Rayat Shikshan Sanstha's

YASHAVANTRAO CHAVAN INSTITUTE OF SCIENCE, SATARA

(AUTONOMOUS)

Department of Physics

Syllabus for M.Sc. Part – II w.e.f. from June 2019 onwards

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

Sr. No.	Course Title	Theory				Practical			
		Paper No. &Code	No. of lectures Per week	Total Hours Per week	Credits	Paper No. Title & Code	No. of lectures Per week	Total Hours Per week	Credits
Compulsory Papers						**SSP LAB I:** Practical I + Project MPP 306	12	12	4
1	Experimental Techniques	Paper IX MPT 301	4	4	4				
2	Nanoscience and Nanotechnology	Paper X MPT 302	4	4	4				
3	Solid State Physics- I (Thin Solid Films: Deposition and Properties)	Paper XI MPT 303	4	4	4	**SSP LAB II:** Practical II + Project MPP 307	12	12	4
4	Solid State Physics- II (Semiconductor Physics)	Paper XII MPT 304	4	4	4				
Elective Paper									
5	Nuclear and Particle Physics or Optoelectronics and Photonics	Paper XIII MPT 305A or MPT 305B	4	4	4				
				Total Credits Theory	**20**			**Total Credits Practical**	**08**

M.Sc. – II Semester – IV

Sr. No.	Paper Title	Theory				Practical			
		Paper No. & Code	No. of lectures Per week	Total Hours Per week	Credits	Paper No. Title & Code	No. of lectures Per week	Total Hours Per week	Credits
Compulsory Papers						**LAB III:** (Practical III + Project) MPP 404	12	12	4
1	Solid State Physics- III (Physical Properties of Solid)	Paper XII: MPT 401	4	4	4				
2	Solid State Physics- IV (Energy Conversion and Storage Devices)	Paper XIV: MPT 402	4	4	4				
Elective Paper									
3	Electronic Devices or Laser Physics Special	Paper XV: MPT 403A or MPT 403B	4	4	4	**LAB IV: (**Practical IV + Project) MPP 405	12	12	4
				Total Credits Theory	**12**			**Total Credits Practical**	**08**

MPT: M: M.Sc., **P:** Physics, **T:** Theory **MPP: M:** M.Sc., **P:** Physics, **P:** Practical

2. Evaluation Method: M.Sc. II Semester III

<table>
<tr><th rowspan="2">Paper No. & Code</th><th rowspan="2">ESE</th><th colspan="2">Internal Exam</th><th rowspan="2">Total</th><th rowspan="2">Paper No. & Code</th><th colspan="5">Practical</th></tr>
<tr><th>ISE I</th><th>ISE II</th><th>Exam & Presentation</th><th>Journal</th><th>Project</th><th>Day to Day Performance</th><th>Total</th></tr>
<tr><td>Paper IX :MPT 301</td><td>80</td><td>10</td><td>10</td><td>100</td><td rowspan="2">LAB I: MPP 306</td><td rowspan="2">70 (50+20)</td><td rowspan="2">10</td><td rowspan="2">15</td><td rowspan="2">5</td><td rowspan="2">100</td></tr>
<tr><td>Paper X :MPT 302</td><td>80</td><td>10</td><td>10</td><td>100</td></tr>
<tr><td>Paper XI :MPT 303</td><td>80</td><td>10</td><td>10</td><td>100</td><td rowspan="3">LAB II: MPP 307</td><td rowspan="3">70 (50+20)</td><td rowspan="3">10</td><td rowspan="3">15</td><td rowspan="3">5</td><td rowspan="3">100</td></tr>
<tr><td>Paper XII :MPT 304</td><td>80</td><td>10</td><td>10</td><td>100</td></tr>
<tr><td>Paper XIII :MPT 305A or MPT 305B</td><td>80</td><td>10</td><td>10</td><td>100</td></tr>
<tr><td>Total</td><td>400</td><td>50</td><td>50</td><td>500</td><td>Total</td><td>140</td><td>20</td><td>30</td><td>10</td><td>200</td></tr>
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M. Sc. II Semester IV

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<tr><th rowspan="2">Paper No. & Code</th><th rowspan="2">ESE</th><th colspan="2">Internal Exam</th><th rowspan="2">Total</th><th rowspan="2">Paper No. & Code</th><th colspan="5">Practical</th></tr>
<tr><th>ISE I</th><th>ISE II</th><th>Exam & Presentation</th><th>Journal</th><th>Project</th><th>Day to Day Performance</th><th>Total</th></tr>
<tr><td>Paper XIV :MPT 401</td><td>80</td><td>10</td><td>10</td><td>100</td><td rowspan="2">LAB III: MPP 404</td><td rowspan="2">70 (50+20)</td><td rowspan="2">10</td><td rowspan="2">15</td><td rowspan="2">5</td><td rowspan="2">100</td></tr>
<tr><td>Paper XV :MPT 402</td><td>80</td><td>10</td><td>10</td><td>100</td></tr>
<tr><td>Paper XVI :MPT 403A or :MPT 403B</td><td>80</td><td>10</td><td>10</td><td>100</td><td>LAB IV: MPP 405</td><td>70 (50+20)</td><td>10</td><td>15</td><td>5</td><td>100</td></tr>
<tr><td>Total</td><td>240</td><td>30</td><td>30</td><td>300</td><td>Total</td><td>140</td><td>20</td><td>30</td><td>10</td><td>200</td></tr>
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M.Sc. II (Physics) (Semester-III)

MPT 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 and 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 describe principle and operation AAS, atomization.
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 Pradhunam. (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)

MPT 302: 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 in nanotechnology 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, Density of states in Three Dimensional, Two-Dimensional, One-Dimensional and Zero-Dimensional Systems,Quantum Confinement in Quantum Wells, Quantum Wires, Quantum Dots, Summery.

Unit II: Properties of nonmaterial's: **(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 and colossal 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 logic, Spin field effect transistor (Spin-FET), Spin Diodes.

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)

MPT 303: Solid State Physics- I

(Thin Solid Films: Deposition and properties) (**Credits: 04)**

Learning Objectives:

1. To understand the about thin film and its 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.(Unit I, II, III, IV)
2.Nanotechnology principle and practices by Sulabha K. Kulkarni (2007). (Unit II, IV)
3.Properties of Thin Films by Joy George, Marcel and Decker, (1992). (Unit I,II, III)
4.Chemical deposition of metal chalcogenide thin films, C. D. Lokhande, Materials Chemistry and PhysicsVolume 27, Issue 1, January 1991, Pages 1-43. (Unit II)
5.Versatility of chemical spray pyrolysis technique, P.S. Patil, Materials Chemistry and physics 59 (3), 185-198. (Unit II)
6.Handbook of semiconductor electrodeposition, R.K. Pandey, S.N. Sahu, S. Chandra. (Unit II)

MPT 304: 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 (7^{th} Edition). (Unit I, II, III, IV)
2. Physics of semiconductor devices by S. M. Sze (2^{nd} 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)

MPT 305A: 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, exchange forces with diagram, Tensor 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.

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)

MPT305B: 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. (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.
4. To measure dielectric constant, magnetic susceptibility,
5. To study the properties and shape of LASER.
6. To understand XRD pattern.
7. To synthesis of material by Co-precipitation method etc.

MPP 306: LAB-I (Practical I+ Project)

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

MPP 307: LAB-II (Practical 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.

M.Sc. II Semester IV
MPT 401: Solid State Physics-III
(Physical Properties of Solid) **(Credits: 04)**

Learning Objectives:

1. To study the Drude and Sommerfeld Theory of metals.
2. To study Transport Properties of Metals like Sommerfeld theory of electrical conductivity, the mean free path in metals, Thermal scattering and thermal conductivity of metals.
3. To study Phonons, Plasmons, Polaritons, and Polarons
4. To study Zero-D, One-D, Two-D, Importance and applications of nanotechnology.

Unit I: Theory of metals **(15)**

Basic assumptions of Drude Model, Collision or Relaxation times, DC electrical conductivity, Sommerfeld theory of metals, Failures of the free electron model. Band theory of solid, Brillouin zones, The tight-binding method, Linear combinations of atomic orbitals, Application to bands from s-Levels, Wannier functions, Other methods for calculating band structure, Independent electron approximation, General features of valence band wave functions, Cellular method, Muffin-Tin potentials, Augmented plane wave (APW) method, Pseudopotentials.

Unit II: Transport Properties of Metals **(15)**

Some features of the electrical conductivity of metals, A simple model leading to a steady state, Drift velocity and relaxation time, The Boltzmann transport relation, The Sommerfeld theory of electrical conductivity, The mean free path in metals, Thermal scattering, The electrical conductivity at low temperature, The thermal conductivity of metals, Dielectric Properties of insulators. Macroscopic electrostatic Maxwell equations, Theory of Local Field, Theory of polarizability, Clausius- Mossotti relation, Long- wavelength optical modes in Ionic crystals.

Unit III: Phonons, Plasmons, Polaritons, and Polarons **(15)**

Vibrations of monatomic lattices: First Brillouin zone, Group velocity, Long wavelength limit, Lattice with two atoms per primitive cell. Quantization of lattice vibrations, Phonon momentum Dielectric function of the electron gas, Plasma optices, Dispersion relation for Electromagnetic waves, Transverse optical modes in a plasma, Longitudinal Plasma oscillations, Plasmons, Polaritons, LST relations, Electron- electron interaction, Electron- phonon interaction: Polarons.

Unit IV: Magnetic Properties of Materials **(15)**

Introduction, Magnetic permeability, Magnetisation, Electric current in atoms-bohr magnetron, Electron spin and magnetic moment due to nuclear spin, Diamagnetism, Paramagnetism, Langevin's with experiment classical theory of paramagnetism, Weiss theory of paramagnetism, Quantum theory of paramagnetism, Comparison of theory with experimental results. Ferromagnetism, Spontaneous Magnetisation in ferromagnetic materials, Quantum theory of ferromagnetism Magnetic resonance, Nuclear magnetic resonance (NMR), The resonance condition.

Learning Outcomes:

1. Students will able to understand Drude Theory of metals, Sommerfeld theory of metals andbasic assumptions of model, Band theory of solid.
2. Students will able to explain the features of electrical conductivity of metals, Sommerfeld theory of electrical conductivity, Theory of polarizability and Clausius- Mossottirelation.
3. Students will able to explain vibrations of monatomic lattices: first Brillouin zone, Quantization of lattice vibrations, Phonon momentum.
4. Students will able to understand magnetic permeability, Magnetic resonance and NMR.

Reference Books:

1. Solid State Physics by N W Ashcroft and N D Mermin, HRW, International editions (1996). (Unit I, II)
2. Introduction to Solid State Physics by C Kittle (8th edition) John Willey Publication (1979). (Units III, IV)
3. Solid State Physics by A J Dekker (1986) Macmillan India Ltd. (Unit II)
4. Solid State Physics by S O Pillai (7^{th}edition) New Age International (P) Ltd. Publishers. (Unit I, II)
5. Fundamentals of Solid State Physics by B. S. Saxena, P. N. Saxena, R. C. Gupta and J. N. Mandal, Pragati prakashan Meerut. (Unit I, IV)

MPT 402: 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, Ni/Cd batteries, 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 high Voc and fill factor, Analytical techniques; Solar simulator, Quantum efficiency, Minority carrier life 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)

Basics of electrochemical cell, Primary batteries, Rechargeable batteries, Battery parameters(Battery capacity, Battery voltage, Battery life cycle, Discharge/charge rate), Ni/Cd batteries charging methods and techniques, Characteristic curves, Lithium batteries, Chemistry and Physics of lithium batteries, Anode and cathode materials, Applications.

Supercapacitors: Similarities and differences between supercapacitors and batteries, Energetics, Double layer electrostatic capacitor, Pseudocapacitance, Origin, Kinetic theory, Regon plot, Electrolyte factor, Energy density and Power density, Impedance of a pseudocapacitance, Technology development, Various oxides as pseudocapacitors.

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 Ni/Cd batteries and 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 Chetan Singh 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. (Unit I)
4. Battery Technology Handbook by H. A. Kiehne, Marcel Dekker, Inc., New York, Basel.(Unit III)
5. Electrochemical Supercapacitors, Scientific fundamentals and Technological Applications 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)

MPT 403A: 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)

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

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 (Shockley 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:
1. Students will able to explain Bipolar Junction Transistor, MOSFET and different microwave devices.
2. Students will able to explain Thyristors, Programmable unijuction Transistor, Silicon Controlled Rectifier and Four layer diode.
3. Students will able to explain Light emitting Diodes, Organic LED and Laser operation.
4. Students will able to explain 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)

MPT 403B: Optoelectronics and Photonics

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 phenomenon 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. 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.

MPP 404 LAB-III: (Practical III+ Project)

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

MPP 405 LAB-IV: (Practical IV + Project)

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 Chetan SinghSolanki, 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

Syllabus Structure of P.G.: w.e.f. june 2019

M.Sc. - I Semester-I

Sr. No.	Course Title	Theory: Paper No. & Code	Theory: No. of lectures Per week	Theory: Total Hours Per week	Theory: Credits	Practical: Paper No. Title & Code	Practical: No. of lectures per week	Practical: Total Hours Per week	Practical: Credits
1	Mathematical Methods in Physics	MPT 101	4	4	4	**LAB I:** (Practical I + Project) MPP 105	12	12	4
2	Classical Mechanics	MPT 102	4	4	4				
3	Quantum Mechanics – I	MPT 103	4	4	4	**LAB II:** (Practical II + Project) MPP 106	12	12	4
4	Atomic and Molecular Physics	MPT 104	4	4	4				
				Total Credits Theory	**16**	**Total Credits Practical**			**08**

M.Sc. - I Semester-II

Sr. No.	Course Title	Theory: Paper No & Code	Theory: No. of lectures per week	Theory: Total Hours Per week	Theory: Credits	Practical: Paper Title & Code	Practical: No. of lectures per week	Practical: Total Hours Per week	Practical: Credits
1	Quantum Mechanics II	MPT 201	4	4	4	**LAB III:** (Practical III + Project) MPP 206	12	12	4
2	Statistical Mechanics	MPT 202	4	4	4				
3	Electro-dynamics	MPT 203	4	4	4	**LAB IV:** (Practical IV + Project) MPP 207	12	12	4
4	Condensed Matter Physics	MPT 204	4	4	4				
5	Solid State Physics - I (Thin Solid Films: Deposition and Properties)	Paper XI MPT 205	4	4	4				
				Total Credits Theory	**20**	**Total Credits Practical**			**08**

MPT : M:M.Sc.**, P:**Physics**, T:**Theory **MPP : M:**M.Sc., **P:**Physics, **P:**Practical

3. Structure of Syllabus: M.Sc.-II Semester- III

Sr. No.	Course Title	Theory: Paper No. &Code	Theory: No. of lectures Per week	Theory: Total Hours Per week	Theory: Credits	Practical: Paper No. Title & Code	Practical: No. of lectures Per week	Practical: Total Hours Per week	Practical: Credits
Compulsory Papers						**SSP LAB I:** (Practical III + Project MPP 306	12	12	4
1	Experimental Techniques	Paper IX MPT 301	4	4	4				
2	Nanoscience and Nanotechnology	Paper X MPT 302	4	4	4				
3	Solid State Physics- II (Semiconductor Physics)	Paper XII MPT 303	4	4	4	**SSP LAB II:** (Practical IV + Project) MPP 307	12	12	4
4	Solid State Physics-III (Physical Properties of Solid)	Paper XII: MPT 304	4	4	4				
Elective Paper									
5	Nuclear and Particle Physics or Optoelectronics and Photonics	Paper XIII MPT 305A or MPT 305B	4	4	4				
				Total Credits Theory	**20**			**Total Credits Practical**	**08**

M.Sc. - II Semester - IV

Sr. No.	Paper Title	Theory: Paper No. & Code	Theory: No. of lectures Per week	Theory: Total Hours Per week	Theory: Credits	Practical: Paper No. Title & Code	Practical: No. of lectures Per week	Practical: Total Hours Per week	Practical: Credits
Compulsory Papers						**LAB III:** (Practical III + Project) MPP 403	12	12	4
1	Solid State Physics- IV (Energy Conversion and Storage Devices)	Paper XIV: MPT 401	4	4	4				
Elective Paper									
2	Electronic Devices or Laser Physics Special	Paper XV: MPT 402A or MPT 402B	4	4	4	**LAB IV:** (Practical IV + Project) MPP 404	12	12	4
				Total Credits Theory	**08**			**Total Credits Practical**	**08**

MPT: M: M.Sc., **P:** Physics, **T:** Theory **MPP: M:** M.Sc., **P:** Physics, **P:** Practical