S ARDAR PATEL UNIVERSITY
VALLABH VIDYANAGAR

SYLLABUS EFFECTIVE FROM: 2019-20
Syllabus for M.Sc. (Applied Physics) Semester IV
Course Code: PT04CAPC01
Elements of Nuclear and Particle Physics

UNIT – 1

Basic nuclear properties: size, shape and charge distribution, spin and parity. Liquid drop model, Binding energy, semiempirical mass formula, Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces, Yukawa's hypothesis, Deuteron and its properties, inter-nucleon potential, charge independence and charge symmetry-polarization, Single particle shell model, Even-Z and even-N nuclei and collective structure, Rotational motion of the nucleus, Vibration of spherical nuclei.

UNIT-2

The Radioactive decay law, Quantum theory of radioactive decay, Types of decays, Natural radioactivity, Radiometric dating, Geiger-Nuttall law for Alpha decay, Angular momentum and parity in alpha decay, Beta decay: Experimental information about Beta particles, Energy release in Beta decay (Q value), Angular momentum and parity selection rules, Experimental detection of neutrino, Gamma decay-electromagnetic transition, Gamma ray transition probability, Artificial radioactivity. Characteristics of Nuclear Fission, Nuclear Fusion, Sources of energy in stars, nucleo-synthesis processes.

UNIT- 3

Applications of Nuclear Physics: Uranium Fission reactor, Design of Nuclear Reactor, Breeder Reactors, Controlled fusion, Lawson Criterion. Tokamak design, Trace element analysis, Mass spectroscopy with accelerator, Alpha decay application, Diagnostic and therapeutic nuclear medicine, Hadron therapy, Radiation Dose, Shielding materials. Thermo-nuclear weapon, RBS (Rutherford back scattering), Proton Induced X-Ray Emission (PIXE) Analysis, Neutron Activation analysis (NAA) – Chemical analysis, Mössbauer Spectroscopy.

UNIT- 4

Classification of elementary particles, types of interactions, conservation laws, momentum-parity and spin – isospin – baryon and lepton numbers, Gell-Mann-Nishijima relationship, mesons and baryons, quark model, CPT invariance, Parity non-conservation in weak decays, detection and properties of neutrino, concept of antiparticles, Summary of Standard model of Particle physics.

Basic Text & Reference Books:

1. Introductory Nuclear Physics by Kenneth S Krane, John Wiley & Sons, Singapore (1988)
2. Fundamentals of Nuclear Physics by J. C. Verma, R. C. Bhandari & D.R.S. Somayajulu (2005) CBS Publishers & Distributers, New Delhi.
3. Fundamentals of Nuclear Physics by Jahan Singh, Pragati Prakashan, Meerut 1st ed. (2012).
4. Introduction to Particle Physics' by M P Khanna, Prentice Hall of India (1999) New Delhi
5. An Introduction to Nuclear Physics' by W N Cottingam & Greenwood, Cambridge Univ. Press UK
6. Introduction to Elementary particles' by David Griffiths, John Wiley & Sons Singapore (1987).

Course Code: PT04CAPC02
Sophisticated Experimental & Characterization Techniques

UNIT: 1

Thin film deposition techniques: Radio frequency and magnetron Sputtering, CVD reaction types, PECVD, LECVD, MOCVD, HTCVD, Introduction to Epitaxy, lattice misfit, epitaxy of compound semiconductors, Applications of epitaxy : Optical communications, Light emitting semiconductor devices (e.g. GaN), Molecular beam epitaxy (MBE), Liquid Phase epitaxy (LPE), Vapour phase epitaxy (VPE), Langmuir Blodgett films, Spray method : Spray Hydrolysis, Spray pyrolysis, Ion Implantation techniques.

UNIT: 2

Principles of Cryo-cooling and Thermometry: Cooling techniques, Liquifaction of gases, Closed cycle refrigerators, sample helium bath cryostats, Dilution refrigerators, Pomeranchuk cooling, adiabatic demagnetization, nuclear spin demagnetization. Primary thermometers, ^{3}He melting-curve Thermometer, Superconducting fixed-point Thermometers, Nuclear- Orientation Thermometers. Secondary Thermometers: Resistance Thermometers, Thermoelectric Elements, Magnetic Thermometers, Nuclear Spin Resonance Thermometers.

UNIT: 3

Low and high resolution mass spectrometry, Chromatography-mass spectrometry, Tandem mass spectrometry, Gas chromatography, Liquid chromatography, Ion chromatography, gel permeation chromatography. Atomic absorption spectroscopy, emission spectrographic analysis, flame emission spectrometry, inductively coupled argon plasma emission spectroscopy, neutron activation analysis.

UNIT: 4

SAXS and SANS (small angle X-ray and neutron scattering, spectroscopy, synchrotron X-ray sources, SEM/EPMA (scanning electron microscopy, electron probe microanalysis) Scanning Auger microscopy(AES), SIMS (Secondary ion mass spectrometry), Ultraviolet and Bremsstrahlung isochromat spectroscopy, Angular dependent X-ray photoelectron spectroscopy. Low energy electron diffraction (LEED), Reflection high energy electron diffraction (RHEED), Electron energy loss spectroscopy (EELS), Surface Scanning tunneling microscopy (STM), Atomic-force microscopy (AFM).

Basic Text & Reference Books:

1. Handbook of thin film technology by L.I. Maissel and R. Glang (McGraw-Hill).
2. The Materials Science of thin films by Milton Ohring (Academic press).
3. Thin Film Phenomena by K. L. Chopra (McGraw-Hill).
4. Surface Science: An Introduction By K. Oura, V.G. Lifshitz, A. A. Saranin, A. V. Zotov and M. Katayama, Springer-Verlag, 2003.
5. Materials characterization and chemical analysis by John P. Sibilia.
6. Preparation of thin films by Joy George
7. Low Temperature Physics: Christian Enns and Siegfried Hunklinger, Springer-Berlag Berlin Heidelberg (2005).
8. Matter and Methods at low Temperature (3rd edition): Frank Pobell, Springer-Verlag Berlin Heidelberg (2007).
9. Experimental Techniques in Low Temperature Physics (3rd Edition): Guy K. White, Clarendon Press, Oxford (1979)

Course Code: PT04CAPC03
Advanced Devices and Sensors

UNIT: 1

Importance of sensors in industries, Classification of sensors, Measurement standards, Gas sensors-classification, Indirect and Direct Techniques, electrochemical sensors, catalytic gas sensors, semiconductor gas sensors, ceramic, thick and thin film sensors, array of gas sensors, electronic noise.

Applications-Temperature, Humidity, Liquid level, Fluid flow and Microbend sensors, Fiber optic sensors (FOSs), Fiber Optic Chemical Sensors, Distributed Sensing System using OTDR, Integrated Optics Sensors, Seismic Sensors

UNIT: 2

Classification and Basic requirements of Transducers, selection of transducers, Principles of displacement Transduction, circuit based on transduction, Temperature transducer, displacement transducer, Transduction Methods, Solid state, thin film, Calibration, Platinum type sensors, Thermisters, Thermocouples, IC Temperature Sensors, Radiation measurement, optical pyrometers. Classification of Biosensors, Enzyme based biosensors, Electrodes for Electrochemical Biosensors, Optical Biosensors.

UNIT: 3

Pressure: Diaphragms, Elastic elements, pressure transducers and catheter tip transducers, Strain: Factors affecting strain measurements, operation of resistance gauge, types of Characteristics devices Load cell and its types, Torque measurement and its types, Phenomenon Force, strain, torque, pressure & acceleration Transducer, Hall Effect transducers & applications, photoconductive and photo-emissive transducers, Ionization displacement transducer, nuclear radiation transducer, radioactive transducers, digital transducers.

UNIT: 4

Nuclear Magnetic Resonance Spectrometry: Theory of NMR (quantum description, energy levels, classical descriptions, relaxation processes), FT NMR, Environmental effects on NMR spectra (types, origin of chemical shift, spin-spin splitting, theory of chemical shift).

Applications of ^{13}C-NMR (quantitative analysis, structure determination, applications to solid samples).

Molecular Mass Spectrometry: Molecular Mass Spectrum, Ion Sources and types, Ion Sources and spectra, Desorption sources and Methods-MALDI, ESI, Instrumentation (General Description and Instrument components, Resolution and Analyzers).

Applications: Identification of pure compounds, Molar masses, Molecular formula, Structural information, Analysis of mixtures, Quantitative applications. Raman Effect and its applications.

Basic Text & Reference Books:

1. Fiber Optic Sensors: Fundamentals and Applications by D.A. Krohn, 2nd edition, Instrument Society of America (1992).
2. Sensors and Transducers by D. Patranabis, 2nd ed., Prentice-Hall of India (2005).
3. Handbook of Modern Sensors: Physics, Design, and Application by Jacob Fraden, 3rd edition, Springer (2004).
4. Sensors and Transducers by Ian R. Sinclair, 3rd ed., Newnes (2001).
5. Sensors and Transducers by M. J. Usher, Macmillan, London (1985).
6. Introduction to Instrumental Analysis, Robert D. Braun, Pharma-Med Press
7. Principles of Instrumental Analysis, Holler, Skoog, Crouch, Thomson

Course Code: PT04EAPC01
Crystallography and Crystal Growth Methods

UNIT-1

The crystalline state of solids, Unit cells and Bravais lattices, Miller indices, symmetry elements in crystals, Concept of point groups, space group, Reciprocal lattice and diffraction conditions and its relation with Brillouin zones, Graphical construction, Vector- algebraic discussion, Relation to inter-planar spacing, Ewald construction, Laue equation, Powder Crystal Method, Rotating crystal method, Projection-Spherical, stereographic & gnomonic.

UNIT-2

Lattice vacancies: Schottky and Frenkel, Diffusion, self diffusion in metals, color centers, Dislocations : shear strength of single crystals, slip, dislocations, Burger's vector, stress fields of dislocations, strain energy of a dislocation low angle grain boundaries, dislocation densities, dislocation multiplication and slip, Surface imperfections: grain boundary, tilt and twist boundary, stacking faults: stacking faults in fcc crystals, stacking faults in hcp crystals, strength of alloys, dislocation and crystal growth, whiskers.

UNIT-3

Importance of crystal growth, Classification of crystal growth methods, Basic steps: Generation, transport and adsorption of growth reactants, Nucleation: homogeneous nucleation and heterogeneous nucleation, Classical theory of nucleation: Gibbs Thomson equations for vapour and solution, Kinetic theory of nucleation – Becker and Doring concept on nucleation rate, Energy of formation of a spherical nucleus, Statistical theory on nucleation: Equilibrium concentration of critical nuclei, Free energy of formation.

Basics of melt growth – Heat and mass transfer – Conservative growth processes: Bridgman-Stockbarger method – Czochralski pulling method – Kyropolous method – Nonconservative processes: Zone-refining – Vertical and horizontal float zone methods – Skull melting method – Vernueil flame fusion method.

UNIT-4

Growth from low temperature solutions: Selection of solvents and solubility – Meir's solubility diagram – Saturation and supersaturation – Metastable zone width – Growth by restricted evaporation of solvent, slow cooling of solution and temperature gradient methods– Crystal growth in Gel media: Chemical reaction and solubility reduction methods– Growth from high temperature solutions: Flux growth Principles of flux method – Choice of flux – Growth by slow evaporation and slow-cooling methods – Hydrothermal growth method. Growth by vapour – sublimation – condensation, Vapour transport techniques, Growth by chemical vapour transport reaction: Transporting agents, Growth of some industrially important crystals, Diamond – HPHT, Zeolites – Hydrothermal technique, Semiconductors and superconducting materials – Flux growth, Epitaxial growth technique.

Basic Text & Reference Books:

1. Crystal growth processes by J. C. Brice
2. The Physics of engineering solids by T. S. Hutchison and D.C. Baird
3. Crystal growth: Processes and Methods by P. Santana Raghavan and P. Ramasamy
4. Solid State Physics by M.A. Wahab
5. Materials science and Engineering an introduction by William D. Callister. Jr.
6. Introduction to Solid State Physics by Charles Kittel.
7. Principle of Solid State Physics by F. Levy
8. Elements of Solid State physics by J.P. Srivastava
9. Introduction to dislocation by D. Hull
10. Elementary Solid State Physics by M.A. Omar

Course Code: PT04EAPC02
Advanced Electronic Devices

UNIT - I

BJT design limitations: Need for band tailoring & its methods, Hetrojunction bipolar transistor - Si based HBTs, GaAs/AIGaAs HBTs, InGaAs/InAlAs and InGaAs/InP HBTs, JFET, MESFET : I-V characteristics in active and saturation regimes. Effects in real devices- Velocity field relations, Channel length modulation.

UNIT - II

Heterojunction FETs-Key motivations. Charge control model for MODFET, Current control in MODFET: Active and saturation regions, High frequency, high speed issues - Small signal characteristics, Equivalent circuit, Large signal analog applications and requirements of semiconductor parameters. Charge coupled devices, Advanced MOS devices-HMOS and SIMOX.

UNIT – III

Metal Oxide Semiconductor capacitor, Accumulation, Depletion and Inversion regions, Capacitance-Voltage characteristics of the MOS structure, MOSFET current-Voltage characteristics, Substrate bias effects, Depletion and enhancement MOSFETs, Complementary MOSFETs, Important effects in long channel and short channel MOSFETs, High frequency issues.

UNIT - IV

Optical absorption in semiconductors, photocurrent in a P-N diode, Photoconductive detector, P-I-N photodetector, Avalanche Photodetector, APD design issues, Materials for light emitting devices, Internal and external quantum efficiency, LED performance issues, Light-current characteristics, Spectral purity, Temporal response, Advanced LED structures, Hetrojunction LED, Edge emitting LED, Surface emitting LED.

Basic Text & Reference Books:

1. Semiconductor Devices - An introduction, Jasprit Singh, McGraw-Hill Inc.
2. Physics of Semiconductors and their Heterostructures, Jasprit Singh, McGraw-Hill Inc.
3. Semiconductor Optoelectronic Devices, Pallab Bhattacharya, Prentice Hall of India.
4. Electronic Devices and Components, J. Seymore, Longman Scientific and Technical Publication.

Course Code: PT04CAPC04

EXPERIMENTAL METHODS-VII

Sr. No.	Title of Experiment
1	Determination of elastic strength and particle size using laser diffraction
2	XRD non-cubic structure determination -I
3	XRD non-cubic structure determination -II
4	Sheet Resistance measurement of thin film using four probe
5	Switching characteristics of Silicon Control Rectifiers (SCR)
6	Study and measure the P-I characteristics of laser diode, which used in optical fiber communication as a light source.
7	Brewster's angle measurement and verification of Malus's law
8	Experimental Demo on Liquid Chromatography and Mass Spectroscopy
9	Study of nuclear counting statistics: Beta ray absorption/ gamma ray detection using G M counter

Course Code: PT04CAPC05

EXPERIMENTAL METHODS-VIII

Sr. No.	Title of Experiment
1	Determination of electron Lande g factor using Electron Spin Resonance
2	Determination of nuclear g factor using Nuclear Magnetic Resonance
3	To measure the photo-current as a function of the irradiance at constant voltage
4	To investigate hysteresis loop, corrosivity and retentivity of iron core
5	Study of Thermoluminescence of F centre in Alkali Halide crystal
6	Study of defect in crystal using chemical etching
7	Study of the characteristics of sensor/transducer
8	Experimental Demo on Gas Chromatography

Course Code: PT04CAPC06

COMPREHENSIVE VIVA

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