Rayat Shikshan Sanstha's

SADGURU GADGE MAHARAJ COLLEGE, KARAD

(An Autonomous College- Affiliated to Shivaji University, Kolhapur)

Revised M. Sc. Part-II Physics (CBCS) Syllabus w. e. f. July 2023

Syllabus for M.Sc. Part – II

1. Structure of Syllabus: M.Sc. – II Semester – III

Sr. No.	Course Title	Theory				Practical			
		Paper Code	No. of lectures Perweek	Total Hours Per week	Credits	Paper Title Code	No. of lectures Per week	Total Hours Perweek	Credits
Compulsory Papers									
1	Experimental Techniques	**P22-301**	4	4	4	**SSP LAB I** **PP22-306**	12	12	4
2	Electro-dynamics	**P22-302**	4	4	4				
3	Solid State Physics- II (Semiconductor Physics)	**P22-303**	4	4	4	**SSP LAB II**+ Project **PP22-307**	12	12	4
Elective Paper									
4	i) Nanoscience and Nanotechnology ii) Optoelectronics and Photonics	**P22-304** **P22-305**	4	4	4				
Total Credits Theory					**16**	**Total Credits Practical**			**08**
Total credit (16+08)= 24									

Structure of Course: M.Sc.-II Semester-IV

Sr. No.	Paper Title	Theory				Practical			
		Paper Code	No. of lectures Perweek	Total Hours Perweek	Credits	Paper Title& Code	No. of lectures Perweek	Total Hours Perweek	Credits
Compulsory Papers									
1	Nuclear and Particle Physics	**P22-401**	4	4	4	**LAB III** **PP22-406**	12	12	4
2	Solid State Physics -III (Thin Solid Films: Deposition and Properties)	**P22-402**	4	4	4				
3	Solid State Physics- IV (Energy Conversion and Storage Devices)	**P22-403**	4	4	4	**LAB IV** +Project **PP22-407**			
Elective Paper									
4	i) Electronic Devices ii) Laser Physics	**P22-404** **P22-405**	4	4	4		12	12	4
Total Credits Theory					**16**	**Total Credits Practical**			**08**
Total credit (16+08)= 24									

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Paper Code	Title of Paper	Theory (TH) or Practical (PR)	Evaluation scheme (Marks)			Credits
			CCE	SEE	Total	
M.Sc. II, Sem. III						
P22-301	Experimental Techniques	**TH**	**20**	**80**	**100**	**04**
P22-302	Electro-dynamics	**TH**	**20**	**80**	**100**	**04**
P22-303	Solid State Physics- II (Semiconductor Physics)	**TH**	**20**	**80**	**100**	**04**
P22-304	i) Nanoscience and Nanotechnology	**TH**	**20**	**80**	**100**	**04**
P22-305	ii) Optoelectronics and Photonics	**TH**				
P22-306	Physics Practical I	**PR**	**-**	**100**	**100**	**04**
P22-307	Physics Practical II + Project	**PR**	**-**	**100**	**100**	**04**
PAEC-II	AEC: Communicative English-II	**TH**	**-**	**-**	**-**	**-**
	Total	**-**	**80**	**520**	**600**	**24**
M.Sc. II, Sem. IV						
P22-401	Nuclear and Particle Physics	**TH**	**20**	**80**	**100**	**04**
P22-402	Solid State Physics -III (Thin Solid Films: Deposition and Properties)	**TH**	**20**	**80**	**100**	**04**
P22-403	Solid State Physics- IV (Energy Conversion and Storage Devices)	**TH**	**20**	**80**	**100**	**04**
P22-404	i) Electronic Devices	**TH**	**20**	**80**	**100**	**04**
P22-405	ii) Laser Physics	**TH**				
P22-406	Physics Practical III	**PR**	**-**	**100**	**100**	**04**
P22-407	Physics Practical IV + Project	**PR**	**-**	**100**	**100**	**04**
PGE-I	GE: Generic Elective	**TH**	**-**	**-**	**-**	**-**
PSEC-II	SEC: Fundamentals of Information Technology-II	**TH**	**-**	**-**	**-**	**-**
	Total	**-**	**80**	**520**	**600**	**24**
	Grand Total	**-**	**160**	**1040**	**1200**	**48**

M.Sc. II (Physics) (Semester-III)
P22-301: EXPERIMENTAL TECHNIQUES (Credits: 04)

Learning Objectives:

1. To understand the low pressure production techniques, measurement of low pressure.
2. To understand low temperature production and its devices.
3. To study the working of Atomic Absorption Spectrometry (AAS)..
4. To understand various spectroscopy & resonance techniques.

Unit I: Vacuum Techniques (15)

Production of low pressures: Rotary Pump, Diffusion Pump, Sputter ion pump, Measurement of low pressure: McLeod Gauge, Pirani Gauge Thermocouple gauge and Penning gauge. Leak detection: Simple methods of LD, Palladium barrier and Halogen leak detectors.

Unit II: Low Temperature Techniques (15)

Production of low temperatures: Adiabatic cooling, The Joule-Kelvin expansion, Adiabatic demagnetization, 3He cryostat, The dilution refrigerator, Principle of Pomerunchuk cooling, Principle of nuclear demagnetization. Measurement of low temperature, Gas thermometer, Resistance thermometer, Vapour pressure thermometer.

Unit III: Atomic Absorption Spectrometry (AAS) (15)

Principle and block diagram of AAS, Operation, Monochromator action, Modulation. Apparatus: Double beam instrument, Radiation sources, Aspiration and Atomization; Interferences, Control of AAS parameters, Reciprocal sensitivity and Detection limit.

Unit IV: Spectroscopy and Resonance Techniques (15)

Infrared spectroscopy: Instrumentation, Sample holding techniques, FTIR, Applications. Raman Spectroscopy: Quantum theory of Raman scattering, Raman spectrometers Nuclear Magnetic Resonance: Resonance condition, NMR Instrumentation, Electron Spin Resonance: Principle of ESR, ESR Spectrometer, ESR spectrum of Hydrogen Atom.

Learning outcomes:

1. Students will able to explain low pressure production techniques, measurement of low pressure and explain leak detection.
2. Students will able to explain low temperature production, measurement of low pressure and cryostat.

3. Students will able to understand working principle of of AAS.
4. Students will able to explain Infrared spectroscopy, Raman Spectroscopy,Nuclear Magnetic Resonance, Electron Spin Resonance.

Reference Books:

1. Advanced Experimental Techniques in Modern Physics – *K. MuraleedharVarier, Antony Jodrph, P PPradhunam.*(Unit I, II)

2. Principles of Instrumental Analysis.- *Douglas A. Skoog, F.James Holler, Stanley R. Crouch* (Unit III, IV)

3. Introduction to Instrumental Analysis.*Robert B. Braun*(Unit III, IV)

4. Molecular Structure and Spectroscopy – *G. Aruldhas (second edition) 2014*(Unit IV)

5. Experimental principles & methods below 1K – O.V.Lounasmaa(Unit II)

6. High vacuum techniques - *J.Yarwood (Chapman & Hall) 1967*(Unit I)

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P22-302: Electrodynamics (Credits: 4)

Learning Objectives: Students will able to:

1. Understand Maxwell's equations and applications.
2. Study E.M. wave equations in waveguide.
3. Study scalar and vector potentials.
4. Understand field charge and its applications.

Unit I: Time Varying Fields **(15)**

Time dependents field, faradays law for stationary and moving media, Maxwell's displacement current, Differential and Integral forms of Maxwell's equations, Maxwell's equation for moving medium, microscopic and macroscopic forms in Maxwell's equation.

Unit II: Maxwell's Equations and E.M. Waves **(15)**

Conservation of the bound charge and current densities, E.M. wave equations in waveguide of the arbitrary cross section: TE and TM modes; Rectangular and circular waveguides, hybrid modes, concept of LP modes.

Unit III: Time –Dependent Potentials and Fields **(15)**

Scalar and vector potentials: coupled differential equations, Gauge transformations: Lorentz and Coulomb Gauges, Retarded Potentials, Lienard –Wiechert Potentials, Fields due to a charge in the arbitrary motion.

Unit IV: Radiation from Accelerated Charges and Radiation Reaction **(15)**

Fields of charge in uniform motion, applications to linear and circular motions: cyclotron and synchrotron radiations, Power radiated by point charge – Larmor's formula, Angular distribution of radiated power, Cerenkov radiation and Bremsstrahlung (qualitative treatments). Radiation Reaction: criteria for validity, Abraham –Lorentz formula, Physical basis of radiation reaction – self force.

Text and Reference books:

1. Classical Electrodynamics –S. P. Puri, Narosa Publication 2011 (UNIT VI)
2. Introduction to Electrodynamics – D.J. Griffiths (Prentices- Hall 2002 (4th Edn) (UNIT II, III)
3. Foundation of E.M. Theory- J.R. Reitz, F.J. Milford & R.W. Christy (Narosa Publication House 3rd edition 1993)
4. Classical Electrodynamics – J. D. Jackson (Wiley Eastern 2nd edition) (UNIT III,)
5. Electromagnetics - B. B. Laud Wiley Eastern Publication 1983) (UNIT I)

Learning Outcomes:

Unit – I:

1. Student should able to define time dependents field,
2. Student should able to understand faradays law for stationary and moving media, Maxwell's displacement current.
3. Students should able to Maxwell's equation for moving medium and its microscopic and macroscopic forms

Unit – II:

1. Understanding of Conservation of the bound charge and current densities.
2. Student should able to understand idea of waveguide
3. Student should able to understand rectangular and circular waveguides, hybrid modes, concept of LP modes

Unit – III:

1. Student should able to define Scalar and vector potentials.
2. Understanding of Gauge transformations: Lorentz and Coulomb Gauges.
3. Student should able to understand Retarded Potentials, Lienard –Wiechert Potentials.

Unit – IV:

1. Student should able to understand concept Fields of charge in uniform motion.
2. Understanding of cyclotron and synchrotron radiations
3. Student should able to understand power radiated by point charge – Larmor's formula
4. Student should able to understand Cerenkov radiation and Bremsstrahlung, Abraham –Lorentz formula

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P22-303: SOLID STATE PHYSICS-II

(Semiconductor Physics) (Credits: 04)

Learning Objectives:

1. To understand the energy bands in solids, direct and indirect semiconductors and Fermi level.
2. To understand optical absorption, quasi Fermi levels and diffusion and drift of carriers.
3. To study concept of p-n junction, Zener and avalanche breakdown.
4. To study properties of photodiodes, photodetectors and Lasers.

Unit I: Energy Bands and Charge Carriers in Semiconductors (15)

Bonding forces and energy bands in solids, Direct and Indirect semiconductors, Variation of energy bands with alloy composition, Charge carriers in semiconductors: electrons and holes, Effective mass, Intrinsic and Extrinsic materials, Electrons and holes in quantum wells, The Fermi level, Carrier concentration at equilibrium, Temperature dependence of carrier concentration, Space charge neutrality, Conductivity and Mobility, Drift and Resistance, Effects of temperature and doping on mobility, High field effects.

Unit II: Excess Carriers in Semiconductors (15)

Optical absorption, Luminescence, Direct recombination of electrons and holes, Indirect recombination and trapping, Steady state carrier generation and Quasi Fermi levels, Diffusion processes, Diffusion and Drift of carriers, Built-in fields, The continuity equation, Steady state carrier injection, Diffusion length, The Haynes-Shockley experiment.

Unit III: Junctions (15)

Fabrication of p-n junctions; Thermal oxidation, Diffusion, The contact potential, Space charge at a junction, Qualitative description of current flow at a junction, Carrier injection, reverse-bias breakdown, Zener and Avalanche breakdown, Capacitance of p-n junction, Schottky Barriers, Rectifying contacts, Ohmic contacts, Idea of homojunctions and heterojunctions.

Unit IV: Optoelectronic Devices (15)

Photodiodes: Current and Voltage in an illuminated Junction, Photodetectors: Gain, Bandwidth and Signal-to-Noise Ratio, Light-Emitting Diodes, Lasers: Semiconductor Lasers, Population Inversion at a Junction, Emission Spectra for p-n Junction Lasers, The Basic Semiconductor Laser, Heterojunction Lasers, Materials for Semiconductor Lasers, Energy level diagram of lasers and metastable states.

Learning outcomes:

1. Students will able to explain energy bands in solids, direct and indirect semiconductors concept of Fermi level.
2. Students will able to explain optical absorption phenomenon, quasi Fermi level, diffusion and drift of carriers in semiconductors.
3. Students will able to explain fabrication of p-n junction, Zener and avalanche breakdown, rectifying and ohmic contacts.
4. Students will able to explain properties of photodiodes, photodetectors, Lasers.

References:

1. Solid state electronic devices by B. G. Streetman (7th Edition). (Unit I, II, III, IV)
2. Physics of semiconductor devices by S. M. Sze (2nd Edition).(Unit I, II, III, IV)
3. Solid State and Semiconductor Physics by McKelvey.(Unit II)
4. Introduction to semiconductor materials and devices by M. S. Tyagi (Unit III)
5. Lasers and nonlinear optics by G.D. Baruah (Unit IV)

P22-304: NANOSCIENCE AND NANOTECHNOLOGY (Credits: 04)

Learning Objectives:

1. To provide in depth knowledge of nanoscience and its technological aspects.
2. To explain dimensions dependent properties of nanoscale materials.
3. To make students aware of various types of technologically important nanostructures.
4. To familiarize with current and recent scientific and technological developments innanotechnology based devices.
5. To introduce applications of nanomaterials in various fields.
6. To create foundation for research and development in nanoscience and technology.
7. To motivate the students to build-up a progressive and successful career in nanotechnology.

Unit I: Quantum Mechanics of Low Dimensional Systems: **(15)**

History and Introduction of Nanoscience and Nanotechnology, Classification of nanomaterials, Quantum confinement effect, Applications, Density of states in Three Dimensional,Two-Dimensional, One-Dimensional and Zero-Dimensional Systems, Quantum Confinement in Quantum Wells, Quantum Wires and Quantum Dots.

Unit II: Properties of nanomaterials: **(15)**

Mechanical properties, Structural properties, Electrical conductivity, Optical properties and Melting point of materials, Semiconductor materials, Luminescence in semiconductor materials.

Special Nanomaterials: Graphene, Carbon nano tubes and Types (CNT), Fullerenes, Aerogels, Core Shell Nanostructures.

Unit III: Magnetic Properties of nanomaterials: **(15)**

Magnetism, Types of magnetic materials, Effect of Nanostructuring on magnetic properties, Dynamics of Nanomagnets, Giant Magnetoresistance, Ferrofluids, Nanomagnetic Materials.

Unit IV: Transport properties of Nanomaterials: **(15)**

Excitons in Nanomaterials, Coulomb Blockade, Coulomb Blockade in a tunnel junction, Observing the Coulomb Blockade, Quantum Transport in Quantum dots, Single electron transistor, Spin polarized transport, Spin field effect transistor (Spin-FET).

Learning Outcomes:

1. Students will be able to understand the change in the properties of materials from bulk to nano level and quantum confinement in 0 D, 1 D and 2 D Materials.
2. Students will understand technological importance of nanomaterials and replacement of bulk materials.

3. Students will get exposure to different applications of nanomaterials.
4. Student will be confident to pursue further higher education and research in Nanoscience and Nanotechnology.

References:

1. Nanosciecne and Nanoechnology: Fundamentals to Frontiers; *M.S. Ramachandra Rao and Shubra* Singh (Wiley). (Unit I,II,III,IV)
2. Nanosciecne and Nanoechnology; *K. K. Choudhary*, Narosa Publishing House.(Unit I,IV)
3. Nanotechnology: Principals and Practices; *Sulabha K. Kulkarni*, Capital Publishing Company.(Unit II,III)
4. Introduction to Nanotechnology; *Charles P. Poole, Jr., Frank J Owens*; Wiley. Nanostructures and Nanomaterials; *G. Cao and Y. Wang*; Word Scientific Publication.(Unit III,IV)

P22-305: Optoelectronics and Photonics (Credits: 04) Learning

Objectives:

1. To understand concepts of light emitting materials.
2. To study different modulators and electro-optic devices.
3. To understand principle of optical fibers and their types.
4. To understand second, third order non linear optical media and concepts of optical digital computer.

UNIT I- Optoelectronic devices: (15)

Photoconductivity, Light dependent resistor, photodiode, phototransistor, solar cell, metal semiconductor detector, Liquid crystal display, charged coupled devices, light emitting diode Laser diode: Spontaneous and stimulated emission, laser structures, time response of lasers, advanced semiconductor laser structures, temperature dependence of laser output. PIN photodiode, Avalanche photodiode, Heterojunction photodiode, Organic light emitting diodes (OLED) , way to perceive colors, conventional, transparent, inverted and flexible OLEDs, Organic thin films transistors (OTFT), OTFT based display technology; Organic laser-Lasing process, optically pumped lasing structures, applications; Organic multilayer, photodetectors; organic photovoltaic cells.

UNIT II- Optoelectronic modulators: (15)

Polarization of Light, Elliptical polarization, Optics of anisotropic media: The index ellipsoid, Birefringence, Optical activity, Electro-optic effect, Electro-optic modulators, Acousto-optic modulators, use of optoelectronic modulator, Kerr modulator- Kerr effect, Magneto-optic modulator – Faraday effect, Acousto-optic effect, Electro-optic Devices: Wave retarders, rotators and optical isolators, Intensity Modulators, Phase Modulators, Traveling Wave Modulator, Acousto-optic Devices: Raman-Nath acousto-optic modulator, Acousto-optic deflector, parametric oscillation.

UNIT III- Fiber optics: (15)

Basic characteristics and ray propagation in an optical fibers, Step –index and graded-index fibers, Multipath dispersion, pulse dispersion, material dispersion, combined effect of multipath and maerial dispersion, rms pulse width. Modes In planar waveguides – TE modes of a symmetric step-index planar waveguide, power distribution and confinement factor, wave propagation in a cylindrical wave guide, single mode fiber and its characteristic parameters, dispersion and attenuation in SMF, Optical fiber cable and connections, Dispersion compensation mechanism, Dispersion-tailored and dispersion compensating fibers, Birefringent fibers and polarization mode dispersion, Fiber bandwidth. fiber material and its fabrication, Erbium-doped fiber amplifiers, Fiber Bragg gratings. Photonic Crystal and Holey fibers. Fiber optic communications: Analog and digital fiber optic communication system,

System architectures, Nonlinear effects in fiber optic: Stimulated Raman Scattering, Stimulated Brillouin Scattering, Self Phase Modulation, Cross Phase Modulation, Four wave mixing, Optical Solitons optical amplifiers : semiconductor optical amplifier, Fiber raman amplifier.

UNIT IV- Non-linear Optics: (15)

Non-linear optical media, second order non-linear optics- SHG, Three wave mixing. Third order non-linear optics, THG and self-phase modulation, Coupled wave theory of three-wave mixing. Four wave mixing and Optical Phase conju- gation. Frequency conversion, Parametric Ampli_cation and Oscillation. Self focusing of light. Optical Bistability**Concept Optical digital computer** - Optical components for binary digital computer, Optical Switches- SEED , Photonic logic gates.

Learning Outcomes:

1. Students will able to explain concepts of photodiodes, LEDs, OLEDs based displays.
2. Students will able to explain electro-optic and magneto-optic phenomenons and devices based on it.
3. Students will able to explain principle of optical fibers, analog and digital fiber optic communication system.
4. Students will able to explain second, third order non linear optical media and concepts of optical digital computer, optical switches etc.

References:

1) Optoelectronics: An Introduction - J. Wilson & J. F. B. Hawkes,

2) Optical Electronics – Ajoy Ghatak&K.Thyagarajan,

3) Introduction to Fiber Optics – Ajoy Ghatak & K.Thyagarajan (Unit III)

4) Optical Properties of Solids – Frederick Wooten

5) Quantum Electronics – Amnon Yariv, John Wiley & Sons,

M.Sc. (Physics) Practical Semester III

Learning Objectives:

1. To deposit thin films by various methods such as CBD, Electrodeposition, Hydrothermal, Reflux, Sol-gel, SILAR, Spray Pyrolysis etc.
2. To measure band gap energy by UV-Visible spectrophotometer, TEP, contact angle of thin films.
3. To measure dielectric constant, magnetic susceptibility,
4. To study the properties and shape of LASER.
5. To understand XRD pattern
6. To synthesis of material by Co-precipitation method etc.

PP22-306: LAB-I

EXPERIMENTS:

1. Deposition of thin films by CBD method
2. Electrodeposition/ anodization of thin films
3. Synthesis of thin films by Hydrothermal/Solvothermal method
4. Preparation of thin films by Reflux method
5. Synthesis of material by Sol-gel method
6. Preparation of thin films by SILAR method
7. Synthesis of nanoparticles by Co-precipitation method
8. Preparation of thin films by Spray Pyrolysis method
9. Microwave synthesis of thin films
10. Preparation of film by Doctor Blade method

PP22-307: LAB-II + Project

EXPERIMENTS:

1. Band gap energy Measurement of thin films by UV-Visible spectrophotometer
2. TEP measurement of thin film
3. Resistivity measurement of thin film by two probe method
4. Contact angle measurement of thin films
5. Crystal structure of thin film.
6. Measurement of dielectric constant by LCR
7. Magnetic Susceptibility (Gouy balance method)
8. To study the shape of the LASER beam: divergence angle, cross section and to evaluate beam spot.
9. Determination of physical density, X-ray density and porosity of given material
10. Data plotting using Origin 8 software.

Learning Outcomes:

Students will able to:

1. Deposit thin films by various methods such as CBD, electrodeposition, hydrothermal, reflux, Sol-gel, SILAR, Spray Pyrolysis etc.
2. Measure band gap energy by UV-Visible spectrophotometer, TEP, contact angle of thin films.
3. Measure dielectric constant, magnetic susceptibility
4. Study the properties and shape of LASER.
5. Understand XRD pattern.
6. Synthesis of materials by Co-precipitation method.

References:

1. Thin Film Phenomena by K L Chopra McGraw -Hill Book Company, NY 1969.
2. Nanotechnology principle and practices by Sulabha K. Kulkarni (2007)
3. Properties of Thin Films by Joy George, Marcel and Decker, (1992).
4. Handbook of semiconductor electrodeposition, R.K. Pandey, S.N. Sahu, S. Chandra.

Structure of Course: M.Sc.-II Semester-IV

Sr. No.	Paper Title	Theory				Practical			
		Paper Code	No. of lectures Perweek	Total Hours Perweek	Credits	Paper Title& Code	No. of lectures Perweek	Total Hours Perweek	Credits
Compulsory Papers									
1	Nuclear and Particle Physics	**P22-401**	4	4	4	**LAB III** **PP22-406**	12	12	4
2	Solid State Physics -III (Thin Solid Films: Deposition and Properties)	**P22-402**	4	4	4				
3	Solid State Physics- IV (Energy Conversion and Storage Devices)	**P22-403**	4	4	4	**LAB IV** +Project **PP22-407**			
Elective Paper									
4	i) Electronic Devices ii) Laser Physics	**P22-404** **P22-405**	4	4	4		12	12	4
Total Credits Theory					**16**	**Total Credits Practical**			**08**

P22-401: NUCLEAR AND PARTICLE PHYSICS (Credits: 04)

Learning Objectives:

1. To understand nucleon nucleon interaction.
2. To study nuclear models and nuclear reactions.
3. To study gaseous radiation detectors and semiconductor radiation detectors.
4. To study elementary particles

Unit- I: Nucleon -Nucleon Interaction: (15)

Nature of the nuclear forces, Forms of nucleon-nucleon potential, Deuteron Problem :The theory of ground state of deuteron, Excited states of deuteron, n-p scattering at low energies (cross section), Phase shift analysis, Scattering length, n-p scattering for square well potential (effective range theory); p-p scattering at low energies, Symmetry and charge independence of nuclear forces, High energy N-N scattering (qualitative discussion only of n-p and p-p scatterings).

Unit -II: Nuclear Models and Nuclear Reactions (15)

Evidence for nuclear shell structure, Single particle shell model-its validity and limitations, Collective model (collective vibration and collective rotation). Review of alpha, beta and gamma decays, Compound nucleus reaction: Origin of the compound nucleus, Hypothesis, Discrete resonances, Continuum states, Direct Reactions: Experimental characteristics, Direct inelastic scattering and Transfer reactions.

Review of alpha, beta and gamma decays, Gamow's theory of alpha decay.

Unit -III: Radiation detectors (15)

Basic principle of radiation detectors, Gaseous detectors, Ionization chamber, Multiwire proportional chambers, Planar drift chamber, Scintillation detectors, Different types of organic and inorganic scintillators, Semiconductor detectors, Position sensitive detectors , Lithium drifted silicon detectors, Lithium drifted germanium detectors, High purity germanium detectors.

Unit IV: Particle Physics (15)

Classification of fundamental forces, Classification of elementary particles and their quantum numbers (Charge, Spin, Parity, Isospin, Strangeness, Baryon number, Lepton number), Gell-Mann-Nishijima formula, quark model [SU (3)], CPT invariance, Application of symmetry arguments to particle reactions, Parity-non-conservation in weak interaction.

Learning Outcomes:

1. Students will able to understand nucleon nucleon potential, deuteron problem n-p and p-p scattering at low energy and effective range theory.
2. Students will able to explain Shell model, collective model, nuclear decay process and direct and compound nuclear reactions.
3. Students will able to explain basic principal of radiation detectors, organic detectors, inorganic Detectors and different semiconductor detectors.
4. Students will able to explain elementary particles, quark model, CPT invariance.

Reference Books:

1. Nuclear Physics- D. C. Tayal (Himalaya Publishing House, New Delhi 1995)(Unit I, II, IV)
2. Nuclear and Particle Physics- S. L. Kalani and Shubhra Kalani (Viva Books Pvt. Ltd.) (Unit I, II, IV)
3. Nuclear radiation Detectors- S. S. Kapoor and V. S. Ramamurthy (Wiley Eastern Limited) (Unit III)
4. Nuclear Physics- Iriving Kaplan (Narosa, Madras, 1989). (Unit I, II)
5. Nuclear Physics: An Introduction- S. B. Patel (New Age international Ltd.)(Unit II)
6. Nuclear and Particle Physics- W.E. Burcham and M.Jobes, (Addison Wesley, Longman, England, 1995).(Unit III, IV)
7. Introduction to Particle Physics- M.P. Khanna (Prentice Hall, India,1999). (Unit IV)
8. Particle Detectors- Claus Grupen and Boris Shwartz (Second Edition, Cambridge University Press. 2008) (Unit III)

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P22-402: Solid State Physics- III
(Thin Solid Films: Deposition and properties) (Credits: 04)

Learning Objectives:

1. To understand basics of thin film and their technological applications.
2. To study Mechanism of thin film formation: Condensation and nucleation
3. To study physical and chemical methods of thin film formation.
4. To study properties of thin films and different methods of characterization

Unit I: Introduction: Thin Film (15)

Introduction: Thin Film, Technological Applications of Thin Films, Mechanism of thin film formation: Condensation and nucleation, Growth and Coalescence of islands, Crystallographic structure of films, Factors affecting structure and properties of thin films; Epitaxial thin films.

Unit II: Classification of Methods Used for Synthesis of Thin Films (15)

Physical methods: Vacuum Techniques (i) Thermal evaporation methods: Resistive heating, Electron Beam Evaporation, (ii) Sputtering system: Glow discharge, DC sputtering, Radio frequency sputtering, Magnetron sputtering, Ion beam sputtering.

Chemical Methods: Chemical vapor deposition system (CVD)**,** Chemical bath deposition: Ionic and solubility products, Preparation of binary semiconductors, Electrochemical deposition: Deposition mechanism and Preparation of compound thin films, Spray pyrolysis: Deposition mechanism and preparation of compound thin films.

Unit III: Properties of Thin Films: **(15)**

Mechanical properties: Stresses and strain in thin films, Mechanical constants of thin films, Electrical and magnetic properties: Electrical conduction in thin metallic discontinuous and continuous films, Optical properties: Optical constants of thin films, Experimental methods as Reflection, Interferometry and Critical angle method.

Unit IV: Methods for Characterizations of Thin Films: (15)

Thickness Measurement Methods: Weight Difference Method, Stylus Method, Ellipsometry, Characterization Methods: X-ray diffraction (XRD), Scanning Electron Microscopy (SEM) and Energy dispersive analysis of X-rays (EDAX)**,** UV-VIS spectroscopy, X-ray photoelectron spectroscopy (XPS), Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM).

Learning Outcomes:

1. Students will able to explain technological applications of thin Films, mechanism of thin film formation, Crystallographic structure of films.
2. Students will able to explain physical and chemical method of thin film preparation.
3. Students will able to explain mechanical, electrical, optical and magnetic properties of thin film.
4. Students will able to explain various characterization techniques, thickness measurement methods.

Reference books

1. Thin Film Phenomena by K L Chopra McGraw -Hill Book Company, NY 1969
2. Nanotechnology principle and practices by Sulabha K. Kulkarni (2007)
3. Properties of Thin Films by Joy George, Marcel and Decker, (1992)
4. Chemical deposition of metal chalcogenide thin films, C. D. Lokhande, Materials Chemistry and Physics Volume 27, Issue 1, January 1991, Pages 1-43.
5. Versatility of chemical spray pyrolysis technique, P.S. Patil, Materials Chemistry and physics 59 (3), 185-198.
6. Handbook of semiconductor electrodeposition, R.K. Pandey, S.N. Sahu, S. Chandra.

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P22-403: SOLID STATE PHYSICS-IV

(Energy Conversion and Storage Devices) (Credits: 04)

Learning Objectives:

1. To understand solar cell and its characteristics.
2. To study generations of Solar cell and types of solar cells.
3. To study battery parameters, Lithium batteries and Supercapacitors.
4. To understand importance of Hydrogen as a future fuel.

UNIT I: Photovoltaics (15)

P-N junction under illumination, Light generated current, I-V equation, Characteristics, Upper limits of cell parameters, Losses in solar cells, Equivalent circuit, Effects of various parameters on efficiency, Solar cell design, Design for high Isc, Antireflective coating (ARC), Design for highVoc and fill factor, Analytical techniques; Solar simulator, Quantum efficiency, Minority carrierlife time and Diffusion length measurement.

UNIT II: Types of solar cells (15)

Generations of Solar cells, Trends of η of solar cell, Dye sensitized solar cells, Advantages and disadvantages, Quantum dot sensitized solar cells, Perovskite solar cells, Photo Electro Chemical (PEC) Solar cells, Tandem solar cells, Polymer solar cells.

UNIT III: Batteries and Supercapacitors (15)

Primary batteries, Rechargeable batteries, Battery parameters (Battery capacity, Battery voltage, Battery life cycle, Discharge/charge rate), Lithium batteries: Anode and cathode materials, Applications.

Supercapacitors: Similarities and differences between capacitor, supercapacitors and batteries, Electrochemical capacitor: Introduction, Ragone plot, Charge-discharge of supercapacitor; Electric double layer capacitor: electrode-electrolyte interfaces (models), construction, advantages and disadvantages; pseudocapacitor: electrochemical pseudocapacitor of electrode-electrolyte interface; Electrolyte factor, Energy density and Power density, Impedance of a pseudocapacitance, Technology development, Electrode materials.

UNIT IV: Hydrogen Energy (15)

Hydrogen Fuel: Importance of Hydrogen as a future fuel, Sources of Hydrogen, Fuel of vehicles. Hydrogen production: Production of Hydrogen by various methods, Solar water splitting, Direct electrolysis of water, Direct thermal decomposition of water Hydrogen storage: Gaseous, Cryogenic and Metal hydride. Utilization of hydrogen: Fuel cell – Principle, construction and applications.

Learning Outcomes:

1. Students will able to explain solar cell, its characteristics and analytical techniques.
2. Students will able to explain generations and types of Solar cell.
3. Students will able to explain Lithium batteries and supercapacitors.
4. Students will able to explain methods of Hydrogen production and principle of Fuel cell.

References:

1. Solar photovoltaics, Fundamentals, Technologies and Applications by ChetanSingh Solanki, PHI Learning Private Limited, Delhi-110092.(Unit I, II, III)
2. Polymer Photovoltaics: A practical approach by Frederik C. Krebs, Spie press Bellingham, Washington USA.(Unit II)
3. Solar energy: Principle of thermal collection and storage by S. P. Sukhatme, J. Y. Nayak
4. Battery Technology Handbook by H. A. Kiehne, Marcel Dekker, Inc., New York, Basel.(Unit III)
5. Electrochemical Supercapacitors, Scientific fundamentals and TechnologicalApplications by B. E. Conway, Kluwer Academic/ Plenum Publishers, New York, Boston, Dordrencht, London, Moscow. (Unit III)
6. Solar Hydrogen Energy Systems, T. Ohta (Pergamon Press)1979 (Unit IV)
7. Energy beyond oil by Fraser armstrng, Katherine Blundell, oxford university press.(Unit IV)
8. Nanostructures and Nanomaterials: Synthesis, Properties and Applications by Guozhong Cao, Ying Wang (World Scientific).(Unit II)

P22-404: ELECTRONIC DEVICES (Credits: 04)

Learning Objectives:

1. To understand BJT, MOSFET and microwave devices.
2. To study Thyristors and Unijuction Transistor.
3. To understand Photonic devices
4. To understand memory devices.

Unit I: Bipolar Transistors and Microwave Devices: (15)

Review of Bipolar junction transistor (BJT), Transistor action, static characteristics, Frequency response and Switching, MOSFET: Si-SiO_2 systems, CMOS and BiCMOS devices.

Microwave Devices: Basic Microwave Technology, Tunnel diode, IMPATT diode, Transferred Electronic devices (TED).

Unit II: Thyristors and Unijunction Transistor (15)

Silicon Controlled Rectifier (SCR): Characteristics and Parameters, SCR Controlled Circuit, Traic and Diac.

Other four layer devices: Four layer diode (Shockeley diode), Bilateral four layer diode,

Unijunction Transistor (UJT): Characteristics, Parameters, Application of UJT as Relaxation oscillator, Programmable unijuntion Transistor.

Unit III: Photonic Devices: (15)

Radiative transitions and optical absorption, Light Emitted Diode: Visible LED, Organic LED, Infrared diode, Semiconductor lasers, Laser operation, Population inversion, Heterojuction Laser, Laser diode materials.

Unit IV: Memory Devices: (15)

Semiconducting memories, memory organization and operation, Read and Write operation, Expanding memory size, Classification and characteristics of memories, Static and dynamic RAM, SRAM and DRAM, Charge couple memory (CCD) Devices.

Learning Outcomes: Students will able to explain

1. Bipolar Junction Transistor, MOSFET and different microwave devices.
2. Thyristors, Programmable unijuction Transistor, Silicon Controlled Rectifier and Four layer diode.
3. Light emitting Diodes, Organic LED and Laser operation.
4. Semiconducting memories, memory organization and operation and CCD.

Reference Books:

1. Semiconductor devices - Physics and Technology 2nd Edition, S. M. Sze(Unit I, III)

2. Electronic devices & circuits - David Bell, 3rd Edition Prentice Hall Publication.(Unit II)

3. Introduction to Semiconductor devices - M. S. Tyagi(Unit I, III)

4. Modern Digital Electronics, R. P. Jain (Unit IV)

P22-405: Laser Physics Special

Learning Objectives:

1. To understand principles of lasing action.
2. To study different types of resonators.
3. To study Switching phenomenon's.
4. To study different laser systems

UNIT I- Basic Laser Principle and Laser System: (15)

Summary of black body radiation, Quantum theory for evaluation of the transition rates and Einstein coefficients-allowed and forbidden levels-metastable state; population inversion; rate equations for three level and four level lasers, threshold of power calculation, various broadening mechanism, homogeneous and inhomogeneous broadening.

Basic Laser System: Basic concept of construction of laser system, various pumping system, pumping cavities for solid state laser system, characteristics of host materials and doped ions.

UNIT II- Optical beam propagation and Resonators: (15)

Paraxial ray analysis, wave analysis of beams and resonators, propagation and properties of Gaussian beam, Gaussian beam in lens like medium, ABCD law-Gaussian beam focusing

Resonators: Stability of resonators-'g' parameter, various types of resonators, evaluation of beam waist of such combination, design aspect of resonator for various types of lasers, unstable resonator and their application.

UNIT III-Q-switching and Ultrafast Phenomenon: (15)

Giant pulse theory, different Q-switching techniques: mechanical Q-switching, electrooptic Q-switching, acoustooptic Q-switching, dye Q-switching, Raman-Nath effect.

Ultrafast Phenomenon: Principle of generation of ultrafast pulses (mode locking), basic concepts for measurement of fast processes, Streak technique, Stroboscopy, sampling technique, nonlinear optical methods for measuring ultrashort pulses.

UNIT IV-Different laser systems: (15)

Gas Lasers: (i) Molecular gas lasers- CO2 laser & N2 (ii) ionic gas laser – Ar+ laser (iii) gas dynamic laser (iv) high pressure pulsed gas laser Solid State Laser: (i) Nd:YAG laser, (ii) Nd:Glass laser, comparison of performances (iii) Tunable solid state laser: Ti:sapphire laser; Alexandrite laser Chemical Laser: HF laser, HCl laser, COIL Excimer laser; Color centre laser; Free electron laser; semiconductor diode laser

Learning Outcomes:

1. Students will able to understand fundamental concepts related to LASING action like pumping systems, metastable state, population inversion and stimulated emission.
2. Students will able to understand design aspect of resonator for various types of lasers.
3. Students will able to Q switching and ultrafast phenomenons.
4. Students will able to explain lasing action in different types of lasers like CO_2, N_2, Nd:YAG etc.

References:

1. Principles of lasers- O Svelto (Unit I)
2. Solid State Laser Engineering- W Koechner.
3. Quantum Electronics- A Yariv.
4. The Physics and Technology of Laser Resonator- D R Hall & P E Jackson.
5. Introduction to optical electronics- K A Jones
6. Laser- B A Langyel (Unit IV)
7. Gas laser- A J Boom (Unit IV)

M.Sc. II (Physics Practical) Semester IV

Learning Objectives:

1. To measure the resistivity of films by four probe method.
2. To study I-V characteristics and spectral response of solar cell.
3. To study characteristics of LDR, phototransistor and SCR.
4. To interpret data using Origin 8 software.
5. To calculate the flat band potential of Si wafer.
6. To analyze the Photoluminescence, Raman, IR, XPS,TGA-DTA spectra.
7. To calculate the electrochromic properties using Cyclic –Voltammetry.
8. To measure the gas sensitivity of given sample.
9. To calculate surface area of given sample using BET.

PP22-406: LAB-III

EXPERIMENTS:

1. Measurement of resistivity of film by four probe method.
2. To study BJT as a switch
3. Study of supercapacitor properties
4. Photocatalytic dye degradation
5. I-V characteristics of solar cell.
6. Spectral response studies of solar cell.
7. Flat band potential of Si wafer.
8. To study characteristics of LDR.
9. To study characteristics of photodiode.
10. Bistable multivibrator

PP22-407: LAB-IV + Project

EXPERIMENTS:

1. Photoluminescence
2. Analysis of Raman spectrum
3. Cyclic –Voltammetry
4. Analysis of FTIR spectrum
5. Gas sensitivity
6. TGA-DTA
7. Measurement of film thickness by optical method.
8. Interpretation of data using Origin 8 software.
9. XPS
10. Chronoamperometry

Learning Outcomes: Students will able to:

1. Measure the resistivity of films by four probe method.
2. Study I-V characteristics and spectral response of solar cell.
3. Study characteristics of LDR, phototransistor and SCR.
4. Interpret data using Origin 8 software.
5. Calculate the flat band potential of Si wafer.
6. Analyze the Photoluminescence, Raman, IR, XPS,TGA-DTA spectra.
7. Calculate the electrochromic properties using Cyclic –Voltammetry.
8. Measure the gas sensitivity of given sample.

References:

1. Solar photovoltaics, Fundamentals, Technologies and Applications by ChetanSinghSolanki, PHI Learning Private Limited, Delhi-110092

2. Electrochemical Supercapacitors, Scientific fundamentals and Technological Applications by B. E. Conway, Kluwer Academic/ Plenum Publishers, New York,Boston, Dordrencht, London, Moscow.

3. Introduction to Instrumental Analysis.*Robert B. Braun*

4. Principles of Instrumental Analysis- *Douglas A. Skoog, F.James Holler, Stanley R. Crouch*