Rayat Shikshan Sanstha's

YASHAVANTRAO CHAVAN INSTITUTE OF SCIENCE, SATARA

(AUTONOMOUS)

Lead college

of

Karmaveer Bhaurao Patil University, Satara

Syllabus For

Master of Science

Part - II

PHYSICS

Syllabus to be implemented w.e.f. June 2024

as Per NEP-2020

Preamble:

This syllabus is framed to give advanced knowledge of Physics to postgraduate students at second year of two years of M.Sc. degree course.

The goal of the syllabus is to make the study of Physics popular, interesting and encouraging to the students for higher studies including research.

The new syllabus is based on a basic and applied approach with vigor and depth. At the same time precaution is taken to make the syllabus comparable to the syllabi of other universities and the needs of industries and research. The syllabus is prepared after discussion at length with number of faculty members of the subject and experts from industries and research fields. The units of the syllabus are well defined, taking into consideration the level and capacity of students

Credit Framework for M.Sc. II

Structure of Course: M.Sc. – II Semester – III

Level	Semester	Course Code	Course Title	No. of Lectures Per Week	Credits
		Discipline Specific Courses (Mandatory)			
6.5	III	MPT 531	Nanoscience and Nanotechnology	4	4
		MPT 532	Electrodynamics	4	4
		MPT 533	Solid State Physics- II (Semiconductor Physics)	4	4
		Discipline Specific Elective (Choose Any one among two)			
		MPT 534 E-I MPT 534 E-II	E-I) Electronic Devices E-II) Materials for Semiconductor Technology	2	2
		MPP 535	Research Project	12	6
		MPP 536	LAB- III (based on MPT-531, 532 and 533)	4	2
Total					**22**

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

Level	Semester	Course Code	Course Title	No. of Lectures Per Week	Credits
		Discipline Specific Courses (Mandatory)			
6.5	IV	MPT 541	Nuclear and Particle Physics	4	4
		MPT 542	Solid State Physics -III (Thin Solid Films:Deposition and Properties)	4	4
		MPT 543	Solid State Physics- IV (Energy Conversion and Storage Devices)	4	4
		Discipline Specific Elective (Choose Any one among two)			
		MPT 544 E-I MPT 544 E-II	E-I) Experimental Techniques E-II) Methods of Testing of Material	4	4
		MPP 545	On Job Training (OJT)	8	4
		MPP 546	LAB- IV (based on MPT-541, 542 and 543)	4	2
Total					**22**

SEMESTER III

MPT 531: NANOSCIENCE AND NANOTECHNOLOGY

Course Objectives: student should be able to:

1. understand depth knowledge of nanoscience and its technological aspects.
2. study dimensions dependent properties of nanoscale materials.
3. aware of various types of technologically important nanostructures.
4. learn current and recent scientific and technological developments in nanotechnology-based devices.

Credits=4	**MPT 531: NANOSCIENCE AND NANOTECHNOLOGY**	**No. of hours: 60**
UNIT I	**Nanolithography**	**(15)**
	Introduction, Lithography Using UV Light and Laser Beams, Use of X-rays in Lithography, Lithography Using Particle Beams, Scanning Probe Lithography, Soft Lithography	
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 Nano structuring 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.	

Course Outcomes: After completion of syllabus, student will be able to:

1. identify 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. describe technological importance of nanomaterials and replacement of bulk materials.

3. differentiate different applications of nanomaterials.
4. utilize nanoscience in further higher education and research in Nanoscience and Nanotechnology.

References:

1. M.S. Ramachandra Rao and Shubra Singh, Nanoscience and Nanotechnology: Fundamentals to Frontiers; (Wiley), 2013.
2. K. K. Choudhary, Nanoscience and Nanotechnology; Narosa Publishing House, 2016.
3. S. K. Kulkarni, Nanotechnology: Principals and Practices; Capital Publishing Company, 2014.
4. Charles P. Poole, Jr., Frank J Owens, Introduction to Nanotechnology; Wiley, 2020.
5. M. A. Shah, K. A. Shah, Nanotechnology: The Science of Small, Willey 2nd Edition 2019.

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MPT 532: Electrodynamics

Course Objectives: student should be able to:

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

Credits=4	MPT 532: Electrodynamics	No. of hours: 60
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, 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 a 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.	

Course Outcomes: After completion of syllabus, student will be able to:

1. define time dependents field, solve Maxwell’s equation for moving medium and its microscopic and macroscopic forms
2. describe conservation of the bound charge and current densities, differentiate between waveguides
3. define Scalar and vector potentials, Gauge transformations, Retarded Potentials,
4. explain concept Fields of charge in uniform motion, cyclotron and synchrotron radiations, power radiated by point charge – Larmor’s formula, Cerenkov radiation and Bremsstrahlung, Abraham –Lorentz formula

References:

1. S. P. Puri, Classical Electrodynamics, Narosa Publication, 2011.
2. D.J. Griffiths, Introduction to Electrodynamics, Prentices- Hall Publication 4th Edition, 2002.
3. J.R. Reitz, F.J. Milford & R.W. Christy, Foundation of E.M. Theory, Narosa Publication House 3rd edition, 1993.
4. J. D. Jackson, Classical Electrodynamics, Wiley Eastern 3rd edition, 2007.
5. B. B. Laud, Electromagnetics, Wiley Eastern Publication, 1983.

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MPT 533: SOLID STATE PHYSICS-II

(Semiconductor Physics)

Course Objectives: student should be able to:

1. understand the energy bands in solids, direct and indirect semiconductors and Fermi level.
2. know optical absorption, quasi Fermi levels and diffusion and drift of carriers.
3. learn concept of p-n junction, Zener and avalanche breakdown.

4. study properties of photodiodes, photodetectors and Lasers.

Credits=4	**MPT 533: SOLID STATE PHYSICS-II (Semiconductor Physics)**	**No. of hours: 60**
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: After completion of syllabus, student will be able to:

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

References:

1. B. G. Streetman, Solid state electronic devices, Prentice Hall India Learning Private Limited Publisher, 6th Edition, 2006.
2. S. M. Sze, Physics of Semiconductor devices, Wiley, 3rd Edition, 2015.
3. J. P. McKelvey, Solid State and Semiconductor Physics, Krieger Publishing Company, 1993.
4. M. S. Tyagi, Introduction to semiconductor materials and devices, Wiley, 2008.
5. G. D. Baruah, Lasers and nonlinear optics, Pragati Prakashan, 2023.

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MPT 534 (E-I): ELECTRONIC DEVICES

Learning Objectives: student should be able to:

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

Credits=2	SEMESTER-III MPT 534 (E-I): ELECTRONIC DEVICES	No. of hours: 30
UNIT I	**Thyristors, Bipolar and Unijunction Transistor**	**(7)**
	Semiconductor Controlled Rectifier (SCR): (S. M. Sze, PP 192 onwards) BJT: Introduction, Transistor configuration, Transistor as a switch, Switching speed of transistor, (R. P. Jain, PP 83 onwards), Unijunction Transistor (UJT): Programmable unijunction Transistor, Silicon unilateral and bilateral switch, Field-controlled thyristor (S. M. Sze, PP 234-240).	

UNIT II	**Photonic Devices**	**(8)**
	Radiative, non-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 III	**Memory Devices I**	**(8)**
	Introduction, types of memory devices, Semiconducting memories, memory organization and operation, Read and Write operation. (R. P. Jain, PP 463 onwards)	
UNIT IV	**Memory Devices II**	**(7)**
	Introduction, Expanding memory size, Classification and characteristics of memories, Static and dynamic RAM, SRAM and DRAM, Charge-coupled memory (CCD) Devices (R. P. Jain, PP 463 onwards)	

Learning Outcomes: Students will able to:

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

Reference Books:

1. S. M. Sze, Physics of Semiconductor devices, Wiley, 3rd Edition, 2015.
2. D. A. Bell, Electronic devices & circuits, Prentice Hall Publication, 5th Edition, 2018.
3. M. S. Tyagi, Introduction to semiconductor materials and devices, Wiley, 2008.
4. R. P. Jain, Modern Digital Electronics, McGraw Hill Education, 4th Edition, 2009.
5. V K Mehta & R. Mehta, Principles of Electronics, S. Chand Publishing, 2020.

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MPT 534 (E-II): Materials for Semiconductor Technology

Course Objectives: Students should be able to

1. study semiconductors and their electrical properties
2. learn the various combinations of contacts between semiconductor and metal

3. know p-n junction and its application
4. understand the optical material

Credits=2	MPT 534 (E-II): Materials for Semiconductor Technology	No. of hours: 30
UNIT I	**Electrical Properties of Semiconductor**	(7)
	Semiconductor, energy band diagram, Intrinsic Semiconductors: The Mechanism of Electrical Conduction, Electrical Charge Transport in the Crystal Lattice of Pure Silicon, Energy-Band Diagram, Extrinsic Semiconductors: n-Type (Negative-Type) and p-Type (Positive-Type)	
UNIT II	**Semiconductor Devices**	(8)
	The pn Junction: The pn Junction Diode at Equilibrium, forward bias, reverse-biased Applications for pn Junction: Rectifier Diodes, Breakdown Diodes, Tunnel diode, Photodiode	
UNIT III	**Semiconductor interface structure**	(8)
	Metal-n type semiconductor junction and its rectifying action, Metal-p type semiconductor junction and its rectifying action, Schottky contact and ohmic contact, metal-metal contact and its rectifying action, semiconductor -insulator interface	
UNIT IV	**Selection of Materials**	(7)
	Introduction, material properties- design parameters, electronic materials- Light Emitting Diode. Optical Materials- introduction, optical properties, optical system and devices, Glass for smartphones and tablets	

Course Outcomes: Students will be able to

1. differentiate between the intrinsic semiconductor and extrinsic semiconductor
2. differentiate between ohmic and Schottky contact
3. describe p-n junction and its application for devices
4. explain how to obtain design parameters and select the electronic material from metals

REFERENCES:

1. W. F. Smith, J. Hashemi, F. Presuel-Moreno, Foundations of Materials Science and Engineering, McGraw Hill Publisher, 6th Edition, 2022.
2. R. L. Singhal, Solid State Physics, KedarNath Ram Nath & Co., Meerut Publisher, 2007.
3 J. F. Shackelford and M. P. Clode, Introduction to materials science for engineers, Upper Saddle River,

N.J.: Prentice Hall International Publisher, 1998.
4. D. A. Neamen, Semiconductor Physics and devices: basic principles, New York: McGraw Hill Higher Education, 2012.

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MPP 535: Research Project (6 Credits)

Students will undertake research in specific area of his Major/Core with an advisory supported by a teacher/Faculty member. Students are required to take 6 credit Research Project for semester III under the guidance of faculty members.

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M.Sc. Practical Semester III

MPP 536: LAB III

Learning Objectives: Students should be 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 material by Co-precipitation method etc.

Credits=2	**MPP 536: LAB III**	**No. of hours: 60**
	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	

	11. Band gap energy Measurement of thin films by UV-Visible spectrophotometer 12. TEP measurement of thin film 13. Resistivity measurement of thin film by two probe method 14. Contact angle measurement of thin films 15. Thermal diffusivity of brass 16. Measurement of dielectric constant by LCR 17. Magnetic Susceptibility (Gouy balance method) 18. X-ray diffraction studies using Origin software 19. Determination of physical density, X-ray density and porosity of given material 20. To study characteristics of LDR	

Course Outcomes: After completion of syllabus, student will be able to:

1. Deposit thin films using CBD method, reflux method, sol-gel method, SILAR, Spray Pyrolysis.
2. evaluate band gap energy by UV-Visible spectrophotometer
3. Measure Thermal diffusivity of brass, Resistivity by two probe method and dielectric constant by LCR
4. Plot and analyze X-ray diffraction studies using Origin software
5. Determine physical density, X-ray density and porosity of given material
6. Verify characteristics of LDR

References:

1. K L Chopra, Thin Film Phenomena, McGraw -Hill Book Company, NY 1969.
2. S. K. Kulkarni, Nanotechnology: Principals and Practices; Capital Publishing Company, 2014.
3. J. George, Preparation of Thin Films, CRC Press Publisher, 1992.
4. R.K. Pandey, S.N. Sahu, S. Chandra, Handbook of semiconductor electrodeposition, CRC Press Publisher, 1st Edition, 2017.

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SEMESTER-IV

MPT 541: NUCLEAR AND PARTICLE PHYSICS

Learning Objectives: Students should be able to:

1. understand nucleon nucleon interaction.
2. study nuclear models and nuclear reactions.

3. learn gaseous radiation detectors and semiconductor radiation detectors.
4. know elementary particles

Credits=4	**MPT 541: NUCLEAR AND PARTICLE PHYSICS**	**No. of hours: 60**
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: Students will able to

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

References:

1. D. C. Tayal, Nuclear Physics, Himalaya Publishing House, New Delhi, 1995.
2. J. Singh, Fundamentals of Nuclear Physics, Pragati Prakashan, 2023.
3. I. Kaplan, Nuclear Physics, Narosa Publisher, 1989.
4. W.E. Burcham and M. Jobes, Nuclear and Particle Physics, Addison Wesley, Longman, England, 1995.
5. M.P. Khanna, Introduction to Particle Physics, Prentice Hall, India,1999.
6. C. Grupen and B. Shwartz, Particle Detectors, Cambridge University Press, 2nd Edition, 2008.

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MPT 542: Solid State Physics- III
(Thin Solid Films: Deposition and properties)

Learning Objectives: Students should be able to:

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

Credits=4	**MPT 542: Solid State Physics- III (Thin Solid Films: Deposition and properties)**	**No. of hours: 60**

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 (Gravimetric method),Optical method, Stylus Method, Ellipsometry, Characterization Methods Working and Application: 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: Students will be able to:

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

References:

1. Chemical deposition of metal chalcogenide thin films, C. D. Lokhande, Materials Chemistry and Physics 27, (1991) 1-43.
2. K L Chopra, Thin Film Phenomena, McGraw -Hill Book Company, NY 1969.
3. S. K. Kulkarni, Nanotechnology: Principals and Practices; Capital Publishing Company, 2014.
4. Versatility of chemical spray pyrolysis technique, P.S. Patil, Materials Chemistry and Physics 59 (1999) 185-198.
5. J. George, Preparation of Thin Films, CRC Press Publisher, 1992.

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MPT 543: SOLID STATE PHYSICS-IV
(Energy Conversion and Storage Devices)

Learning Objectives: Students should be able to:

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.

Credits=4	**MPT 543: SOLID STATE PHYSICS-IV (Energy Conversion and Storage Devices)**	**No. of hours: 60**
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: Students will be able to:

1. explain solar cell, its characteristics and analytical techniques.
2. differentiate between generations and types of Solar cell.
3. describe Ni/Cd batteries and Lithium batteries and supercapacitors.

4. explain methods of Hydrogen production and principle of Fuel cell.

References:

1. ChetanSingh Solanki, Solar photovoltaics, Fundamentals, Technologies and Applications, PHI Learning Private Limited, Delhi, 2015.
2. T. Ohta, Solar Hydrogen Energy Systems, Pergamon Press, 1979.
3. H. A. Kiehne, Battery Technology Handbook, Marcel Dekker Inc Publisher, 1989.
4. B. Jarząbek, Polymer Films for Photovoltaic Applications, Mdpi AG Publisher, 2022.
5. A. Yu, V. Chabot, J. Zhang, Electrochemical Supercapacitors for Energy Storage and Delivery: Fundamentals and Applications, CRC Press, 1st Edition, 2017.

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MPT 544 (E-I): EXPERIMENTAL TECHNIQUES

Course Objectives: student should be able to:

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

Credits=4	MPT 544 (E-I): EXPERIMENTAL TECHNIQUES	No. of hours: 60
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: Students will be able to:

1. explain low pressure production techniques, measurement of low pressure and explain leak detection.
2. describe low temperature production, measurement of low pressure and cryostat.
3. explain working principle of AAS.
4. evaluate Infrared spectroscopy, Raman Spectroscopy, Nuclear Magnetic Resonance, Electron Spin Resonance.

References:

1. W. J. Dirk, Advanced Modern Physics theoretical foundations, World Scientific, 2021.
2. G. Aruldhas, Molecular Structure and Spectroscopy, Publisher Prentice Hall India Learning Private Limited, 2nd Edition, 2007.
3. V. K. Jain, Introduction to Atomic and Molecular Spectroscopy, Narosa Publisher, 2009.
4. L.N. Rozanov, Vacuum Technique, CRC Press, 2002.

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MPT 544 (E-II): Advanced Industrial Materials

Course Objectives: Students should be able to

1. study of advanced industrial materials.
2. understand different types of alloys.
3. imbibe the polymeric materials.
4. learn the ceramics and it’s properties.

Credits=4	MPT 544 (E-II): Advanced Industrial Materials	No. of hours: 60
UNIT I	**Need of advanced materials**	(15)
	Introduction, Demand of advanced materials, design principles and processing. Structural Materials: Porous matrix ceramics-composites, Metallic foam, Cellular Materials, Nano tubes, Nano wires	
UNIT II	**Engineering alloys**	(15)
	Production of iron and steel, aluminum alloys, copper alloys, stainless steel, Titanium alloys, special purpose alloys and their applications	
UNIT III	**Polymeric materials**	(15)
	Introduction to polymeric materials, Processing of plastic materials, General-purpose thermoplastic: Polyethylene, polypropylene, Polyacrylonitrile, Polymethyl Methacrylate (PMMA) and their applications.	
UNIT IV	**Ceramics**	(15)
	Introduction to ceramics, Processing of ceramics, Traditional and Engineering ceramics, Mechanical properties of ceramics, Thermal properties of ceramics, Electrical properties of ceramics	

Course Outcomes: Students will be able to

1. explain the basics of advanced industrial materials.
2. analyze the different types of alloys along with its properties.
3. describe the polymeric materials.
4. explain ceramics and it’s properties.

REFERENCES:

1. M. V. Gandhi and B. D. Thompson, Smart materials and structures. London:Chapman & Hall Publisher, 1992.

2. V. Raghavan, Materials Science and Engineering: A First Course, Prentice Hall India Learning Private Limited Publisher, 6th Edition, 2015.
3. P. Rama Rao, Advances in materials and their applications, Wiley, 1st Edition, 1993.
4. R. S. Sedha R.S Khurmi, Materials Science, S. Chand Publisher, 2004.

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MPP 545 On Job Training (OJT) (4 Credits)

OJT will provide the opportunities for internship with local/regional industries, business organization, health and allied areas, local government, etc. so that students may actively engaged with the employability opportunities. Students will undergo 4 credit work based learning/OJT/internship.

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MPP 546: LAB IV

Learning Objectives: Students should be able to

1. study I-V characteristics and spectral response of solar cell.
2. study characteristics of LDR, phototransistor and SCR.
3. calculate the flat band potential of Si wafer.
4. analyze the Photoluminescence, Raman, IR, TGA-DTA spectra.
5. calculate the electrochromic properties using Cyclic –Voltammetry.
6. measure the gas sensitivity of given sample.

Credits=2	**SEMESTER-IV**	**No. of hours: 60**
	MPP 546: LAB IV	**(60)**
	1. To study the effect of series resistance on I-V characteristics of Silicon solar cell using simulation 2. To study the effect of shunt resistance on I-V characteristics of Silicon solar cell using simulation 3. To study the effect of working temperature on I-V characteristics of Silicon solar cell using simulation 4. To study the effect of layer thickness on I-V characteristics of Silicon solar cell using simulation 5. I-V characteristics of Silicon solar cell 6. Spectral response studies of solar cell 7. Study of supercapacitor properties 8. To study characteristics of photodiode	

	9. Counting statistics using G M Tube 10. Flat band potential of Si wafer 11. Bistable multivibrator 12. To study BJT as a switch 13. Analysis of Photoluminescence spectrum 14. Analysis of Raman spectrum 15. Analysis of Cyclic –Voltammetry 16. Analysis of FTIR spectrum 17. To study effect of operating temperature on gas sensing performance of given sample. 18. Analysis of TGA-DTA spectrum 19. Measurement of film thickness by optical method. 20. To study effect of gas concentration (ppm) on gas sensing performance of given sample.	

Learning Outcomes: Students will able to:

1. simulate effect series resistance, shunt resistance, working temperature, layer thickness on I-V characteristics and spectral response of solar cell.
2. study characteristics of LDR, phototransistor and SCR.
3. calculate the flat band potential of Si wafer.
4. analyze the Photoluminescence, Raman, IR, TGA-DTA spectra.
5. calculate the electrochromic properties using Cyclic –Voltammetry.
6. measure the gas sensitivity of given sample.

References:

1.ChetanSingh Solanki, Solar photovoltaics, Fundamentals, Technologies and Applications, PHI Learning Private Limited, Delhi, 2015.

2. H. A. Kiehne, Battery Technology Handbook, Marcel Dekker Inc Publisher, 1989.

3. Jarząbek, Polymer Films for Photovoltaic Applications, Mdpi AG Publisher, 2022.

4. A. Yu, V. Chabot, J. Zhang, Electrochemical Supercapacitors for Energy Storage and Delivery: Fundamentals and Applications, CRC Press, 1st Edition, 2017.