: Compound nucleus, Direct and compound nuclear reaction mechanisms, Relativistic kinematics, Coulomb excitation, Elementary approach to potential scattering theory, S-wave neutron scattering in the compound nuclear reaction model, Derivation and discussion of Breit-Wigner resonance formula, Discussion of direct reactions, Ground state deuteron, Magnetic moment, Quadrupole moment, Stripping in zero range approximation, Pick-up reaction.

Nuclear Deacay: Elementary ideas of alpha, beta and gamma decays, Fermi theory of beta decay, Angular momentum and Parity Selection rules, Allowed and forbidden transitions, Comparative half –lives, Parity violation of weak interaction, Gamma decay, Multipole transition in nuclei, Selection rules, Internal conversion, Nuclear isomerism.

Unit-IV

Nuclear Energy: Fundamentals of nuclear fission and extended liquid drop model, Bohr-Wheeler theory of fission, Neutron released in the fission process, Neutron chain reaction, Multiplication factor, Condition for criticality, Cross-sections, Fusion, Thermonuclear reactions, Energy production in stars.

Nuclear Reactor:– The fission reactors, Heterogeneous natural uranium reactor,Thermal reactor, Introduction to nuclear power, nuclear fuel moderators, coolants, control mechanism, different types of nuclear power reactors, Fast breeder reactor,dual purpose reactors,concept of fusion reactors.

Nuclear Physics: B.L.Cohen, TMGH, Bombay

13. The Elements of Nuclear Reactor Theory: Glasston & Edulund
14. Physics and nuclei and particles P. Marmier and E. Sheldon, Vol I and II, Academic press, NY 1970/1971
15. Structure of the Nucleus M. A. Preston and R. K. Bhaduri, Addison Wesley, 1975
16. The Physical Theory of Neutron Chain Reactors: M. Weinberg and E. P. Wigner, University of Chicago Press, 1958
17. Introduction to Nuclear Reactions: Satchler
18. R. K. Bhaduri, Models of Nucleon, Addison-Wesley, Reading, MA, 1988

Text and Reference books:

1. Introduction to Nuclear Physics: F.A.Enge, Addison-Wesley 1975
2. Atomic and Nuclear Physics: Ghoshal
3. Nuclear Physics: R.R. Roy and B.P.Nigam, Wiley-Eastern Ltd.1983
4. Introductory Nuclear Physics: Y.R.Waghmare, Oxford- IBH, Bombay,1981
5. Nuclear Structure: Bohr and B.R. Mottelson, Vol.1(1969), 2(1975) Benjamin Reading
6. Introductory Nuclear Physics: Kenneth S. Kiane, Wiley, New York 1988
7. Introductory Nuclear Physics: Burcham
8. Nuclear Physics: Kaplan, 2nd edition, Narosa 1989
9. Nuclear interaction: G.E.Brown and A.D.Jackson, North-Holland, Amsterdam, 1976
10. Nuclear Interaction: Benedetti, John Wiley & Sons, NY 1964
11. Atomic Nucleus: R.D.Evans,Mc-Grow Hill NY 1955
12. Nuclear Physics: B.L.Cohen, TMGH, Bombay
13. The Elements of Nuclear Reactor Theory: Glasston & Edulund
14. Physics and nuclei and particles P. Marmier and E. Sheldon, Vol I and II, Academic press, NY 1970/1971
15. Structure of the Nucleus M. A. Preston and R. K. Bhaduri, Addison Wesley, 1975
16. The Physical Theory of Neutron Chain Reactors: M. Weinberg and E. P. Wigner, University of Chicago Press, 1958
17. Introduction to Nuclear Reactions: Satchler
18. R. K. Bhaduri, Models of Nucleon, Addison-Wesley, Reading, MA, 1988

Semster III Paper III Materials Science – I (OPTIONAL)

Unit- I

Equilibrium and kinetics: Stability and metastability, Basic thermodynamic functions, Statistical nature of entropy, Kinetics of thermally activated process.

Phase diagrams: The phase rule, free energy composition diagram, correlation between free energy and phase diagram, calculation of phase boundaries, thermodynamics of solutions, single component system (water), two component system containing two phases and three phases, Binary phase diagrams having intermediate phases, Binary phase diagrams with eutectic system. Lever principle, maximum, minimum, super lattice, miscibility gap, microstructure changes during cooling, application to zone refining.

Unit - II

Phase transformations: Time scale for phase changes, peritectic reaction, eutectoid and eutectic transformations, order disorder transformation, transformation diagrams, dendritic structure in alloys, transformation on heating and cooling, grain size effect on rate of transformation at constant temperature and on continuous cooling, grain size effect on rate of transformation, nucleation kinetics, growth kinetics, interface kinetics leading to the crystal growth.

Diffusion in solids: Fick's laws and their solutions, the Kirkendall effect, mechanism of diffusion, temperature dependence of diffusion co-efficient, self diffusion, interstitial diffusion, the Snoek effect in diffusion, diffusion in ionic crystals, diffusion path other than the crystal lattice, thermal vibrations and activation energy, diffusion of carbon in iron.

Unit – III

Structure of materials

Difference between structures of metals and ceramics, close-packed structures: BCC, FCC & HCP metals. Structure of semiconductors: Si, Ge, ZnS, pyrites, chalcopyrite's, ZnO etc.; structure of ceramics: metal oxides, nitrides, carbides, borides, ferrites, perovskites, etc.

Classification of materials: Crystalline and amorphous materials, high T_c superconductors, alloys & composites, semiconductors, solar energy materials, luminescent and optoelectronic materials, Polymer, Liquid crystals and quasi crystals, Ceramics. Importance of oxides in metallurgy – Ionic and electronic conduction, application in sensors and electronic devices.

Unit-IV

Solid State Ionics: Definition, classification and characteristic properties of solid electrolytes. Complex impedance spectroscopy, Arrhenius theory of ionic conductivity.

Chemical sensors: Nernst equation, potentiometer and amperometric sensors for various gases, electrochemical redox-reaction, advantages of electrochemical sensors.
Solid state battery and fuel cell: Primary and secondary solid state cells, advantages of lithium batteries, ion intercalation compounds for secondary cell, open circuit voltage and short circuit current, intercalation compounds for secondary cell, open circuit voltage and short circuit current, Energy density, power density. Fuel cells –advantages and disadvantages, classification, efficiency- emf of fuel cells, hydrogen/oxygen fuel cell, criteria for the selection electrode and electrolyte, methanol fuel cell, solid oxide fuel cells, phosphoric acid fuel cells, molten carbonate fuel cell, proton exchange membrane fuel cell, biochemical fuel cell.

Text and Reference books:

1. Vanvellak: Materials Science.
2. V. Raghvan: Materials Science.
3. D. Kingery: Introduction to ceramics.
4. R. E. Reedhil: Physical metallurgy.
5. Martin Start Sharger: Introductory materials.
6. Sinnot: Solid state for engineers.
7. Kelly and Groves: Crystal and defects.
8. Kittel: Solid state physics, Vth edition.
9. M. A. Azaroff: Elements of crystallography
9. Introduction to solid state theory: Modelung.

Semster III Paper IV X-rays I (OPTIONAL)

Unit I

Continuous and Characteristic X-rays: Various types of demountable and sealed X-ray tubes. Production of X-rays. Efficiency of X-ray production. Continuous and characteristic X-ray spectra. X-ray emission from thick and thin targets.

Basics of high-tension circuits and vacuum systems used for the operation of X-ray tubes.

Isochromats: Principles of Bremsstrahlung and characteristics isochromats

Synchrotron radiation: Production and properties of radiation from storage rings, Insertion devices. Pelletron as a source of X-rays.

Unit II

Absorption of X-rays and X-ray Fluorescence: Absorption of X-rays. Physical process of X-ray absorption. Measurement of X-ray absorption coefficients. Units of dose and intensity. Radiography.

Microradiography and their applications.

X–ray fluorescence. Auger effect. Fluorescence yield. X –ray fluorescence analysis and its applications. Techniques and applications of Auger electron spectroscopy, Photoelectron spectroscopy, Proton induced X-ray emission, Electron probe micro analyser.

Unit III

X-ray spectroscopy: Experimental techniques of wavelength and energy dispersive x-ray spectroscopy.

Bragg and double crystal spectrographs. Focussing spectrographs. Tangential incidence grating spectrographs. Dispersion and resolving power of spectrographs, Photographic and other methods of detection, resolving power of detectors.

X –ray emission and absorption spectra. Energy level diagram. Dipole and forbidden lines, Satellite lines and their origin, Regular and irregular doublets. Relative intensities of X-ray lines.

Unit IV

Chemical Effects in X-ray Spectra: Chemical effects in X-ray spectra. White line, Chemical Shifts of absorption edges, Fine structures (XANES and EXAFS) associated with the absorption edges and their applications. X-ray spectroscopy with synchrotron sources.

Dispersion Theory: Dispersion theory applied to X-rays, Calculation of the dielectric constant, Significance of the complex dielectric constant, Refraction of X-rays, Methods for measurement of refractive index

X-ray optics – X-ray microscopy and Telescopy. Design of beam lines for synchrotron applications. Applications in X-ray Astronomy.

Text and Reference Books:

1. A. H. Compton and S. K. Allison: X-rays in Theory and Experiment
2. G. L. Clark: Applied X-rays.
3. Sproull: X-rays.
4. J. A. Nielsen and D. Mc. Morrow: elements of Modern X-ray Physics.
5. A. G. Michette and C. J. Buckley: X-ray Science and Technology.
6. M. A. Blokhin: X-ray Spectroscopy.
7. B. K. Agarwal: X-ray Spectroscopy.
8. E. P. Bertin: Principles and Practice of X-ray Spectrometric Analysis.

9. L. V. Azaroff: X-ray Spectroscopy.
10. C. Bonnelle and C. Mande: Advances in X-ray Spectroscopy.
11. D. C. Koningsberger and R. Prins: X-ray Absorption Principles, Applications, Techniques of EXAFS, SEXAFS and XANES.
12. N. F. M. Henry, H. Lipson and W. A. Wooster: The interpretation of X-ray Diffraction Photographs
13. K. Lonsdale: Crystals and X-rays.
14. B. D. Cullity: Elements of X-ray Diffraction.
15. M. M. Woollfson: X-ray Crystallography.
16. M. J. Buerger: X-ray Crystallography.
17. C. Kunz: Synchrotron Radiation.
18. Bacon: Neutron Physics.

M.Sc. II (Physics)

Semster III Paper V (OPTIONAL)
Nanoscience and Nanotechnology – I

Unit I:

Introduction to Nanoscience:

Free electron theory (qualitative idea) and its features, Idea of band structure, Density of states for zero, one, two and three dimensional materials, Quantum confinement, Quantum wells, wires, dots, Factors affecting to particle size, Structure property relation, Size dependence properties. Determination of particle size, Increase in width of XRD peaks of nano-particles, Shift in photoluminescence peaks, Variation on Raman spectra of nano-materials.

Unit II:

Synthesis of Nanomaterials:

Physical methods**:** High energy Ball Milling, Melt mixing, Physical vapour deposition, Ionised cluster beam deposition, Laser ablation, Laser pyrolysis, Sputter deposition, Electric arc deposition, Photolithography.

Chemical methods**:** Chemical vapour deposition, Synthesis of metal & semiconductor nanoparticles by colloidal route, Langmuir-Blodgett method, Microemulsions, Sol-gel method, Combustion method, Wet chemical method

Unit III:

Nanomaterials Characterizations:

X-ray diffraction, UV-VIS spectroscopy, Photoluminescence spectroscopy, Raman spectroscopy, Transmission Electron Microscopy, Scanning Electron Microscopy, Scanning Tunnelling Electron Microscopy, Atomic Force Microscopy, Vibration Sample Magnetometer, Spintronics

Unit IV:

Special Nanomaterials and Properties:

Carbon nanotubes, Porous silicon, Aerogels, Core shell structures. Self assembled nanomaterials. Metal and semiconductor nanoclusters

Mechanical, Thermal, Electrical, Optical, Magnetic, Structural properties of nanomaterials

Text and Reference books:

1. Nanotechnology: Principles & Practicals. Sulbha K. Kulkarni ,Capital Publishing Co.New Delhi.
2. Nanostructures & Nanomaterials Synthesis, Properties & Applications**.** Guozhong Cao, Imperials College Press London.
3. Nanomaterials: Synthesis, Properties & Applications**.** Edited by A.S. Edelstein & R.C.Commorata. Institute of Physics Publishing, Bristol & Philadelphia.
4. Introduction to Nanotechnology. C.P. Poole Jr. and F. J.Owens, Wiley Student Edition.
5. Nano: The Essentials. T.Pradeep , McGraw Hill Education.
6. Handbook of Nanostructures: Materials and Nanotechnology. H. S. Nalwa Vol 1- 5, Academic Press, Bostan.

7. Nanoscience and Technology: Novel Structure and Phenomena. Ping and Sheng

8. Hand Book of Nanotechnology, Bhushan

List of experiments:

1. Synthesis of metal oxide nanoparticles by wet chemical method.
2. Synthesis of inorganic nanomaterials by combustion method.
3. Synthesis of nanomaterials by sol-gel method.
4. Synthesis of conducting polymer nanofibres by interfacial polymerization.
5. Synthesis of conducting polymer nanotubes by self assembly.
6. Synthesis of conducting polymer nanocomposites by in-situ polymerization.
7. Synthesis of metal oxide nanoparticles by hydro-thermal method.
8. Study of optical absorption of nanomaterials.
9. Deposition of thin films by spray pyrolysis technique.
10. Determination of particle size of nanomaterials from x-ray diffraction.
11. Study of photoluminescence of well known luminescent nanoparticles.
12. Deposition of thin films by spin coating method.
13. Thermoluminescence study of nanomaterials.
14. Deposition of thin films by dip coating technique.
15. Study of particle size effect on luminescence.
16. Electrical characterization of nanostructured materials.
17. Deposition of thin film in vacuum.
18. Electrical resistivity of nanomaterials using four probe method
19. Photoluminescence study of prepared red/blue/green luminescent nanomaterials.
20. Characterization of nanomaterials using SEM/TEM.

Semster III Paper VI Atomic and Molecular Physics (Spectroscopy-I)

Unit I

Quantum states of an electron in an atomic Electron spin, spectrum of hydrogen, Helium and alkali atoms, Relativistic corrections for energy levels of hydrogen; Basic principles of interaction of spin and applied magnetic field.

Concepts of NMR spectroscopy concepts of spin-spin and spin-lattice relaxation, chemical shift; spin-spin coupling between two and more nuclei; chemical analysis using NMR. Mossbauer effect-Recoil less emission of gamma rays, chemical shieft, magnetic hyperfine interaction,

Unit II

electron spin resonance, experimental setup, hyperfine structure and isotopic shift,width of spectral lines, LS & JJ coupling, Zeeman, Paschen Back & Stark effect. Spontaneous and Stimulated emission, Einstein A & B Coefficients; LASERS, optical pumping, population inversion, rate equation, modes of resonators and coherence length, Role of resonant cavity, three and four level systems, Ammonia MASER, ruby, He-Ne, CO2, dye and diode lasers, Lasers applications

Unit III

Rotational, vibrational and Raman spectra of diatomic molecules, Quantum theory, Molecular polarizability, Intensity alteration in Raman spectra of diatomic molecules, Experimental setup for Raman spectroscopy in the structure determination of simple molecules. polyatomic molecules, symmetric top asymmetric top molecules. Hunds rule.

Unit IV

Electronic spectra of diatomic molecules, Born Oppenheimer approximation, Vibrational Coarse structure of electronic bands, intensity of electronic bonds, Franck Condon principle, and selection rules,dissociation and pre dissociation, dissociation energy, rotational fine structure of electronic bands. General treatment of molecular orbitals, Hund's coupling cases.

Text Book and References:

1. Molecular Spectroscopy: - Jeane L. McHale.
2. Mossbauer spectroscopy –M. R. Bhide.
3. NMR and Chemistry – J. W. Akitt.
4. Structural Methods in inorganic chemistry, E.A V.Ebsworth, D. W. H.Rankin, S.Crdock.
5. Introduction to Atomic Spectra – H. E. White.
6. Fundamental of Molecular Spectroscopy – C. B. Banwell.
7. Spectroscopy Vol. I, II and III, Walker and Straghen.
8. Introduction to Molecular Spectroscopy – G. M. Barrow.
9. Spectra of diatomic molecules – Herzberg.
10. Molecular spectroscopy – Jeanne L. McHale.
11. Molecular spectroscopy – J. M. Brown.
12. Spectra of Atoms and Molecules – P. F. Bemath.
13. Modern Spectroscopy – J. M. Holkas.
14. Laser spectroscopy and instrumentation- Demtroder

Semster III Paper VII (OPTIONAL)
Applied Electronics- I

Unit – I

Operational Amplifiers, Block diagram of a typical operational amplifier, analysis, open loop configuration, inverting and non-inverting amplifiers, operational amplifier with negative feedback,voltage series feedback, effect of feedback on close loop gain, input resistance output resistance bandwidth and output offset voltage, voltage follower.

Practical operational amplifier, input offset voltage, input bias current, input off set current, total output off set voltage, CMRR, frequency response, dc and ac amplifier, summing, scaling and averaging amplifier, instrumentation amplifier, integrator and differentiator.Application of Op-Amp as fixed and variable voltage regulator.

Oscillators principles- Barkhausen criterion for oscillations, The phase shift oscillator, Weinbridge oscillator, LC tunable oscillator, multi-vibrators, mono-stable and astable, comparators, square wave and triangular wave generators

Unit – II

Communication electronics: Amplitude modulation , generation of AM waves, demodulation of AM waves, DS BSC modulation, generation of DSBSC waves, coherent detection DSBSC wave, SSB modulation, generation and detection of SSB waves, Vestigial sideband modulation, frequency division multiplexing (FDM).

Microwave communication: Advantage and disadvantage of microwave transmission, loss in free space propagation of microwaves, atmospheric effect on propagation, Fresnel zone problem, ground refection,fading sources, detector components, antennas used in microwave communication systems

Unit – III

Digital Electronics: Various logic gates ;OR, AND NOT, NOR and NAND gates Exclusive OR gate, Boolean algebra, De Morgan’s theorem, , Decoder/demultiplexer, Dataselector/ multiplexer, Encoder Sequential logic: Flip flops, 1 bit memory, the RS flip flop, JK flip flop, JK master slave flip-flop, T flipflop,D, Flip-flop, Shift registers, synchronous and asynchronous counters, Cascade counters.

Microprocessor: Introduction to microcomputers, Memory. Input-output devices, interfacing devices.8085 CPU, architecture, bus timing, de-multiplexing, the address bus, generating control signals,instruction set, addressing modes, illustrative programmes, assembly language programmes, looping, counting and indexing, counters and timing delay, stack and sub routings. read only memory (ROM) and applications. Random access memory (RAM) and applications,

Digital to analogue converters. Ladder and weighted register types, analog to digital converters, ,successive approximations and dual slop converters, application of DAC and ADC,

Unit – IV

Microwave devices: Klystrons, magnetrons, and travelling wave tubes, velocity modulation, basic principle of two cavity klystrons and reflex klystrons, principle of operation of magnetrons, Helix travelling wave tubes, wave modes, transferred electron devices, gunn effect, principle of operation,modes of operation, read diode, IMPATT diode, TRAPATT diode..

Text and Reference Books:

1. Electronic devices and circuit theory: Robort Boylested and L. Nashdsky (PHI, New Delhi).
2. OP-Amps and linear integrated circuits: Ramakanth A. Gayakwad (PHI 2nd Edn).
3. Digital principles and Applications: A. P. Malvino and D. P. Leach (Tata Ma-Graw Hill).
4. Microprocessor architecture, programming and Application with 8085/8086, Ramesh S. Gaonkar (Wiley-Estern).
5. Microelectronics: Jacob Millman (Mc-Graw Hill Interna).
6. Optoelectronics: Theory and Practices: Edited by Alien Chappal (Mc Graw Hill).
7. Microwaves: K. L. Gupta (Wiley Ester New Delhi).
8. Advanced electronics communication systems: Wayne Tomasi (Phi Edn).
9. Fundamentals of microprocessors and Micro-computers: B. Ram. (Dhanpat Rao and Sons.).

Semster III Paper VIII (Elective) Numerical Methods and Programming

Unit I
Errors in Numerical Calculation, General Error Formula, Errors in Series approximation (1.3, 1.4, 1.5 of ref.1) Representation of numbers in memory (2.4 of ref. 2), floating point arithmetic (2.3,2.4, 2.5 of ref. 3) Advanced methods of solution of non-linear equations, ,Newton Raphson method, successive approximation, Bairstow's method, Ramanujan's method, Graeffe's root squaring method, Quotient difference method (ref. 1 and 2)

Unit II
Matrices: Determinant, consistency of equations, vector and matrix norms,
Solution of linear equations: direct methods a) matrix inversion b) Gaussian elimination, partial pivoting, Gauss-Jordan method, matrix inversion using Gaussian elimination,
LU decomposition, Iterative methods (Jacobi and Gauss-Seidel methods) (Ref. 1 and 2)
Eigenvalue problem: power method (ref. 2) , Jacobi method (ref. 4)

Unit III
System of differential equations, higher order differential equations (ch. 10 of ref. 2)
Numerical methods of partial differential equations ADI method, (9.2.4), parabolic equations, hyperbolic equations (8.4, 8.5 ref. 1) Introduction to finite element method (10.1)

Unit IV
C programming (Ch 1, 2, 3, 4, 5 of ref. 5 and 7.1, 7.2)

Text and Reference books:

1) S. S. Sastry Introductory methods of Numerical Analysis 4th Ed.
2) R. S. Salaria A textbook on Computer oriented numerical methods 4th ed.
3) V. Rajaraman : Computer oriented numerical methods 3rd ed
4) F. Scheid: Schum's outlines in Numerical Analysis 2nd ed
5) B. Kerningham and D. M. Ritchie : The C Programming Language 2nd ed.
6) Y. Kanetkar: Let us C

Semster III Paper IX Elective X-rays

Unit – I

Production of X-rays and Physical Crystallography: Various types of demountable and sealed X-ray tubes. Production of X-rays. Efficiency of X-ray production. Continuous and characteristic X-ray spectra. X-ray emission from thick and thin targets. High tension and vacuum techniques.

Synchrotron radiation : Production and properties of radiation from storage rings, Insertion devices. Pelletron as source of X-rays.

Absorption of X-rays and X-ray Fluorescence: Absorption of X-rays. Physics process of X-ray absorption. Measurement of X-ray absorption coefficients.

Unit - II

X-ray Spectroscopy: Experimental techniques of wavelength and energy dispersive x-ray spectroscopy. Bragg and double crystal spectrographs. Focussing spectrographs. Tangential incidence grating spectrographs. Methods of detection and measurement, Resolving power of detectors.

X –ray emission and absorption spectra. Energy level diagram. Dipole and forbidden lines, Satellite lines and their origin, Regular and irregular doublets. Relative intensities of X-ray lines.

Chemical Effects in X-ray Spectra: Chemical effects in X-ray spectra. Fine structures (XANES and EXAFS) associated with the absorption edges and their applications. X-ray spectroscopy with synchrotron sources. Soft X-ray spectroscopy of the solid state.

X-ray fluorescence. Photoelectron spectroscopy, Auger effect. Fluorescence yield. X-ray fluorescence analysis and its applications.

Unit-III

Scattering and Dispersion of X-rays: Scattering of X-rays. Thomson scattering. Polarisation of X-rays. Compton scattering. Wave mechanical treatment of scattering. Scattering by a pair of electrons. Scattering by a helium atom. Scattering by many electrons. Raman’s theory of X-ray scattering. Experiments on scattering by monatomic and polyatomic gases, liquids and amorphous solids.

Dispersion theory applied to X-rays. Calculation of the dielectric constant. Refraction of X-rays. Methods for measurement of refractive index. X-ray optics and X-ray microscopy.

Unit – IV

Classification of crystals. Symmetry elements. Crystal systems. Point groups. Space groups. Reciprocal lattice.

Diffraction of X-rays: Diffraction of X-rays by crystals. Atomic and crystal structure factors. Amplitude of scattering by a crystal. Different factors affecting the intensity of diffraction lines.

The integrated intensity of reflection. Temperature effect. Debye-Waller factor.

Experimental methods of structure analysis. Laue method. Debye Scerrer method. Rotation oscillation method. Weisenberg camera.

Principles of energy dispersive and time analysis diffractometry.

Structures of metals and alloys. Phase transformations. Order-disorder phenomenon. Super lattice lines. Determination of grain size. Study of nano-particles.
Use of synchrotron radiation in structural studies.
Electron and neutron diffraction techniques and their applications. Comparison with X-ray diffraction.

Text and Reference Books

1. A. H. Compton and S. K. Allison: X-rays in theory and Experiment.
2. G. L. Clark: Applied X-rays.
3. Sproull : X-rays.
4. J. A. Nielsen and D. Mc. Morrow: Elements of Modern X-ray Physics.
5. A. G. Michette and C. J. Buckley: X-ray Science and Technology.
6. M.A. Blokhin: X-ray Spectroscopy.
7. B. K. Agarwal: X-ray Spectroscopy.
8. E. P. Bertin: Principles and Practice of X-ray Spectrometric Analysis.
9. L. V. Azaroff: X-ray Spectroscopy.
10. C. Bonnelle and C. Mande: Advances in X-ray Spectroscopy.
11. D. C. Koningsberger and R. Prins: X-ray Absorption Principles, Applications, Techniques ofEXAFS, SEXAFS and XANES.
12. N.F.M. Henry, H. Lipson and W. A. Wooster: the interpretation of X-ray Diffraction Photographs.
13. K. Lonsdale: Crystals and X-rays.
14. B. D. Cullity: Elements of X-ray Diffraction.
15. M. M. Woollfson: X-ray Crystallography.
16. M. J. Buerger: X-ray Crystallography.
17. C. Kunz: Synchrotron Radiation.
18. Bacon: Neutron Physics.

Semster III Paper X Materials Science (Elective)

Unit – I:

Phase diagrams: The phase rule, free energy composition diagram, correlation between free energy and phase diagram, calculation of phase boundaries, thermodynamics of solutions, single component system, two component system containing two phases and three phases, Binary phase diagrams of Cu-Ni and Sb - Bi systems, lever principle, maximum, minimum, super lattice, miscibility gap, microstructure changes during cooling, application to zone refining.

Phase transformations: Time scale for phase changes, peritectic reaction, eutectoide and eutectic transformation, order-disorder transformation, transformation diagram, dendritic structure of alloys, transformation on heating and cooling, grain size effect on rate of transformation at constant temperature and on continuous cooling , grain size effect on rate of transformation, nucleation kinetics, growth kinetics, interface kinetics leading to the crystal growth.

Unit – II:

Diffusion in solids: Fick's laws and their solutions, the Kirkendall effect, mechanism of diffusion, temperature dependence of diffusion co-efficient, self diffusion, interstitial diffusion, the Snoek effect diffusion, diffusion in ionic crystals, diffusion path other than the crystal lattice, thermal vibrations and activation energy, diffusion of carbon in Iron.

Solid electrolytes: Theory of solid electrolytes, solid state batteries, solar cells and their applications.

Unit – III:

Preparative methods: Solid State reaction, epitaxy, topotaxy, examples of solid state reactions, Li_4SiO_4, $YBa_2Cu_3O_7$, Na β/ β' alumina.

Sol-gel methods – synthesis of MgAl2O4 – synthesis of silica glass – spinning of alumina fibers, preparation of indium tin oxide (ITO) and other coating – Fabrication of YSZ ceramics- preparation of alumina based abrasives. Use of homogeneous, single source precursors- Hydrothermal synthesis – Intercalation and deintercalation – vapor phase transport- Combustion sunthesis – Crystal growth techniques – High pressure methods.

Film deposition techniques and processes: Introduction, vacuum systems – Evaporation – Molecular beam apitaxy – Sputter deposition – Chemical vapour deposition – Laser ablation – Electroplating.

Unit – IV:

Solid state characterization techniques: X-ray diffraction - Introduction – basic principles – experimental considerations – applications, structure determination, phase analysis, grain size analysis. Microscopic techniques: SEM, AFM and STEM.

Thermal analysis – Principle and applications of thermo-gravimetric analysis – differential thermal analysis – differential scanning calorimetry.
Spectroscopic techniques – Photoacoustic spectroscopy – principle – instrumentation – applications.
Photoelectron spectroscopy – Instrumentation – solid state surface studies – surface charging and calibration problems – valence energy level studies – surface charging and calibration problems – Valence energy level studies – UV photoelectron spectra – X-ray photoelectron spectra – Auger electron spectroscopy.

Text and Reference Books:

1. Basic solid State Chemistry, 2nd Edition, Anthony R. West, John Wiley & Sons, 1996.
2. New Directions in Solid State Chemistry, C. N. R. Rao and J. Gopalkrishnan, Cambridge University Press, Cambridge, 1986.
3. Chemical Approach to the synthesis of inorganic materials, C. N. R. Rao Wiley Eastern Ltd. 1994.
4. Materials Science and Engineering – an Introduction, W. D. Callister Jr. John Wiley & Sons,1991.
5. Materials Science, J. C. Anderson, K. D. Leaver, R. D. Rawlings and J. M. Alexander, 4thEdition, Chapman & Hall (1994).
6. Encyclopedia of Materials Characterization by C. Richards Brundle, C. A. Evans. Jr and S. Wilson, Butterworth, 1992.
7. Spectroscopy Vol 3. B. P. Straughn and S. Walker, Chapman and hall, 1976.
8. Spectroscopy in Catalysis, J. W. Niemantsverdriet, VCH, 1995.
9. Instrumental Methods of analysis, Willard, Merritt, Dean and Settle, CBS Publishers, New Delhi, Sixth Edition, 1986.
10. P. Ganguly and C. N. R. Rao. "Photoacoustic spectroscopy of solids and surfaces: Proc. Indian Acad. Scie. (Chem. Sci)99(1981)153-214.
11. Chemistry of Advances Materials an overview, Leonard V. Interrante and mark J. Hampden-Smith (Ed) Wiley – VCH, 1998.
12. Nanostructured Materials and Nanotechnology, Hari Singh Nalwa, Academic Press (1998).
13. Environmental photochemistry with semiconductor nanoparticles by P. v. Kumar and K.Vinodgopal in Organic and Inorganic Photochemistry edited by V. Ramamurthy and Kirk S.Schanze, Marcel Dekker Inc (1998).

Semster III Paper Paper – XI (Elective) Spectroscopy I

Unit – I:

Spectra of alkaline, earth elements, penetrating and non-penetrating orbits, Coupling schemes, Zeeman effect, Paschen Back effect in two electron systems, Stark effect. Normal and inverted terms

Unit - II:

Width of special lines, Natural and Doppler broadening. Asymmetric and pressure shift intensity rules. Hyperfine structure, Complex spectra. Wave equation for many electron atom. Saha's theory of ionization.

Unit –III:

Quantum mechanical treatment of vibration and rotation spectra. Mass potential. Infra-red and Raman spectra of vibrating and rotating diatomic molecules, Vibration-rotation interaction. Anharmonic oscillator and non-rigid rotator energy levels.

Unit – IV:

Thermal distribution of quantum states. Intensities of rotational and vibrational and vibration – rotational spectra of diatomic molecules, Isotope effect in rotational and vibrational spectra. Rotations and vibrations of polyatomic molecules, symmetric top asymmetric top molecules. Hund's rules

Text and Reference books:

1. Gupta, Kumar and Sharma: Elements of spectroscopy.
2. 2. White, H. E. : Introduction to Atomic Spectra.
3. Herzberg : Spectra of Diatomic Molecules.
4. Banwell: Fundamental of Molecules.
5. S. Walker and Straw : Spectroscopy, Vol. I and II.
6. Wilson, Decius and Gross :Molecular Vibrations.
7. Gans (Chapman and Hall): Vibrating Molecules.

Semster III Paper Paper – XII (Elective) Lasers, Fiber Optics and Applications

Unit – I

Laser characteristics**:** Gaussian beam and its properties, Stable two minor optical resonators Longitudinal and transverse modes of laser cavity, Mode selection, Gain in the regenerative laser cavity,

Unit – II

Threshold for 3 and 4 levels laser systems, mode locking pulse shortening pico-second and femto second operations, Spectral narrowing and stabilization. Ruby laser, Nd YAG Laser, Semiconductor lasers,

Unit – III

Laser System**:** Diode pump solid state lasers, Nitrogen laser, Carbon dioxide laser, Excimer laser, Dye laser, high power laser systems and industrial applications.

Unit – IV

Laser Specroscopic techniques and other applications**:** Laser fluorescence and Raman scattering and their use in pollution studies, nonlinear interaction of light with matter, Laser induced multi-photon processes and their applications, Ultra high resolution spectroscopy with lasers and its applications.

Text and Reference books:

1. Laser: Svelto.
2. Optical electronics: Wariv.
3. Laser spectroscopy: Demtroder.
4. Non-linear spectroscopy: Etekhov.
5. Introduction to fiberoptics, A.Ghatak and K.Thyagarajan,Cambridge Univ.Press.

Semester III Paper XIII (elective) Digital Electronics and Microprocessor

Unit – I:

Logic gates: Characteristics of TTL, ECL, CMOS circuits with reference to fan in / out noise, speed, power dissipation with suitable examples.

Simplyfying logic circuits: Algebric method – SOP (minterm) and POS (maxterma) forms. Karnaugh mapping – Fundamental products, pairs, gaurds, octats, Don't's care conditions. Complementary

Karnaugh map. Diagonal adjacencies. NAND-NAND and NOT-NOR networks. Applications of K maps to half adder, full adder.

Arithmetic circuits: Number representation. Binary point, negative numbers, sign and magnitude. 1s and 2 s complement adder, parallel binary adder, BCD addition, parallel BCD adder, binary multiplication and division. Circuits using 7483 and 7486 be discussed. ALU with emphaisi on IC 74181 in details. TTY, Video display, TVT sweep, dotmatric, encoding, decoding.

Unit – II

Multiplexers, demultiplexers : IC 74150 multiplexer and IC 74154 demultiplexer. Tristate buffers, their use in bus organization. Key board encoders, BCD, octal, Hex and scanned matrix keyboard.

Communication in Analog and Digital Domains: Modulation and demodulation in analog (AM FM, PM SSB – SC etc.) Pulse modulation systems. (PAM, PWM, PDM). Pulse code modulation, coding, FDM and TDM, Code noise immunity, Code transmission and bands and speeds, ASK, FSK, PSD, computer and digital communication: Modems, DART, URSI, Local area networks, Radio telemetry.

Unit – III:

A/D and D/A converters: Weighted resistor and R-2R ladder D/A converters. A/D converter – parallel comparator and Application. ADC 0808, 08116/08117, DAC 0800, look up table, measurement of electrical and physical quantities. Introduction to architecture, pin configuration etc. of 8086, 80286, 80486 (Intel)

Memories Allied Devices: Design consideration of Bipolar RAM, MOS memory and dynamic RAM, ROM, EXROM and CCD. Read/Write operation. Expanding memory sizewordsize and word capacity. FIFO and LIFO. Study of 7489 RAM and 745370 RAM and other chip. Magnetic bubble memories. Floppy disks-track and sector organization, data format Winchester disk (hard disk).

Unit – IV:

Microprocessor Architecture: The parts of up. CPU, memory requirements, numerical data, representation of characters, microprocessor instructions, program storage, instruction execution fetch and execute cycles, addressing modes including simple memory paging, direct scratch and pad addressing.

The instruction set including memory reference, immediate conditional jump-shift, change control, stack and program counter, subroutines, flow charts, masking, simple programs.

I/O Systems: Program interrupts including multiple interrupt priorities. Interfacing memory mapping, memory mapped and I/P mapped I/O. Use of decoders, I/O posts. ic 8212. simple programs, program looping serial and parallel looping time delay, program for scanned matrix keyboard, IC 8155 and IC8255 (with block diagram of internal circuits) Typical programs using these ICS.

Text and Reference Books:

1. Design of Digital Systems : P. C. Pitman (Galgotia Pub).
2. Digital Computer Electronics :A. P. Malvino (TMH).

3. Digital Fundamentals: T. L. Floyd (Universal Book Stall).
4. Theory and Problems of Digital Principles : R. L. Tokheim (TMH).
5. Modern Digital Electronics : R. P. Jain (TMH).
6. Introduction to UP : A. K. Mathur (PHL).
7. Up and Small Digital Computer Systems for Scientist and Engineers L G. A. Korn, (McGraw Hill).
8. An Introduction to Micro-computer: Adam Osborne(Galgotia).
9. Introduction top 4 bit and 8 bit UP : Adam Osborne.

Semster IV Paper I ***Solid State Physics***

Unit I

Defects: Vacancies, Point defects, line defects and stacking faults, Burgers vector and Burger circuit, presence of dislocation, dislocation motion, perfect and imperfect dislocations, slip planes and slip directions, dislocation reactions, experimental methods to observe dislocations, colour centres and their models.

Luminescence: types of luminescence, phosphors, concentration quenching, sensitization, characteristic (KCl:Tl type) and donor-acceptor (ZnS type) luminescence. Nonradiative and radiative transition, Mechanism of luminescence, configuration coordinate diagrams.

Unit II

Dielectric Properties: Dielectric loss and relaxation, ferroelectricity, classification, theories ferroelectricity, Devonshire and Cochran's theories, domains, antiferroelectrics. Lyddane – Sachs-Teller relation, Zeroes and poles of dielectric function. Dielectric response of an electron gas, plasmons, electron collisions.

Magnetic Properties:

Quantum theory of paramagnetism, magnetism of iron group and rare earth ions, crystal fields theory (elements) quenching of orbital moments. Ferromagnetism, Weiss theory, exchange integral, band model, Ising model, spin wave, magnons, domain walls, magnetostriction, anisotropy energy, thickness of domain walls. Antiferromagnetism, Neel's theory, susceptibility below Neel's temperature.

Unit III

Magnetic resonance and its applications in solids, experimental arrangements and basic principles of NMR, ESR and Mossbauer spectroscopies,

Unit IV

Superconductivity, occurrence, Type I and II super conductors, Meissner effect, isotope effect, microwave and infrared properties. Thermodynamics of transition. London equation, coherence length, elements of B. C. S. theory, tunnelling Josephson effect. Ginzsburg- Landau theory and application to Josephson effect: d-c Josephson effect, a-c Josephson effect, macroscopic quantum interference. Josephson junction. Vortices and type I & type II superconductors, high temperature superconductor (elementary).

Text and Reference books:

1. C. Kittle: Introduction to Solid State Physics (2nd and 4th Edition).
2. A. J. Dekker : Solid State Physics.
3. Kubo and Nagamiya : Solid State Physics.
4. Levrenz : Introduction to Luminescence of Solids.
5. Feynman Lectures: Vol. III.
6. Board and Huano : Dynamical Theory of Crystal Lattice.
7. Ferroelectricity Jona and Shirane

Semster IV Paper II Nuclear and Particle Physics-II

Unit-I

Elementary Particle Physics: Classification of fundamental forces, Strong, Weak and Electromagnetic Interactions between elementary particles, Hadrons, quarks, baryons, mesons and leptons, Symmetry and conservation laws, Baryons and mesons multiplets, Symmetry breaking, Gell-Mann-Okubo mass formula.

Unit-II

Spin and Parity assignment, isospin, Strangeness, Gell-Mann- Nishijima formula, C, P & T invariance and applications of symmetry, argument to particle reactions, Quark model, Charm, Bottom and top quarks, Spontaneous symmetry breaking and Higgs mechanism,Higgs bosons, Standard model for electro weak unification.

Unit-III

Particle Detectors:

Gas Counters: Ionization chambers, Proportional counters, Multiwire proportional counters, Geiger-Muller counters, Neutron detectors.

Solid state detectors: Semiconductor detectors, Integrating solid state devices, Surface barrier detectors.

Scintillation counters: Organic and inorganic scintillators- Theory, characteristics and detection efficiency.

High energy particle detectors: General principles, Nuclear emulsion, Cloud chambers, Bubble chambers, Cerenkov counter, Detection and properties of neutrino.

Unit-IV

Accelerators:

Historical Developments:Different types of accelerators, Layout and components of accelerators, Accelerator applications.

Transverse Motion: Hamiltonian for Particle motion in accelerators, Equation of betatron motion, Particle motion in dipole and quadrupole magnets, Linear betatron motion, Transfer matrix and stability of betatron motion, Effect of space – charge force on betatron motion.

Synchrotron Motion: Longitudinal equation of motion, Synchrotron Hamiltonian.

Linear Accelerators: Historical milestone, Fundamental properties of accelerating structures, Particle acceleration by EM waves, Longitudinal particle dynamics in Linac, Transverse beam dynamic in a Linac.

Ion beam accelerator, ion beam optics, High energy accelerators (e.g. Large Hadron collider at Geneva) for particle physics research.

Text and Reference Books:

1. Introduction to Nuclear Physics: F.A.Enge, Addison-Wesley 1975
2. Atomic and Nuclear Physics: Ghoshal
3. Nuclear Physics: R.R. Roy and B.P.Nigam, Wiley-Eastern Ltd.1983
4. Introductory Nuclear Physics: Y.R.Waghmare, Oxford- IBH, Bombay,1981
5. Nuclear Structure: Bohr and B.R. Mottelson, Vol.1(1969), 2(1975) Benjamin

Reading
6. Introductory Nuclear Physics: Kenneth S. Kiane, Wiley, New York 1988
7. Introductory Nuclear Physics: Burcham
8. Nuclear Physics: Kaplan, 2nd edition, Narosa 1989
9. Nuclear interaction: G.E.Brown and A.D.Jackson, North-Holland, Amsterdam, 1976
10. Nuclear Interaction: Benedetti, John Wiley & Sons, NY 1964
11. Atomic Nucleus: R.D.Evans,Mc-Grow Hill NY 1955
12. Concept of Nuclear Physics: B.L.Cohen, TMGH, Bombay
13. Nuclear radiation detectors: S.S. Kapoor and V.S. Ramamurthy, Wiley –Eastern, New Delhi, 1986.
14. Nuclear radiation detection: W.J. Price, Mc Graw Hill, NY 1964
15. Quarks and Leptons: F. Halzen and A. D. Martin, John-Wiley & Sons, New York, 1984
16. Modern Elementary Particle Physics: G. Kane, Addision-Wesly, 1987
17. Unitary Symmetry and Elementary Particles: D. B. Lichtenberg, 2nd Edition, Academic Press
18. An introduction to particle physics: M. Leon, Academic Press, New York, 1973
19. Accelerator Physics: S. Y. Lee, World Scientific, Singapore, 1999
20. Theory of Resonance Linear Accelerators: M. Kapchinsky,Harwood Academic Publishers
21. Linear Accelerators: P. Lapostole and A. Septier, North Holland.
22. Particle Accelerators: P. Blewett, McGraw-Hill Book Co.
23. Particle Accelerators and Their Uses: W. Scharf, Harwood Academic Publishers

Semster IV Paper III Materials Science – II (OPTIONAL)

Unit –I

Mechanical response of Materials : Elasticity, model of elastic response, inelasticity, viscoelasticity, stress-strain curves, concept of various mechanical properties such as hardness, yield strength, toughness, ductility, yield toughness, ductility, brittleness, stiffness, young modulus, shear modulus, shear strength, Frenkel model, Peierls-Nabarro relation, Plastic deformation, importance of dislocation movements, sessile dislocations, relation of slip process and crystal structures, Franck reed source for dislocation etc, Creep, fatigue in materials, Fracture, Strengthening of materials.

Corrosion and degradation of materials – electrochemical considerations – passivity forms of corrosion – corrosion inhibition.

Unit – II

Dielectrics: Electronic, ionic and orientational polarizabilities for free atoms and molecules, Lorentz cavity, Clausius-Mossotti relation, static and frequency dependence of dielectric constant. Macroscopic theory of dielectric polarization and oscillating fields.

Spintronics and Photonics: Atomic origin of magnetism. Diamagnetism, paramgnetism, ferromagnetism and anti ferromagnetism, spin glass, magnetic bubbles, domain walls, magnetic multilayers, magnenites, GMR and CMR, DMS materials. Photonic band gap materials.

Unit – III

Materials Synthesis: Concept of equilibrium and nonequilibrium processing and their importance in materials science.

Synthesis of Bulk materials: Metallic and non metallic, Ceramics and other materials. Only basic elements of powder technologies, compaction, sintering calcination, vitrification reactions,with different
example, phenomenon of particle coalescence, porosity. Quenching : concept, glass formation,

Synthesis of nanostructured materials: Physical method – Bottom up: cluster beam evaporation, Ion beam deposition, Gas evaporation, Chemical method – Hydrothermal, combustion, bath deposition with capping techniques and top down: Ball milling. Solvated metal atom dispersion – thermal decomposition – reduction methods – colloidal and micellar approach.

Unit –IV

Microstructure characterization by direct & indirect methods

Diffraction techniques: interpretation of x-ray powder diffraction patterns, Identification & quantitative estimation of unknown samples by X-ray powder diffraction technique and fluorescent analysis. Theory and method of particle size analysis. Integral breadth method, Warren-Averbach's Fourier method, profile fitting method, Rietveld Method.

Microscopic techniques –TEM, SEM & STEM. AFM, XPS, EDX. Electron and neutron diffraction

Text and Reference Books:

1. Basic Solid State Chemistry, 2nd Edition, Anthony R. West, John Wiley & Sons, 1996.
2. New Directions in Solid State Chemistry, C. N. R. Rao and J. Gopalkrishnan, Cambridge University Press, Cambridge, 1986.
3. Chemical approaches to the synthesis of inorganic materials, C. N. R. Rao Wiley Eastern Ltd.1994.
4. Materials Science and Engineering – An Introduction, W. D. Callister Jr. John Wiley & Sons,1991.
5. Materials Science, J. C. Anderson, K. D. Leaver, R. D. Rawlings and J. M. Alexander, 4^{th} Edition, Chapman & Hall (1994).
6. Nanostructured Materials and Nanotechnology, Hari Singh Nalwa, Academic Press (1998).
7.Fuel Cells – A. Mcdougall, Macmillan 1976 Ch 3,5,7,8 and 11.

Experiments:

1. Crystal structure determination by powder diffraction.
2. Synthesis of semiconductor oxides by chemical route.
4. Crystal growth from slow cooling of the melt.
5. Thermal analysis of binary alloy.
6. Differential thermal analysis solid solution.
7. To study electrochemical method of corrosion control.
8. Dielectric behaviour of LiNbO3 and BaTiO3 in crystals and ceramics.
9. Electrical conductivity of ionic solids.
10. Testing of hardness of a material.
11. Band gap measurements of oxide film using UV-Vis Spectroscopy.
12. Multiple beam interferromentric study of surfaces.
13. Thermal conductivity of bad conductor.
14. Thermal expansion coefficient of metals.
15. Study of transport property in solid electrolytes.
16. Verification Nernst law/Oxygen sensor
17. Determination of Thermoelectricity Power.

Semster IV Paper IV X-ray spectroscopy and crystallography – II (Optional)
Unit I
Solids and symmetry elements: Crystalline state, Anisotropy, Symmetry, Self consistency of symmetry operations. Space lattice and unit cell of a crystal, Choice of a unit cell, Crystal systems, Bravais lattices, space groups and point groups.
Morphology and angular relationships: Goniometry, Crystal faces and internal arrangement, Miller indices, Law of rational indices, Indices of a direction.
Perspective projections: Gnomonic projection, Stereographic projection, Orthographic projection.
Reciprocal lattice concept: Graphical construction, Relation to interplanar spacing, Interpretation of Bragg's law.

Unit II
Scattering of X-rays: Thomson scattering, Compton scattering, Wave mechanical treatment of scattering, Scattering by a pair of electrons, Theory of scattering by a helium atom, Scattering by many electrons, Raman's classical theory of X-ray scattering, Raman effect in X-ray scattering, Basic interactions in X-ray scattering, Experiments on scattering by monatomic and polyatomic gases, liquids and amorphous solids.

Unit III
Physical Basis of X-ray Crystallography: Atomic and crystal structure factors, Structure factor calculations, The integrated intensity of reflection. Different factors affecting the intensity of diffraction lines in a powder pattern. The sources of systematic errors and methods of attaining precision.
Dynamical theory X-ray diffraction.
The Fourier series, Numerical applications, Fourier series in two and three dimensions. The Fourier Transform, electron density projections in crystals, Application to X-ray diffraction.
Unit IV
Experimental Methods of Structure Analysis: Laue method, Debye-Scherrer method, rotation Oscillation method, Weisenberg camera, Moving film method, Principles of energy dispersive and time analysis diffractometry.
Methods of detecting and recording diffraction patterns.
Structures of metals and alloys. Phase transformations, Order-disorder phenomenon.
Super lattice lines. Determination of grain size. Study of nano-particles.
Other Diffraction Techniques: Electron and neutron diffraction techniques and their applications. Comparison with X-ray diffraction.
Small angle scattering, Gainer camera, SAXS and SANS, Applications in particle size determination,
Study of fibres, Study of submicroscopic heterogeneities in metals and other materials.

Text and Reference Books:

1. A. H. Compton and S. K. Allison: X-rays in Theory and Experiment.
2. G. L. Clark: Applied X-rays.
3. Sproull : X-rays
4. J. A. Nielsen and D. Mc Morrow: Elements of Modern X-ray Physics.

5. A. G. Michette and C. J. Buckley: X-ray Science and Technology.
6. M. A.. Blokhin: X-ray Spectroscopy.
7. B. K. Agarwal: X-ray Spectroscopy.
8. E. P. Bertin: Principles and Practice of X-ray Spectrometric Analysis.
9. L. V. Azaroff: X-ray Spectroscopy.
10. C. Bonnelle and C. Mande: Advances in X-ray Spectroscopy.
11. D. C. Koningsberger and R. Prins: X-ray Absorption Principles, Applications, Techniques of EXAFS, SEXAFS and XANES.
12. N. F.M. Henry, H. Lipson and W. A. Wooster: The interpretation of X-ray Diffraction Photographs.
13. K. Lonsdale: Crystals and X-rays.
14. B. D. Cullity: elements of X-ray Diffraction.
15. M. M. Woollfson: X-ray Crystallography.
16. M. J. Buerger: X-ray Crystallography.
17. C. Kunz: Synchrotron Radiation.
18. Bacon: Neutron Physics.

Semster IV Paper V (OPTIONAL) **Nanoscience and Nanotechnology – II**

Unit – I:

Nanophotonics:

Fundamentals of photonics and photonic devices, Lasers, CFLs, LEDs, OLEDs, Wall paper lighting, Display devices, X-ray imaging nanophosphers, Photo therapy lamps and its applications, Nanomaterials for radiation, Dosimetery special for thermoluminescence. Optical stimulated luminescence, Luminescence solar concentration.

Unit – II:

Nanomagnetics:

Basics of Ferromagnetism, effect of bulk nanostructuring of magnetic properties, dynamics of nanomagnets, nanopore containment, giant and colossal magnetoresistance, applications in data storage, ferrofluids, Superparamagnetism, effect of grain size, magneto-transport, Magneto-electronics, magneto-optics, spintronics.

Unit – III:

Nanoelectronics:

Top down and bottom up approach, CMOS Scaling, Nanoscale MOSFETs, Limits to Scaling, System Integration, Interconnects;

NanoDevices: Nanowire Field Effect Transistors, FINFETs, Vertical MOSFETs, Other Nanowire Applications, Tunneling Devices, Single Electron Transistors, Carbon nanotube transistors, Memory Devices,

Unit – IV:

Nanocomposites:

Classification of nanocomposites, Metallic, ceramic and polymer nanocomposites, Tribology of polymeric nanocomposites, Nano ceramic for ultra high temperature MEMS, Optimizing nanofiller performance in polymers, Preparation techniques, Graphene/Fullerene/Carbon nanotube (CNT) polymer nanocomposites, One dimensional conducting polymer nanocomposites and their applications

Text and reference books:

1. H.S.Nalwa; Hand book of Nanostructure materials and nanotechnology; (Vol.1-5), Acad. Press, Boston, 2000
2. C.P.Poole Jr., F.J.Owens; Introduction to Nanotechnology, John Wiley and sons, 2003
3. C. Furetta; Hand book of thermoluminescence; World Scientific Publ.
4. S.W.S. McKEEVER; Thermoluminescence in solids; Cambridge Univ. Press.
5. Alex Ryer; Light measurement hand book; Int. light Publ.
6. M.J.Weber; Inorganic Phosphors; The CRC Press.

7. T.J.Deming; Nanotechnology; Springer Verrlag, Berlin, 1999
8. W.D.Kalister Jr., Materials Science and Engineering, 6th Eds, WSE Wiley, 2003
9. Gusev; Nanocrystalline Materials
10. C. Delerue, M.Lannoo; Nanostructures theory and Modelling
11. Fausto, Fiorillo ; Measurement and Characterization of Magnetic materials

12. Bhushan; Hand Book of Nanotechnology
13. Janos H., Fendler; Nanoparticles and Nanostructured Films
14. T.Pradip; Nano: The Essentials
15. Liu; Hand Book of Advanced Magnetic Materials (4 Vol.)
16. Lakhtakia; Nanometer Structure
17. Banwong, Anurag Mittal; Nano CMOS Circuit and Physical Design
18. G.W.Hanson: Fundamental of Nanoelectronics
19. Edward L. Wolf (2nd Ed.), *Nanophysics & Nanotechnology: An Introduction to Modern Concepts in Nanoscience*, WILEY-VCH, 2006
20. S. Sakka; Sol-gel science and technology processing, characterization and applications; Kluwer Acad. Publ.
21. Goser et al, "*Nanoelectronics & Nanosystems: From Transistor to Molecular & Quantum Devices"*
22. Supriyo Datta, "*From Atom to Transistor*"
23. John H. Davies, *The Physics of Low Dimensional Semiconductors: An Introduction",* Cambridge University Press, 1998.
24. Hari Singh Nalwa, "*Encyclopedia of Nanotechnology*"
25. A. A. Balandin and K. L. Wang, "*Handbook of Semiconductor Nanostructures & Nanodevices*"
26. Cao Guozhong, "*Nanostructures &Nanomaterials - Synthesis, Properties & Applications*"

List of experiments:

21. Synthesis of metal oxide nanoparticles by wet chemical method.
22. Synthesis of inorganic nanomaterials by combustion method.
23. Synthesis of nanomaterials by sol-gel method.
24. Synthesis of conducting polymer nanofibres by interfacial polymerization.
25. Synthesis of conducting polymer nanotubes by self assembly.
26. Synthesis of conducting polymer nanocomposites by in-situ polymerization.
27. Synthesis of metal oxide nanoparticles by hydro-thermal method.
28. Study of optical absorption of nanomaterials.
29. Deposition of thin films by spray pyrolysis technique.
30. Determination of particle size of nanomaterials from x-ray diffraction.
31. Study of photoluminescence of well known luminescent nanoparticles.
32. Deposition of thin films by spin coating method.
33. Thermoluminescence study of nanomaterials.
34. Deposition of thin films by dip coating technique.
35. Study of particle size effect on luminescence.
36. Electrical characterization of nanostructured materials.
37. Deposition of thin film in vacuum.
38. Electrical resistivity of nanomaterials using four probe method
39. Photoluminescence study of prepared red/blue/green luminescent nanomaterials.
40. Characterization of nanomaterials using SEM/TEM.

Semster IV Paper VI (Optional) Atomic and Molecular Physics (Spectroscopy-II)

Unit I

Time dependence in quantum mechanics, Time dependent perturbation theory, rate expression for emission, perturbation theory, calculation of polarizability. Quantum mechanical expression for emission rate.

time correlation function and spectral Fourier transform pair, properties of time correlation functions and spectral time shape,

Fluctuation dissipation theorem rotational correlation function and pure rotational spectra,

Re-orientational spectroscopy of liquids.

Unit II

Saturation spectroscopy, Burning and detection of holes in Doppler broadened two level systems, Experimental methods of saturation spectroscopy in laser, Ramsey fringes, Saturation techniques for condensed matter application,

Laser optogalvanic spectroscopy.Two photon absorption spectroscopy, Selection rules, Expression for TPA cross section –photo acoustic spectroscopy, PAS in gaseous medium, Roseneweig and Greshow theory, Thermally thin, thick samples, Typical experimental set up, Application in Spectroscopy,

Unit III

Stimulated Raman scattering, Quantum mechanical treatment, Raman Oscillation Parametric instabilities, Electromagnetic theory of SRS. Vibronic interaction, Herzberg Teller theory,

Fluorescence spectroscopy, Kasha's rule, Quantum yield, Non-radioactive transitions, Jablonski diagram, Time resolved fluorescence and determination of excited state lifetime.Light detectors, Single photon counting technique, Phase sensitive detectors.

Unit IV

Matrix isolation spectroscopy, Fourier transforms spectroscopy, Laser cooling. Molecular symmetry and group theory, Matrix representation of symmetry elementsof a point group, Reducible and irreducible representations, and character tables specially for C_{2v} and C_3 point group molecules, Normal coordinates normal modes, Application of group theory to molecular vibrations.

Text Book and References:

1. Molecular Quantum Mechanics: P. W. Alkins and R. S., Fridman.
2. Quantum electron – A. Yariv.
3. Introduction to non-linear laser spectroscopy – M. D. Levenson.
4. Photoacoustics and its applications, Roseneweig.
5. J. M. Hollas, High resolution spectroscopy.
6. Cotton, Chemical Applications of Group Theory.
7. Herzberg, Molecular spectra and molecular structure II and III.
8. Demtroder, Laser spectroscopy and instrumentation.
9. King, Molecular spectroscopy.
10. Lakowicz, Principles of fluorescence spectroscopy.
11. Molecular Quantum Mechanics: P. W. Alkins and R. S., Fridman.

Semster IV Paper VII Applied Electronics- II

Unit – I:

An Overview of Electronic Communication system ; block diagram of an digital electronic Communication system, Pulse modulation systems, sampling theorem, low-pass and band-pass signals,PAM channel bandwidth for a PAM signal, Natural sampling, flat top sampling, signal recovery throughhholding, quantization of signals, quantization, differential PCM delta modulation, adoptive delta modulation CVSD. Digital modulation techniques: BPSK, DPSK, QPSK, PSK, QASK, BFSK, FSK, MSK.

Mathematical representation of noise, sources of noise, frequency domain representation of noise, Noise in Pulse Code and Delta modulation system, PCM transmission, calculation of quantization ofnoise, out pit signal power effect of thermal noise, outr signal to noise ratio in PCM, DM, quantization noise in DM, out put signal power, DM oput-put, signal to quantization noise ratio, effect of thermal noise in delta modulation, output signal to noise ratio in DM.

Unit – II

Data transmission : base band signal receiver, probability of error, optimum filter, white noise, matchfilter, and probability of error, coherent reception, correlation PSK, FSK non-coherent detection of FSK,differential PSK, QPSK, calculation of error probability for BPSK, BFSK and QPSK.

Computer communication systems: Types of networks, design features of communication network,examples, TYMNET, ARPANET, ISDN, LAN.Mobile radio and satellite - time division multiplex access (TDMA) frequency division multiplex access(FDMA)
ALOHA, Slotted ALOHA, Carrier sense multiple access (CSMA) Poisson distributionprotocols.

Unit – III

Microprocessor and Micro-computers: Microprocessor and architecture, Pin out and pin functions of 8086/8088 Internal microprocessor architecture, bus buffering and latching ,Bus timings, ready and wait states, minimum mode versus and maximum mode. Real and protected mode of memory addressing, memory paging, addressing modes, data addressing modes, programme memory addressing mode, stack memory addressing modes, instruction sets, data movement instruction, arithmetic and logic instruction, programme control instruction, clock generator (8284A),

Unit –IV

Memory and I/O Interface : Memory devices, ROM,RAM.,DRAM, SRAM, Address decoding , 3 to 8 line decoder 74LS138, 8086, and 80386(16 bits) Memory interface, ,

Introduction to I/O interface , Interfacing using 8255, Introduction to PIT 8254, Basic Communication device(UART) pin diagram and functioning of 16550

Interrupts: Basic interrupt processing, Hardware interrupt, expanding the interrupt structure, 8259A PIC.

Direct memory access: basic DMA operations, 8237 DMA controller, Shared bus operation

Text and Reference books.

1. Principles of communication systems : Taub and Schilling (ii Edn THM ,1994)

2. Principles of communication systems: Taub and Schilling Goutam Saha Third Edition

3. Communication systems : Simon Haykin (iii Edn John Wiley & Sons)

4. The intel microprocessors 8086/80188,80386,80486, Pentium and Pentium processor architecture,

programming and interfacing : Barry B. Brey (PHI iv Edn, 1999)

5. Microprocessor and interfacing ,programming and hardware : Douglas V. Hall (ii Edn, Mc GrawHill International edn. 1992)

6. The 80x86 IBMPC compatible computer: Muhammad Ali Maxidi and J .G. Mazidi (ii Edn.Prentice –Hall International.)

Semster IV Paper VIII Elective **Condensed matter Physics – I**

Unit – I

Lattice dynamics and optical properties of solids: Inter-atomic forces and lattice dynamics of simple metals, Ionic and covalent crystal, Optical phonons and dielectric constants, inelastic neutron scattering, Debye-Waller factor. Anharmonicity, thermal expansion and thermal conductivity.

Interaction of electrons and phonons with photons. Direct and indirect transitions. Absorption in insulators, Mossbauer effect,

Unit – II

Polaritons, one-phonon absorption, optical properties of metals, skin effect and anomalous skin effect.

Electron-Phonon Interaction: Interaction of electrons with acoustic and optical phonons. Superconductivity: manifestations of energy gap. Cooper pairing due to phonons, BCS theory of superconductivity, Ginzsburg- Landau theory and application to Josephson effect: d-c Josephson effect, a-c Josephson effect, macroscopic quantum interference. Josephson junction. Vortices and type I & type II superconductors, high temperature superconductor (elementary)

Unit – III

Principle of powder diffraction method, interpretation of powder photographs, Analytical indexing, Ito's method, Accurate determination of lattice parameters, least squares method, Application of powder method, Oscillations and Burger's precession methods, Determination of relative structure amplitudes from measured intensities (Lorentz and polarization factor), Fourier representation of electron density, The phase problem, Patterson function.

Unit – IV

Exotic solids: Structure and symmetries of liquids, liquid crystal and amorphous solids, aperiodic solids and quasicrystals, Fibonacci sequence, Penrose lattices and their extension to three dimensions, special carbon solids, Fullerenes, tubules, formation characterization of fullerenes and

tubules, Single wall and multi-wall carbon tubules, electronic properties of tubules, carbon nano-tubules, grapheme.

Text and Reference books:

1.X-ray crystallography: Azaroff.

2. X-ray crystallography: Cullity

3. C. Kittel: Introduction to Solid State Physics (2nd and 4th Edition).

4. Liquid crystals Chandrashekhar

7. The physics of quasicrystals: Editors. Steinhardt and Ostulond.

8. Handbook of Nanostructured materials and nanotechnology (Vol 1 to 4) : Editor Hari Singh Nalwa.

Semster IV Paper IX (Elective) Nonlinear Dynamics with Applications to Physics and other Sciences

Unit I

Flows on a line, fixed points and their stability, Population growth, Linear Stability Analysis, Existence and Uniqueness, Impossibility of Oscillations, Potentials, Bifurcations, Saddle-node, Transcritical, Pitchfork, Examples, Imperfect Bifurcation.
(Chapter 2 and 3 of Ref. 1)

Unit II

Flows on a circle, Uniform and Nonuniform Oscillator, Over damped Pendulum, Superconducting Josephson Junction, Fireflies, Examples of Linear System, Classification of Linear System.
(Chapter 4 and 5 of Ref. 1)

Unit III

Phase portraits, Existence and Uniqueness, Fixed points and their Linearization, Conservative Systems,
Reversible Systems, Index theory, Limit Cycles, Ruling out Closed Cycles, Poincare-Benedixon theorem, Lienard Systems, Relaxation Oscillations, Weakly Nonlinear Oscillators.
(Chapter 6 and 7 Ref. 1)

Unit IV

Bifurcations in detail, Saddle-node, transcritical, pitchfork, Hopf, Global Bifurcations, Hysteresis in Driven pendulum, Coupled Oscillators and Quasiperiodicity
(Chapter 8 of Ref. 1)

Reference books:

1. S. W. Strogatz : Nonlinear Dynamics with Applications to Physics, Biology, Chemistry and
Engineering. (Perseus)
2. Edward Ott : Chaos in Dynamical Systems (Cambridge University Press)

Semster IV Paper X Elective ElectroAcoustics

Unit – I:

Fundamentals of ultrasonic, Acoustics interaction with liquids, Velocity in fluids, Absorption due to heat conduction and viscosity, single relaxation, internal degrees of freedom, Relaxation in binary mixtures, Normal and associated liquid essential difference in low and high amplitude ultrasonic wave propagation of low amplitude waves, ultrasonic generators piezoelectric effect. Propagation in Solids Attenuation due to electron phonon interaction; Phonon-Phonon interaction, Measurement Techniques, optical method, interference method, Pulse method, Sign-around method. Applications of ultra-sound in industrial and medical fields.

Unit - II

Architectural Acoustics, Classical ray theory. Decay of sound in live and in dead rooms, Measurement of reverberation time. Effect of absorption on reverberation, Sound absorption coefficient, absorbing materials and their uses. Fundamentals of musical scales. Physics of musical instruments. Public address system and music sound system for auditoria. Instruments used for acoustical tests. Underwater acoustics, Velocity of Sound in Sea-water, sound transmission loss in sea-water. Refraction Phenomena, Masking by noise and by reverberation, Passive detection hydrophone systems.

Unit – III

Loud Speakers, idealized direct radiator, Typical cone Speaker, Effect of voice coil parameters, Horn Loudspeakers, pressure response, Woofer, midrange and tweeter, Crossover net works, Fletcher Munsion Curves, Baffles; Infinite type, vented type and acoustic suspension type, Microphones, Moving coil type, Carbon microphones, condenser microphones, Cardiod type, Polar response, Rating of microphone responses. Reciprocity theorem and calibration. RIAA equalization Preamplifiers, Tone control circuits, Equalization amplifiers, Noise filters, Dolby Noise Reduction, High Fidelity Stereo amplifiers, Recording and reproduction of sound.

Unit – IV

Noise Decibels and levels, dB Scales in acoustics, Reference Quantity for acoustic Power, intensity and pressure, Determination of overall levels from band levels, Basic sound measuring system using sound level meter. Octave band analyzer. Acoustic Calibrator, Definition of Speech interference levels (SIL), Noise criteria for various spaces. Nomogram relating SPL in octave bands to loudness in Tones, Computation of LL and SIL.

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Text and Reference books:

1. Fundamentals of Acoustics: Kinsler and Fry, (Wiley Eastern).
2. Acoustics: Leo L. Beranek (John Wiley and Sons.).
3. Noise Reduction: L. L. Beranek.
4. Fundamentals of Ultrasonic: J. Blitz.
5. Ultrasonic Absorption: A. B. Bhatia.
6. Acoustical Test and Measurements: Don Davis.

Semester IV Paper XI (Elective) NANOSCIENCE

Unit I:

Introduction to Nanoscience:

Free electron theory (qualitative idea) and its features, Idea of band structure, Density of states for zero, one, two and three dimensional materials, Quantum confinement, Quantum wells, wires, dots, Factors affecting to particle size, Structure property relation, Size dependence properties. Determination of particle size, Increase in width of XRD peaks of nano-particles, Shift in photoluminescence peaks, Variation on Raman spectra of nano-materials.

Unit II:

Synthesis of Nanomaterials:

Physical methods**:** High energy Ball Milling, Melt mixing, Physical vapour deposition, Ionised cluster beam deposition, Laser ablation, Laser pyrolysis, Sputter deposition, Electric arc deposition, Photolithography.

Chemical methods**:** Chemical vapour deposition, Synthesis of metal & semiconductor nanoparticles by colloidal route, Langmuir-Blodgett method, Microemulsions, Sol-gel method, Combustion method, Wet chemical method

Unit III:

Nanomaterials Characterizations:

X-ray diffraction, UV-VIS spectroscopy, Photoluminescence spectroscopy, Raman spectroscopy, Transmission Electron Microscopy, Scanning Electron Microscopy, Scanning Tunnelling Electron Microscopy, Atomic Force Microscopy, Vibration Sample Magnetometer, Spintronics

Unit IV:

Special Nanomaterials and Properties:

Carbon nanotubes, Porous silicon, Aerogels, Core shell structures. Self assembled nanomaterials. Metal and semiconductor nanoclusters

Mechanical, Thermal, Electrical, Optical, Magnetic, Structural properties of nanomaterials.

Text and Reference books:

1. Nanotechnology: Principles & Practicals. Sulbha K. Kulkarni ,Capital Publishing Co.New Delhi.
2. Nanostructures & Nanomaterials Synthesis, Properties & Applications**.** Guozhong Cao, Imperials College Press London.
3. Nanomaterials: Synthesis, Properties & Applications**.** Edited by A.S. Edelstein & R.C.Commorata. Institute of Physics Publishing, Bristol & Philadelphia.
4. Introduction to Nanotechnology. C.P. Poole Jr. and F. J.Owens, Wiley Student Edition.
5. Nano: The Essentials. T.Pradeep , McGraw Hill Education.
6. Handbook of Nanostructures: Materials and Nanotechnology. H. S. Nalwa Vol 1-5,
   Academic Press, Bostan..
7. Nanoscience and Technology: Novel Structure and Phenomena. Ping and Sheng
8. Hand Book of Nanotechnology, Bhushan

Semster IV Paper XII (Elective) Spectroscopy

Unit –I:

Electronic spectra of diatomic molecules, Resolution of total regen-function of total energy. Vibrational structure of electronic transitions. Progressions, Sequences Vibrational analysis. Deslander's table. Rotational Structure of electronic bands P. O. R. branches.

Unit - II:

Band head formation, fortran diagram. Evaluation of rotational constants. Intensities in electronic bands. Frank Condone Principle. Condone parabola, General treatment of molecular orbitals, Hund's coupling cases.

Unit – III:

Polyatomic molecules- symmetry consideration. Symmetry operation. Point groups Symmetry potential and Kinetic energy. Outline of group theory. Mathematical methods of studying vibrations, internal coordinates and atomic displacement .

Unit – IV

Bond, stretching. Bending, torsion, G. matrix for a linear triatomic molecules. Kinetic energy for linear triatomic molecule. Symmetry of Benzene molecules its vibrational modes, in-plane and out of plane modes, selection rules..

Text and Reference books:

1. Gupta, Kumar and Sharma: Elements of spectroscopy.
2. 2. White, H. E. : Introduction to Atomic Spectra.
3. Herzberg : Spectra of Diatomic Molecules.
4. Banwell: Fundamental of Molecules.
5. S. Walker and Straw : Spectroscopy, Vol. I and II.
6. Wilson, Decius and Gross :Molecular Vibrations.
7. Gans (Chapman and Hall): Vibrating Molecules.

Semster IV Paper XIII Elective Lasers, Fiber Optics and Applications

Unit – I

Threshold for 3 and 4 levels laser systems, mode locking pulse shortening pico-second and femto second operations, Spectral narrowing and stabilization. Ruby laser, Nd YAG Laser, Semiconductor lasers,

Unit – II

Laser Specroscopic techniques and other applications**:** Laser fluorescence and Raman scattering and their use in pollution studies, nonlinear interaction of light with matter, Laser induced multi-photon processes and their applications, Ultra high resolution spectroscopy with lasers and its applications.

Unit-III Numerical aperture, Coherence bundle, Attenuation in optical fiber, Pulse dispersion in step index optical fiber, Loss mechanism.

Unit – IV

Splice loss, Petermann-2 spot size, Far field patter. Graded index fiber: Model analysis of parabolic index fiber, $LP_{l\,m}$ modes, Multimode fibers with optimum profiles.

Text and Reference books:

1. Laser: Svelto.
2. Optical electronics: Wariv.
3. Laser spectroscopy: Demtroder.
4. Non-linear spectroscopy: Etekhov.
5. Introduction to fiberoptics, A.Ghatak and K.Thyagarajan,Cambridge Univ.Press.

Semester III and IV **(List of Recommended Experiments.)**

Electronics

1. Pulse amplitude modulation / demodulation.
2. Pulse position / Pulse width modulation / demodulation.
3. FSK modulation / demodulation using timer / PLL.
4. Microwave characterization and measurement.
5. PLL circuits and applications.
6. Fibre optics communication.
7. Design of active filters.
8. BCD to seven segment display.
9. A/D and D / A conversion.
10. Experiments using various types of memory elements.
11. Addition, subtraction, multiplication and division using 8085 / 8086.
12. Waveform generation and storage oscilloscope.
13. Frequency, voltage, temperature measurements.
14. Motor speed, temperature control using 8086.
15. Trouble shooting using signature analyzer.
16. Assembler language programming on PC.
17. Experiments based on computer aided design.

Materials Science

1. Crystal structure determination by powder diffraction.
2. Study of microstructures of metal alloys.
3. Dislocation in alkali halide crystals.
4. Crystal growth from slow cooling of the melt.
5. Thermal analysis of binary alloy.
6. Differential thermal analysis of BaTiO3-PbTiO3 solid solution.
7. To study electrochemical method of corrosion control.
8. Dielectric behaviour of LiNbO3 and BaTiO3 in crystals and ceramics.
9. Electrical conductivity of ionic solids.
10. To test hardness of a material by Brinell hardness tester.
11. Photo elasticity study.
12. Multiple beam interferromentric study of surfaces.
13. Thermal conductivity of bad conductor.
14. Thermal expansion coefficient of metals.
15. Study of transport property in solid electrolytes.
16. Verification Nernst law/Oxygen sensor.
17. Determination of Thermoelectricity Power.

X-Rays

1. Study of Crystal Models.
2. X-ray Diffraction Photograph of a Metal Foil by transmission (Hull Method).
3. X-ray Diffraction Photograph of a Metal Foil by Back Reflection.
4. Powder Photograph by Debye Scherrer Method, Computer Analysis.
5. Laue Photograph and Gnomonic Projection.
6. Rotation oscillation Photograph.
7. Diffraction of X-rays by Liquids.
8. Bragg’s Spectrometer: Uhler and Cooksey’s method.

9. Bent Crystal (Cauchois) Transmission Type Spectrograph: Study of K and L Absorption Edges.
10. Bent Crystal (Cauchois) Transmission Type Spectrograph: Study of K and L emission Spectra.
11. Measurement of Intensities of Emission Lines, Computer Analysis.
12. Study of Satellite Lines.
13. Analysis of XANES Spectrum, Computer Analysis.
14. Analysis of EXAFS Spectrum, Computer Analysis.
15. Determination of Planck's constant by X-rays.
16. X-ray Fluorescence Spectrum Analysis.
17. Absorption Coefficient for X-rays by G. M. / Scintillation Counter.
18. Characteristics of G. M. tube.
19. Compton Effect.
20. Operation of a Demountable X-ray Tube.

Nanoscience and Nanotechnology

1. Synthesis of metal oxide nanoparticles by wet chemical method.
2. Deposition of thin films by spray pyrolysis technique.
3. Synthesis of inorganic nanomaterials by combustion method.
4. Synthesis of nanomaterials by sol-gel method.
5. Synthesis of conducting polymer nanofibres by chemical oxidation method.
6. Study of optical absorption of nanoparticles.
7. Determination of particle size of nanomaterials from x-ray diffraction.
8. Study of photoluminescence of well known luminescent nanoparticles.
9. Deposition of thin films by spin coating method.
10. Thermoluminescence study of nanomaterials.
11. Deposition of thin films by dip coating technique.
12. Study of particle size effect on luminescence.
13. Electrical characterization of nanostructured materials.
14. Synthesis of metal oxide nanoparticles by hydro-thermal method.
15. Deposition of thin film in vacuum.
16. Electrical resistivity of nanomaterials using four probe method
17. Photoluminescence study of prepared red/blue/green luminescent nanomaterials.
18. Characterization of nanomaterials using SEM/TEM.
19. Computer modelling methods for studying materials on a wide variety of length and time scales