SARDAR PATEL UNIVERSITY
VALLABH VIDYANAGAR

SYLLABUS EFFECTIVE FROM: 2018-19
Syllabus for M.Sc. (Applied Physics) Semester I

## Course Code: PT01CAPC01
## Basic Mathematical Tools

**Unit 1**

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 2**

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 3**

Phase plane: Pendulum equation and its phase diagram, Autonomous equations in the phase plane, Phase diagram for the simple harmonic oscillator – weak and critical damping, Conservative systems, Damped linear oscillator, Nonlinear damping – dry friction, the brake, the pendulum clock, General phase plane for first-order system, Applications of Population Models – predator-prey problem, general epidemic, recurrent epidemic, Linear approximation at equilibrium points.

**Unit 4**

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

**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, 2nd 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. Nonlinear Ordinary Differential Equations by D. W. Jordan & P. Smith, Clarendon Press, Oxford (1976).
9. Matrices and Tensors in Physics by A W Joshi 3rd Ed., New Age International (P) Ltd. New Delhi.

## Course Code: PT01CAPC02
## Physics of 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 Code: PT01CAPC03
## Applied Electronics

**Unit: 1 PN Junction Based Devices**

Introduction to 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, Applications of some solid state devices.

**Unit: 2 Non-linear Integrated Circuits**

Block diagram of Operational Amplifier IC 741, Characteristics and parameters of Op-Amp, Op-Amp- comparator, Schmitt Trigger, UTP and LTP determination, Timer IC 555 block diagram and working, Timing waveform generators using IC 555- monostable and astable multivibrator, More applications of IC 555 Timer – delay timers, sequential timer, pulsed-tone oscillator, voltage controlled oscillator.

**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 and its applications.

**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 Code: PT01EAPC01
## Nanoscience & Applied Materials

**Unit 1**

Nanoscience & Nanotechnology- Definition, Concepts: Top down and Bottom up, Fundamentals of Nano-science and Nanotechnology, Classification of Nanostructure, Dimensionality & Quantum Confinement, Nanostructured materials, size dependant properties of nanomaterials.

**Unit 2**

Chemical processes: Chemical precipitation and co-precipitation, polyol, and borohydrate reduction methods, Sol-Gel synthesis; Microemulsions synthesis, Hydrothermal, Solvothermal synthesis methods, Microwave assisted synthesis; Sonochemical assisted synthesis, Core-Shell nanostructure, Quantum dot (QDs) synthesis.

**Unit 3**

Carbon nanostructures: Clusters, nanotubes, fullerenes etc., fabrication of carbon nanotubes (Arc discharge method, laser ablation method, CVD method) Electrical, Vibrational and mechanical properties, applications of carbon nanotubes as field emission, EMI shielding, FETs, chemical sensors, catalysis and mechanical reinforcement.

**Unit 4**

Nanotechnology: Nanostructured ferromagnetism (basics, dynamics and ferromagnets and fluids), biological materials, nanostructures, nano wires and protein nanoparticles, biological nanostructures (proteins, micelles, vesicles, multilayered films), energetic and chemical transformation of biological nanomaterials, nanomedicine, biomolecular sensing.

**Books:**


1. Charles P. Poole, Jr., Frank J. Owens; Introduction to Nanotechnology, Wiley-India
2. Nanotechnology: Principles and practices by Sulabha K. Kulkarani, Springer Publication
3. David S. Goodsell; Bionanotechnology- lessons from nature, Wiley-India
4. Carbon Nanomaterials by Yuri Gogotsi, Volker Presser, CRC Press


## Course Code: PT01EAPC02
## Numerical and Statistical Methods for Applied Physics

**Unit 1**

A Calculus refresher- functions and their derivatives – derivative as rate of change – Higher Order Derivatives - Maxima and Minima – Integration - Partial Derivatives – Taylor series - Gradient, Divergence and Curl - Hessian- Maxima and Minima.

Vectors in $R^n$ and matrices- algebra of matrices- inverse of a matrix- determinant and trace- eigen values and eigen vectors- projections and orthogonal matrices.

**Unit 2**

Ordinary differential equations- linear equations of first and second order –systems of linear differential equations- stability of solutions of linear systems of ODE- Legendre, Hermite and Bessel equations and polynomials.

Partial differential equations of science and method of reparation of variables-Applications.

**Unit 3**

Numerical Analysis- Newton Method for implicit equation $f(x) = 0$ – Eular's method and Runge-Kutta method for ordinary differential equations – Methods of Elementary Error Analysis.

Collection and classification of data- frequency table- graphical representations of data- measures of central tendancy: mean, median, mode- measures of dispersion: variance standard deviation, coefficient of variation.

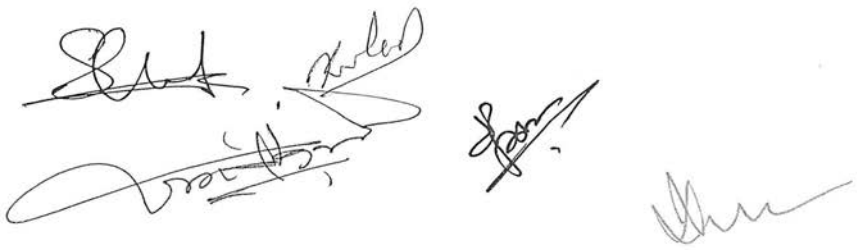
**Unit 4**

Random Variables- probability- joint, marginal and conditional probability – discrete and continuous random variables – probability distribution functions- Expectation and Moments – Binomial, Poisson and Normal distributions- a compendium of some other distribution functions.

Testing of hypotheses – goodness of fit tests- chi-square test- tests of significance- one sample tests for mean- z test and t-test – two sample tests for means and variance.

**Books:**


1. Introduction to Geochemical Modelling, Francis Albarede, , Cambridge University Press (Relevant Materials from Chapters : 1-4) 1995.
2. Higher Engineering Mathematics (37th Edition), B. S. Gerwal, , Khanna Publishers
3. Pisani and Purves – Statistics, Freedman, W.W. Norton & Co., 2011.

## Course Code: PT01CAPC04

## EXPERIMENTAL METHODS-I

| Sr. No. | Title of Experiment |
|---|---|
| 1 | Frequency response of LDR using different filters |
| 2 | Determination of Resistivity of a semiconductor using Four Probe method |
| 3 | Arithmetic operations through combinational Logic Circuits |
| 4 | LCR Damped Harmonic Oscillator |
| 5 | Wave shaping circuits (using R, C and D) |
| 6 | Determination of e/k using a power transistor |
| 7 | Analog to Digital Convertor |

## Course Code: PT01CAPC05

## EXPERIMENTAL METHODS-II

| Sr. No. | Title of Experiment |
|---|---|
| 1 | Thermistor characteristics and estimation of the band gap of the semiconducting material |
| 2 | Measurement of dielectric constant of solid materials by resonance method |
| 3 | Determination of the Planck's Constant using LED |
| 4 | Dead time determination of a Geiger-Muller Counter |
| 5 | Analysis of solar absorption spectra using Hart-Mann formula |
| 6 | Study of chaos through the logistic map of a population growth |
| 7 | Zeeman Effect |

## Course Code: PT01CAPC06

## COMPREHENSIVE VIVA

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