SARDAR PATEL UNIVERSITY
VALLABH VIDYANAGAR

SYLLABUS EFFECTIVE FROM: 2017-18

Syllabus for M.Sc. (Physics)

Semester I

Course Code: PS01CPHY21: Mathematical Physics

Unit 1:

Linear vector space – Definition and examples, scalar product, dual vectors and Cauchy-Schwarz inequality, real and complex vector spaces, metric spaces.

Quantum states:State vectors and wave-functions, The Hilbert space of state vectors, Dynamical variables and linear operators and their algebra.Projection operators.The quantum condition, self-adjointnessSpecial operators such as Hermitian, Unitary etc. and their properties, Eigenvalues and eigenvectors, Expansion of identity,linear independence of vectors, generalized Eigen vectors, orthogonalization.

Unit 2:

Introduction, Analytic functions, Contour integrals, Laurent series, The Residue theorem, Methods of finding residues, Evaluation of definite integrals by use of the residue theorem, The point at infinity; residues at infinity, Mapping. Green's function – definition, Three methods of constructing Green's function, Few examples.

Unit 3:

Integral transforms, Fourier transform and its properties as well as applications such as Gaussian function, finite wave train, etc., Convolution theorem, momentum representation, Laplace transform and its properties, Laplace transforms of some elementary functions and derivatives including some applications in the problems of physics e. g. step function, simple harmonic oscillator, damped oscillator- RLC analogy etc.

Unit 4:

Tensors: Types of tensors and their algebra, Contraction and inner product, Metric tensors, Quotient rule, Dual and irreducible tensors, Christoffel symbols, covariant derivative, Geodesic equation.

Introduction to group theory:Definition and examples, group multiplication table, homomorphism and isomorphism, matrix representations – reducible and irreducible, classes and character, subgroups and cosets, Dihedral group, orthogonal groups and special unitary group, Illustrations of the group concept in various branches of physics.

Basic Text & Reference Books:

1. Mathematical Methods for Physicists by G. Arfkenand Weber, Academic Press, 6th Ed (2005).
2. A text book of Quantum Mechanics, by Mathews &Venkatesan, TMH Publication (2010
3. Mathematical Physics by P. K. Chattopadhyay (Wiley Eastern Limited, (1990).
4. Vector Analysis Murray Spiegel (Schuam Series).
5. Mathematical Methods in Physical Sciences by M. L. Boas, Second Edition, John Wiley & Sons, (1996).
6. Mathematical Methods of Physics by Mathews & Walker, 2^{nd} Ed. 2004 Pearson Education, (Singapore) Indian Br. Delhi, India.
7. Elements of Group Theory for Physicists by A W Joshi, New Age Int. Pub, New Delhi (1997).
8. Matrices and Tensors in Physics by A W Joshi 3rd Ed., New Age International (P) Ltd. New Delhi.

Course No. PS01CPHY22
ATOMIC & MOLECULAR SPECTROSCOPY AND STATISTICAL MECHANICS

Unit: 1 Atoms and Molecules

Schrödinger equation for one-electron atoms – H-atom, the dipole selection rules.Fine structure of hydrogenic atoms, The Lamb shift and its determination, Hyperfine structure and isotopic shifts. Schrödinger equation for Two-electron atoms, the role of Pauli Exclusion Principle, Energy levels of He atom, Doubly excited states, Auto-ionization in Helium. Thomas-Fermi model for many-electron atoms.The Born-Oppenheimer approximation for molecule, electronic structure of diatomic molecules, LCAO approximation for H_2^+ ion.

Unit: 2 Laser Spectroscopy

Emission and absorption spectroscopy: UV-visible-IR absorption (introduction),Classical view of Einstein coefficients; two-level system, Three-level Laser system, Variation of Laser power around threshold.NH_3 maser, He-Ne Laser (energy level diagram), CO_2 Laser, Semiconductor Lasers, Rayleigh and Raman scattering, Stimulated Raman effect, Hyper-Raman effect: Classical treatment, Quantum mechanical treatment, Coherent anti-stokes Raman scattering (CARS), Spin-flip Raman Laser, Free-electron Laser.

Unit: 3 Quantum Statistical Mechanics

Density operators: properties of density matrix, The density Operators of various ensembles, Examples, Density matrix, Partition function of a system of free particles, monoatomic molecules, diatomic molecules. The ideal Bose gas, Bose-Einstein Condensate. The ideal Fermi Gas, Degenerate Fermi gas, Applications: Black body radiation, Relativistic Fermi gas at T= 0, White dwarf stars. Cluster expansion for a classical gas, expansion of the equation of state, Evaluation of virial coefficients.

Unit: 4 Non-equilibrium Statistical Mechanics

Classification of phase transitions, Landau theory of second order phase transition, Examples of phase transitions, Ising model in one and two dimensions, Critical indices, Scaling laws, Boltzmann Transport Equation, Boltzmann H – theorem, Theory of Brownian motion,Diffusion equation.

Books:

1. Physics of Atoms and Molecules, by B. Bransden and C. J. Joachain (Pearson Education Publication, New Delhi).

2. Fundamentals of molecular spectroscopy, by C. N. Banvel.

3. LASERS Theory and Applications, by K. Thyagarajan and A. K. Ghatak (Macmillan India Ltd., 2008).

4. Lasers and Non-linear Optics, by B. B. Laud (New Age International P Ltd., India, 2nd edition, 1996) .

5. Mechanics, 3rd Ed. by Landau &Lifshitz, Pergamon Press, 1976

6. Statistical Mechanics, by R K Pathria, 2nd Ed. 1996, Butterworth- Heinemann, Ordan Hill, Oxford.

7. Statistical Mechanics, by Kerson Huang, Jhon Wiley & Sons, 1987

8. Thermodynamics and Statistical Mechanics, by Griener, Neise and Stoecker, Springer-Ind., Ed.1997.

9. Statistical Mechanics, by R K Srivastava and J Ashok, Prentice Hall of India, 2005

Course No. PS01CPHY23
ANALOG AND DIGITAL ELECTRONICS

Unit: 1 PN Junction Based Devices

Carrier Statistics in P-N junction-Barrier Potential and I-V Characteristics, Applications of P-N junctions- Diode as clipper, Diode as a clamper circuit, Diode as a switch, Reverse Recovery time of diode, optoelectronic devices, light emitting diode, photodiode and phototransistor, solar cells, Uni-junction Transistor, Silicon control rectifier, DIAC and TRIAC.

Unit: 2 Non-linear Integrated Circuits

Block diagram of Operational Amplifier IC 741, Characteristics and parameters of Op-Amp, Non-Linear Applications of Op-Amp- comparator, Schmitt Trigger, UTP and LTP adjustments, Voltage Controlled Oscillator using IC-741, Timer IC 555 block diagram, Timing waveform generators using IC 555- astable multivibrator and monostable multivibrator,

Unit: 3 BCD Codes and Digital Circuits

Review of Binary Coded Decimal codes, Boolean functions, Min-terms and Max-terms. Karnaugh Mapping, Tri-state logic, positive and negative logic, signed binary numbers.

Arithmetic logic circuits: Adders- Half adder and Full adder, Subtractors, comparators, Combinational and Sequential Circuits- Decoders, De-multiplexers, Encoders, Multiplexers,

Registers and Counters.

Unit: 4 Applications of Digital Circuits

Memories: Read Only Memory, Programmable Read Only Memory, Erasable Programmable Read Only Memory & Random Access Memory, expanding memory size. Digital to Analog and Analog to Digital Convertors: Resistive divider, Binary ladder, Digital to Analog Convertor using OPAMP, specifications, parallel comparators, counter method & approximation methods.

Books:

1. Solid State Pulse Circuits by David A. Bell; Prentice Hall of India, New Delhi
2. Digital Electronics by Malvino & Leech.
3. Microelectronics: Digital and Analog by K. R. Botkar.
4. Integrated Electronics by K. R. Botkar.
5. Electronic Devices & Components by J. Seymour
6. Operational Amplifier by Ramakant Gaekwad

Course No. PS01EPHY21
ELEMENTS OF SOLID STATE PHYSICS AND ERROR ANALYSIS

Unit: 1

Elements of crystallography: Symmetry elements, Classification of crystals, Zone and forms, Miller indices, Lattice types, Effect of symmetry, Atomic packing :packing of equal spheres in two and three dimension, hexagonal lattice, fcc lattice, bcc and Simple Cubic lattice, classification of closed packing, voids, voids in closed packing, Pauling's rule and its applications, Common Crystal structures : simplest crystals CsCl, NaCl, alkali metals, Diamond and hexagonal , Transformation theory.

Unit: 2

Lattice vibrations, Vibration of mono-atomic lattice, First Brillouin zone, group velocity and continuum limit, Lattice with two atoms per primitive cell, Quantization of lattice vibrations, phonon momentum, inelastic scattering of neutrons by phonons.

Unit: 3

Elastic properties, Stress and Strain components, Dilation, Elastic compliance, Stiffness, Elastic energy density and the relationships, Elastic constants for cubic isotropic crystal, their reduction due to existence of potential of elastic forces, Elastic waves : Waves in [100], [110] and [111] direction, Experimental determination of elastic constants.

Intrinsic carrier concentration, Impurity conductivity, Models for impurity semiconductors, Thermo-electric effect, Hall Effect.

Unit: 4

Types of measured quantities: Discrete quantities, Continuously distributed quantities, Histogram, Normalized histogram, Best estimate of true value of data, Standard deviation of the means, Gaussian distribution, Properties of Gaussian distribution, Determination of mean value for a Gaussian distribution, Determination of standard deviation for Gaussian distribution and problems, Chi-square test for goodness of fit, Criteria for goodness of fit, Determination of parameters in linear relationships, Graphical method, Method of least squares, Linear least square curve fitting.

Books:

1. Introduction to Solid State Physics by C. Kittle (John Wiley & Sons)
2. Elements of Solid State Physics by J.P. Srivastava (Prentice Hall of India)
3. Solid State Physics: Structure and Properties of Materials by M. A. Wahab (Narosa Publishers).
4. Principles of Solid State Physics by R. A. Levy (Academic Press)
5. Elementary Solid State Physics by M. A. Omar (Addison-Wesley Publishing Company).
6. Elements of X-ray Diffraction- B. D. Cullity
7. Instrumentation, measurement and analysis. B. C. Nakra and K. K. Chaudhry

Course No. PS01EPHY22
Title of Paper: Non-Linear Dynamics, Relativity & Cosmology

Unit: **1 Dynamical systems:** Dissipative systems, Attractors, Equilibrium solutions, Limit cycles, Periodic solutions, Poincare cuts, Static bifurcations, bifurcations of time-dependent solutions.
Lyapunov Exponents and Chaos: One dimensional system, Multidimensional systems Stretching and folding in phase space, Fractal geometry, Systems with chaotic dynamics: dynamics of discrete systems, One dimensional mappings.

UNIT: 2 General relativity: Space, time and gravitation, Covariant differentiation, Riemannian geometry, Space-time curvature, Geodesics, Principle of equivalence Gravitational equations, The Schwarzschild solution.
From Relativity to Cosmology: The Einstein Universe, The expanding Universe, Assumptions of Cosmology, The red shifts Apparent magnitude, Hubble's law, Angular size, Einstein Field equations in Cosmology, Energy tensors of the universe, Solution of Friedmann's equations, Luminosity vs distance, Cosmological models with the l term.

UNIT: 3 The Large Scale Structure of the Universe: Astronomy and Cosmology, Our galaxy, Types of Galaxies Radio sources, Quasars Structures on the large scale, Co-ordinates and catalogues of astronomical objects, Classification of stars, HR diagram; Expansion of the universe, Background radiation, Relativistic cosmology.

UNIT: 4 Big Bang and the Early Universe: The Early Universe, Thermodynamics of the early Universe, Primordial neutrinos, the proton – neutron ratio, Synthesis of helium and other nuclei, The microwave background, Formation of structures in the Universe, The expanding Universe, Growth in the post recombination era, Observational constraints, The inflationary phase, role of dark matter and dark energy.

Basic Text & Reference Books:-
1 Classical Mechanics – System of particles and Hamiltonian Dynamics' by Greiner, Springer International Ed. 2003 (second Indian Reprint 2006).
2 Introduction to Cosmology by J V Narlikar, Cambridge Univ Press, 1998.
3 General Theory of Relativity by P A M Dirac, Prentice Hall of India, 2001.