VISION:

Department of Physics at Anna University shall strive towards the world class centre by producing students with higher technical knowledge, professional skills and other values. The Department shall provide an outstanding experience in teaching, research and consultancy. The Department shall perform frontier research and create knowledge base in pure and applied physics, materials science, laser engineering and areas of technological importance.

MISSION:

Department of Physics, Anna University shall provide high quality physics education, producing well prepared students who are intellectually and technically equipped in their abilities and understanding of physics and in particular materials science. The Department of Physics promotes high quality academic and research programmes and providing extension services in cutting edge technologies in materials science and laser engineering. The Department of Physics ensures the supportive campus climate in academic and research activities by meeting the need of the students, faculty and staff.
ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.PHIL. PHYSICS (FT)
REGULATIONS - 2019
CHOICE BASED CREDIT SYSTEM

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):
   I. To provide training in Research Methodology as a pre Ph.D course.
   II. To provide knowledge in advanced topics in Physics and in particular, Materials Science.
   III. To provide specialized training and advanced knowledge in the field of interest.
   IV. To provide training in undertaking project work, so as to analyze and solve the problem independently.
   V. To provide training for making technical presentation and publishing results in any chosen topic related to the field of specialization.

2. PROGRAMME OUTCOMES (POs):
   After going through one year of study, our M.Phil. (Physics) Graduates will exhibit ability to:

<table>
<thead>
<tr>
<th>PO#</th>
<th>Graduate</th>
<th>Programme Outcome</th>
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<tbody>
<tr>
<td>1.</td>
<td>Research aptitude</td>
<td>An ability to independently carry out research investigation and development work to solve practical problems</td>
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<tr>
<td>2.</td>
<td>Technical documentation</td>
<td>An ability to write and present a substantial technical report/document</td>
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<td>3.</td>
<td>Technical competence</td>
<td>Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program</td>
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<td>4.</td>
<td>Modern Tool Usage</td>
<td>Students will develop and demonstrate an ability to work in laboratory, conduct experiments, visualize data and interpret the results.</td>
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<td>5.</td>
<td>Impact in society</td>
<td>Students will show the understanding of impact of materials in the society and also will be aware of contemporary issues.</td>
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<td>6.</td>
<td>Life-long learning</td>
<td>Continue professional development and learning as a life-long activity.</td>
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</table>
3. PROGRAM SPECIFIC OUTCOMES (PSOs):

By the completion of M.Phil. (Physics) program the student will have following Program specific outcomes.

1. Motivated and trained to carryout research.
2. Trained to handle and analyze the research problems independently.
3. Trained to prepare project reports and research publications.

4. PEO / PO Mapping:

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Mapping of Course Outcome and Programme Outcome

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<tr>
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### SEMESTER I

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**PRACTICAL**

| 2.     | PX5211      | Dissertation              | EEC      | 0    | 0 | 32  | 32                  | 16      |

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## EMPLOYABILITY ENHANCEMENT COURSES (EEC)

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Total Credits: 17

## SUMMARY

### M.PHIL. PHYSICS (FT)

<table>
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OBJECTIVES

- To introduce the students on objectives and various techniques of research.
- To equip students with research methodology essential for pursuing higher studies.
- To make the students to apply scientific tools, concepts and theories to solve scientific problems.
- To enable students in writing scientific research reports, thesis and dissertation.
- To introduce the concept of intellectual property rights and its protection.

UNIT I TECHNIQUES FOR RESEARCH
Research: Definition, characteristics, objectives, research and scientific method - Types of Research: Descriptive vs. analytical, fundamental vs. applied, quantitative vs. qualitative, conceptual vs. empirical - Methodology: Introduction, research process overview, formulating the research problem - defining the research problem - research questions. Literature review: Concepts and theories. Formulation of hypothesis: Sources, characteristics, role of hypothesis - Research design.

UNIT II EXPERIMENTAL DATA PROCESSING
Data collection techniques - concept of measurement - validity and reliability of measurement. Sampling: Statistical population, sampling frame, sampling error, sample size, simple random sample, systematic sample, practical considerations of sampling - models - reconstruction of input signals - preliminary processing of experimental data: filtering - quasi-real experiments - reconstructed signal accuracy.

UNIT III DATA ANALYSIS AND INTERPRETATION

UNIT IV TECHNIQUES OF RESEARCH WRITING AND PRESENTATION

UNIT V INTELLECTUAL PROPERTY RIGHTS

TOTAL : 60 PERIODS

OUTCOME
At the end of this course, the students will be able to
- Understand research problem formulation and analyze research related information
- Apply research design methodology
- Carryout systematic research experiments, data handling, interpretation and presentation.
- Follow research ethics.
- Appreciate the importance of IPR in research and development.
REFERENCES

PX5102 ADVANCED MATERIALS SCIENCE

OBJECTIVES
- To impart knowledge on optoelectronic materials
- To learn about ceramic processing and advanced ceramics
- To understand the processing and applications of polymeric materials
- To gain knowledge on the fabrication of composite materials
- To learn about shape memory alloys, metallic glasses and nanomaterials

UNIT I OPTOELECTRONIC MATERIALS

UNIT II CERAMIC MATERIALS

UNIT III POLYMERIC MATERIALS

UNIT IV COMPOSITE MATERIALS

UNIT V NEW MATERIALS
Shape memory alloys: mechanisms of one-way and two-way shape memory effect, reverse transformation, thermoelasticity and psuedoelasticity, examples and applications - bulk metallic glass: criteria for glass formation and stability, examples and mechanical behavior - nanomaterials: classification, size effect on structural and functional properties, processing and properties of nanocrystalline materials, single walled and multiwalled carbon nanotubes

TOTAL: 60 PERIODS
OUTCOMES
Upon completion of the course, the students will

- acquire knowledge on optoelectronic materials
- be able to prepare ceramic materials
- be able to understand the processing and applications of polymeric materials
- be aware of the fabrication of composite materials
- be knowledgeable of shape memory alloys, metallic glasses and nanomaterials

REFERENCES

PX5001 ADVANCED SOLID STATE IONICS

OBJECTIVES
- To introduce the basic aspects of solid state physics.
- To impart knowledge on solid state ionics, hydrogen storage and nano-ionic materials.
- To introduce the students to micro batteries, fuel cells, super capacitors and their applications.
- To familiarize the students to various characterization techniques for new cathode materials.
- To expose the students to the various application of ionic materials.

UNIT I INTRODUCTION

UNIT II SUPERIONIC MATERIALS AND STRUCTURES

UNIT III EXPERIMENTAL PROBES
Structural characterization - Thermodynamic properties - ion transport (macroscopic properties) - Ion dynamics (microscopic properties) - Phoelectron spectroscopy - EXAFS (extended X-ray absorption fine structure) - Local environment studies - FTIR, Thermal analysis - DTA - DSC - TG. - Particle size analysis - SEM-TEM-BET.

UNIT IV APPLICATION OF SUPER IONIC SOLIDS
Diffusion coefficient measurement in solids/liquids-sensor and partial pressure gauges - oxygen sensors (concentration cell type) - sulfur sensor (formation cell type) - Fuel cells - solid state battery - super capacitors.
UNIT V LITHIUM BATTERIES
Principles and general background of ambient temperature lithium batteries - synthesis of nano materials for lithium batteries - properties, structure and conductivity of organic and inorganic electrolytes for lithium battery systems - thin film deposition - pulsed laser deposition of electrodes - preparation and fabrication - characterization of Li-ion cells - Comparison of lead acid-NiCd and Li-ion batteries - Application of Lithium batteries in electronic devices and electric vehicle - Solar energy conversion devices.

TOTAL: 60 PERIODS

OUTCOMES
- The students would have learnt the basic aspects of solid state physics.
- Gained knowledge on solid state Ionics, hydrogen storage.
- Learnt about micro batteries, fuel cells, super capacitors.
- Learnt about the various characterization techniques available for cathode materials.
- The students are familiar with various applications of ionic materials.

REFERENCES

PX5002 ADVANCED SOLID STATE THEORY

OBJECTIVES
- To introduce the basics of atomic molecular structure.
- To know about density functional theory.
- To make the students to understand the computational methods of band structure.
- To inspire the theoretical aspects of other band structure methods
- To progress the students with predicting properties of matter from electronic structure.

UNIT I ATOMIC MOLECULAR STRUCTURE

UNIT II DENSITY FUNCTIONAL THEORY

UNIT III BAND STRUCTURE METHODS
The tight-binding method - linear combination of atomic orbitals - application to bands from s-levels general features of tight-binding levels - Wannier functions

UNIT IV OTHER BAND STRUCTURE METHODS
UNIT V  PREDICTING PROPERTIES OF MATTER FROM ELECTRONIC STRUCTURE  12
Lattice dynamics from electronic structure theory - phonons and density response functions - periodic perturbations and phonon dispersive curves - dielectric response functions - effective charges - electron-phonon interactions and superconductivity - magnons and spin response functions.

TOTAL: 60 PERIODS

OUTCOMES
• The students will understand the basic concepts of atomic molecular structure.
• Keen knowledge in density functional theory.
• Crack the computational studies of band structure.
• Apply the theoretical aspects of other band structure methods.
• The students will able to understand on predicting properties of matter from electronic structure.

REFERENCES

UNIT I  NUCLEATION  12

UNIT II  CRYSTAL GROWTH THEORY  12

UNIT III  BULK CRYSTAL GROWTH  12

UNIT IV  CRYSTAL GROWTH – FILMS AND EPITAXIAL LAYERS  12
UNIT V  CHARACTERIZATION TECHNIQUES


TOTAL: 60 PERIODS

OUTCOMES
• Students will be able understand the basic theory of nucleus formation and types in it.
• It provides the knowledge on different theories involved in bulk crystal growth.
• It makes the students to understand the different methods of growing single crystals.
• It imparts the knowledge on different methods of thin and thick film growth technology.
• Students will be able to understand and learn how to analyze the grown bulk single crystal and thin films using different characterization techniques.

REFERENCES

PX5004  CRYSTAL STRUCTURE ANALYSIS

OBJECTIVES
• To teach the concept of crystal structures and symmetry, and diffraction theory
• To provide students with a background to X-ray generation, scattering theory and experimental diffraction from single crystals
• To provide instruction on the methods and basis for determining low-molecular weight crystal structures using X-ray Crystallography
• To give the students a background to the instrumentation used for powder diffraction and structure refinement using Rietveld method
• To teach the different levels of structure exhibited by proteins and nucleic acids and methods used in protein crystallography.

UNIT I  SYMMETRY: LATTICE
Unit cell and Bravais lattices - crystal planes and directions - basic symmetry elements operations - translational symmetries - point groups - space groups - equivalent positions - Bragg’s law - reciprocal lattice concept -Laue conditions - Ewald and limiting spheres - diffraction symmetry - Laue groups.

UNIT II  DIFFRACTION
UNIT III  STRUCTURE ANALYSIS  12
Single crystal diffractometers - geometries - scan modes - scintillation and area detectors - intensity data collection - data reduction - factors affecting X-ray intensities - temperature and scale factor - electron density - phase problem - normalised structure factor - direct method fundamentals and procedures - Patterson function and heavy atom method - structure refinement - least squares method - Fourier and difference Fourier synthesis - R factor - structure interpretation - geometric calculations - conformational studies - computer program packages.

UNIT IV  POWDER METHODS  12

UNIT V  PROTEIN CRYSTALLOGRAPHY  12

TOTAL: 60 PERIODS

OUTCOMES
Upon completion of the course the students will
- understand crystal symmetry and reciprocal lattice concept for X-ray diffraction
- gain a working knowledge of X-ray generation, X-ray photography with Laue, oscillation and moving film methods, and space group determination.
- get a working knowledge of single crystal diffractometers and single crystal structure determination using program packages
- understand the instrumentation used for powder diffraction, data collection, data interpretation, and structure refinement using Rietveld method
- get some insight into the structural aspects of proteins and nucleic acids, crystallization of proteins and methods to solve protein structures.

REFERENCES

PX5005  ADVANCED PHYSICAL METALLURGY  L T P C
4  0  0  4

OBJECTIVES
- To study the characteristic properties of intermetallic alloys as well as compositional and surface morphology by various electro-magneto-optical instruments.
- To understand the phase diagrams of (two or more elements) alloys and their invariant reactions during solidification on cooling.
• To study the Fick’s first and second law of diffusion and their applications
• To study some of mechanical properties such as stress-strain, creep, fatigue, hardness etc. of metals.
• To learn the high strength structural steels, tool steels and alloy steels for various engineering applications.

UNIT I  STRUCTURE OF ALLOYS  12

UNIT II  PHASE DIAGRAMS  12

UNIT III  DIFFUSION  12

UNIT IV  MECHANICAL PROPERTIES  12
Stress-strain curve – Compressibility – Plastic deformation mechanisms, Tensile strength – Creep – Fracture – Fatigue failures – Effect of grain size on mechanical properties-Hardness.

UNIT V  ENGINEERING ALLOYS  12

TOTAL : 60 PERIODS

OUTCOMES
• Reveal’s the basic properties of intermetallic phases and their compounds utilized for applications along with characteristic studies such as surface morphology and composition.
• The phase diagrams of binary or multi- component systems which under goes various invariant reactions will be discussed.
• The concept of time independent and dependent diffusion equations applied for surface treatment to improve hardness of tool components will be discussed.
• The various mechanical properties of metals such as tentile, creep, fatigue etc. with change in grain size will be discussed.
• The engineering alloy steels with various alloying elements that improve the strength even at high working temperature will be discussed.

REFERENCES

PX5006  MATERIALS CHARACTERIZATON  L T P C
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OBJECTIVES
• To introduce to the students the important techniques used for materials characterization.
• To make the students learn some important thermal analysis techniques namely TGA, DTA, DSC and TMA.
• To make the students understand the theory of image formation in an optical microscope and to introduce other specialized microscopic techniques.
• To make the students learn and understand the principle of working of electron microscopes and scanning probe microscopes.
• To make the students understand some important electrical and optical characterization techniques for semiconducting materials.
• To introduce the students the basics of x-ray diffraction techniques and some important spectroscopic techniques.

UNIT I  THERMAL ANALYSIS  12

UNIT II  MICROSCOPIC METHODS  12

UNIT III  ELECTRON MICROSCOPY AND SCANNING PROBE MICROSCOPY  12
SEM, EDAX, EPMA, TEM: working principle and Instrumentation – sample preparation – data collection, processing and analysis- Scanning tunneling microscopy(STEM)- Atomic force microscopy(AFM) - Scanning new field optical microscopy.

UNIT IV  ELECTRICAL METHODS AND OPTICAL CHARACTERISATION  12

UNIT V  X-RAY AND SPECTROSCOPIC METHODS  12
Principles and instrumentation for UV-Vis-IR, FTIR spectroscopy, Raman spectroscopy, ESR, NMR,NQR, XPS, AES and SIMS-proton induced X-ray Emission spectroscopy (PIXE) –Rutherford Back Scattering (RBS) analysis-application - Powder diffraction - Powder diffractometer - interpretation of diffraction patterns - indexing - phase identification - residual stress analysis - Particle size, texture studies - X-ray fluorescence spectroscopy - uses.

TOTAL: 60 PERIODS

OUTCOMES
• Students will be able to describe the TGA, DTA, DSC and TMA thermal analysis techniques and make interpretation of the results.
• Students have learned the concept of image formation in Optical microscope, developments in other specialized microscopes and their applications.
• Students have learned the working principle and operation of SEM, TEM, STM and AFM.
• Students have understood Hall measurement, four –probe resistivity measurement, C-V, I-V, Electrochemical, Photoluminescence and electroluminescence experimental techniques with necessary theory.
• Students have learned the theory and experimental procedure for x-ray diffraction and some important spectroscopic techniques and their applications.

REFERENCES
OBJECTIVES

- To introduce the various factors that affect the mechanical behavior of bulk materials.
- To make the students understand about the mechanical properties of thin films.
- To impart knowledge on mechanical properties of biomaterials and biocompatibility
- To make the students understand about nanomechanics.
- To expose the students to the various methods for characterizing the mechanical properties.

UNIT I  MECHANICAL PROPERTIES OF BULK MATERIALS  12
Mechanical properties of inorganic materials (metals, ceramics) and organic materials (polymers, fibres) and composites (material blends, nanocomposites, filled and reinforced systems). Mechanical testing, enthalpy elasticity, rubber elasticity, viscoelasticity, plasticity, viscoplasticity, fracture properties, deformation velocity and temperature influence. Molecular and morphological influence on the mechanical properties. External influence including moisture, solvents and oxidation. Introduction to the mechanical behavior of small scale components, structures and devices.

UNIT II  MECHANICAL PROPERTIES OF THIN FILMS  12
Stresses in thin films - Measurement of stresses in thin films - Wafer curvature and Stoney equation - Stresses due to different deposition processes.

UNIT III  MECHANICAL PROPERTIES OF BIOMATERIALS  12
Introduction to nanomechanics - Force versus distance curve - Single cell mechanics Qualitative introduction to intra- and intermolecular forces - Quantitative description of intra- and intermolecular forces - Molecule - surface interactions - Colloids and interparticle potentials - Van der Waals forces at work: Gecko feet adhesion - The electrical double layer (EDL) theory - Nanomechanics of cartilage - Protein - surface interactions - Nanomechanics and biocompatibility: Protein-biomaterial interactions.

UNIT IV  MECHANICAL PROPERTIES OF NANOMATERIALS  12
Deformation behaviour of nanomaterials. – comparison of mechanical characteristics in bulk and nano – Reason for change in characteristics - Fracture and creep - Nanomechanics and nanotribology.

UNIT V  INSTRUMENTS FOR MEASUREMENT  12

TOTAL: 60 PERIODS

OUTCOMES

- The students would gain knowledge on the various factors that affect the mechanical behavior of bulk materials.
- Understand the mechanical properties of thin films.
- Gained knowledge on mechanical properties of biomaterials and biocompatibility
- The students would be able to analyze about nanomechanics.
- Apply their knowledge gained on characterizing the mechanical properties.

REFERENCES

1. Nanoindentation, Anthony C. Fischer-Cripps, Springer-Verlag GmbH, 2002
3. Nanoindentation, 3rd Edition Fischer-Cripps Laboratories Pty Ltd.

**PX5008**

**NANOMATERIALS CHARACTERIZATION**

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**OBJECTIVES**

- To expose the students with knowledge of understanding the X-Ray analysis and characterization of nanomaterials
- To understand the surface analytical tools for nanomaterials
- To know the electrical and optical spectroscopy
- To inculcate principles and characterization of electron microscopy
- To inspire the nano-imaging spectroscopy

**UNIT I**

**X-RAY ANALYSIS OF NANOMATERIALS**


**UNIT II**

**SURFACE ANALYTICAL TOOLS FOR NANO-MATERIALS**

UV and X-ray photoelectron spectroscopy; Auger electron spectroscopy; low energy electron diffraction and reflection high energy electron diffraction - secondary ion mass spectrometry - Rutherford backscattering - Medium energy ion scattering- Electron energy loss spectroscopy (EELS) and high resolution EELS. X-ray Photoelectron Spectroscopy, Auger photoelectron Spectroscopy.

**UNIT III**

**NANOSCALE ELECTRICAL SPECTROSCOPY**

I-V/C-V; Hall, quantum Hall effects; transient charge spectroscopy. Optical spectroscopy: micro Photoluminescence; Absorption Spectroscopy, Excitation Spectroscopy, micro Raman Spectroscopy; Time domain spectroscopy.

**UNIT IV**

**ELECTRON MICROSCOPY**


**UNIT V**

**NANO-IMAGING SPECTROSCOPY**

Basic principles - Scanning Tunneling Microscopy, Scanning Force Microscopy (SFM/AFM), and scanning holographic microscopy -image interpretations; Scanning Near Field Optical Microscopy and scanning ion conductance microscopy.

**OUTCOMES**

- The students will gain knowledge on X-Ray diffraction and its techniques
- Apply the knowledge in surface analysis
- Gain the keen idea of electrical characterization
- Crack the electron microscopy and thin films
- The students will able to understand scanning spectroscopy

TOTAL: 60 PERIODS
REFERENCES

OBJECTIVES
- To introduce the students on objectives and various techniques of computational materials science.
- To equip students with Ab Initio techniques.
- To make the students to apply tight-binding formalism and methods to solve the Schrodinger equation for large systems.
- To enable students in learning empirical methods and coarse-graining.
- To introduce the concept of Monte Carlo methods.

UNIT I AB-INITIO METHODS

UNIT II TIGHT-BINDING METHODS
Tight-binding formalism – methods to solve the Schrodinger equation for large systems – self-consistent tight-binding formalism – applications to fullerenes, silicon and transition-metal clusters.

UNIT III EMPIRICAL METHODS AND COARSE-GRAINING

UNIT IV MONTE CARLO METHODS
Basis of the Monte Carlo (MC) method: Stochastic processes, Markov process, ergodicity. Algorithms for MC simulation: random numbers, simple sampling technique, importance of sampling technique, dynamic models, applications in classical particles, percolation, polymer systems, spin systems, nucleation, crystal growth and fractal systems.

UNIT V QUANTUM MONTE CARLO METHODS

OUTCOMES
At the end of this course, the students will be able to
- understand Ab Initio methods for materials science research.
- understand tight-binding approximation technique.
- know empirical methods and coarse-graining technique.
- apply Monte Carlo methods for materials simulation.
- Appreciate the importance of quantum Monte Carlo methods.
REFERENCES

PX5010 CONDENSED MATTER PHYSICS

OBJECTIVES
- To introduce the students on objectives of chemical bonding.
- To make the students to learn Block theorem.
- To make the students to know Hartree-Fock and density functional theories.
- To enable students in learning the importance of vibrations in molecules and crystals.
- To introduce the concept of transport theory.

UNIT I CHEMICAL BONDING
The simplest example: H₂⁺, the tight-binding approximation, hybridization and covalent bonding, effect of overlap, eigenvectors and population analysis, charge transfer and ionic bonding, Jellium model and metallic bonding, Van der Waals bonding, cohesive energy of a solid.

UNIT II BLOCH THEOREM AND BAND STRUCTURE METHODS
Plane wave and LCAO formulation of Bloch theorem, Pe- riodicity and gap openings, band structure methods, DOS, k-point sampling, thermodynamic properties of non-interacting Fermi systems.

UNIT III HARTREE, HARTREE-FOCK AND DENSITY FUNCTIONAL THEORIES
The variational approach, HF equations, Koopman theorem, ionization potential and electron affinity, chemical potential, chemical hardness and gap as derivatives of the total energy, shortcomings of HF, derivation of the exchange functional, variational formulation, LDA. Kinetic energy functionals, finite temperature generalization.

UNIT IV VIBRATIONS IN MOLECULES AND CRYSTALS
Classical and quantum treatment, dynamical matrix and phonon spectrum, ZPE, acoustic and optical modes, thermodynamic properties, long wavelength limit and elasticity theory.

UNIT V TRANSPORT THEORY
Dynamics of electrons, Boltzmann equation, application to electrons and phonons, relaxation time approximation (RTA) from Fermi’s Golden rule, Matthiessen’s rule, thermoelectric effects, Drude model of transport and Einstein relations.

TOTAL: 60 PERIODS

OUTCOMES
On successful completions of this course, the students should able to
- Recall and describe the aspect of chemical bonding
- Describe Bloch theorem.
- Understand Hartree-Fock and density functional theories.
- Appreciate the importance of vibrations in molecules and solids.
- Explain the concept of transport physics.
REFERENCES

OBJECTIVES
- To provide knowledge on the concepts of linear and non-linear circuits.
- To introduce the students on the aspects of bifurcation and chaos.
- To make the students to understand the design of discrete map chaos circuits.
- To make the students to study the dynamics of continuous type chaotic circuits.
- To aid the students to design and study higher order chaotic circuits.

UNIT I LINEAR AND NONLINEAR CIRCUITS

UNIT II BIFURCATION AND CHAOS

UNIT III DISCRETE MAP BASED CHAOTIC CIRCUITS

UNIT IV CONTINUOUS TYPE CHAOTIC CIRCUITS

UNIT V HIGHER-ORDER CHAOTIC CIRCUITS

OUTCOMES
After completing this course, the students should be able to
- Understand the basics of linear and non linear circuits.
- Acquire knowledge on bifurcation and chaos in dynamical systems.
- Design discrete type chaos circuits.
- Design continuous type chaos circuits.
- Understand the design philosophy of higher order chaotic circuits.
REFERENCES

PX5012 PHYSICS OF NANODEVICES

OBJECTIVES
- To introduce the concepts of macroscopic current flow.
- To make the students to understand quantum current flow aspects.
- To make the students to understand the aspects of mesoscopic transport.
- To make the students to acquire quantum phenomena
- To introduce the student the functioning of different nanostructured devices.

UNIT I MACROSCOPIC CURRENT FLOW

UNIT II QUANTUM CURRENT FLOW
Need of size shrinking of devices – point contacts: From mesoscopic to atomic – conductance from transmission – transmission probability and current flow in quantum structures: Transmission probability, single potential step, single potential barrier, double potential barrier – Ballistic and diffusive transport.

UNIT III MESOSCOPIC TRANSPORT
Botlizmann transport equation – resistivity of thin films and wires: surface scattering (general principles, 1D, 2D and 3D confinements) – resistivity of thin films and wires: Grain-boundary scattering – measurement of resistance of thin films

UNIT IV QUANTUM PHENOMENA

UNIT V NANOSTRUCTRED DEVICES

TOTAL: 60 PERIODS
OUTCOMES
After completing this course, the students should able to
- Understand the concepts of macroscopic current flow.
- Understand quantum current flow aspects.
- Understand the aspects of mesoscopic transport.
- Acquire knowledge on quantum phenomena
- Understand the functioning of different nanostructured devices.

REFERENCES

PX5013
HIGH PRESSURE PHYSICS

OBJECTIVES
- To introduce the aspects of High pressure science and the technology
- To expertise the measurements of high pressure
- To familiarize high pressure devices for various properties and applications
- To inspire properties of high pressure and spectroscopy studies
- To insight mechanical properties under pressure

UNIT I  GENERAL TECHNIQUES
Definition of pressure – Hydrostaticity – generation of static pressure, pressure units – piston cylinder

UNIT II  HIGH PRESSURE DEVICES FOR VARIOUS APPLICATIONS
X – Ray diffraction, Neutron diffraction – Optical studies – Electrical studies – Magnetic studies –
High and low temperature applications – Ultra high pressure anvil devices.

UNIT III  HIGH PRESSURE PHYSICAL AND CHEMICAL PROPERTIES
PVT Relations in fluids – Properties of gases under pressure – Melting phenomena – viscosity –

UNIT IV  MECHANICAL PROPERTIES AND INDUSTRIAL APPLICATIONS
Elastic constants – Measurements – Mechanical properties – Tension and compression –
Fatigue – creep – Hydrostatic extrusion, material synthesis – superhard materials – Diamond –
oxides and other compounds – water jet.

UNIT V  DYNAMIC PRESSURES

TOTAL: 60 PERIODS
OUTCOMES

- Establish the operation of anvil and Multi-anvil devices
- Crack the gauge operations
- Design various anvil device applications
- Apply ideas of Electronic structure of metals and semiconductors
- After completing this course the students will be able to understand the basic concepts of the high pressure and various technological applications of high pressure.

REFERENCES


PX5014 ADVANCED NONLINEAR OPTICS

OBJECTIVES

- To educate the students about the importance of nonlinear optics.
- To inculcate the student to gain knowledge in understanding the concepts of second harmonic generation and parametric oscillation.
- To introduce the students the phenomena of third order nonlinearities.
- To study in detail the electro optic and photorefractive effects.
- To study the basic physics and applications of stimulated Raman scattering.

UNIT I ORIGIN OF OPTICAL NONLINEARITIES

Effects due to quadratic and cubic polarization – Response functions – Susceptibility tensors – Linear, second order and n\textsuperscript{th} order susceptibilities – Wave propagation in isotropic and crystalline media – The index ellipsoid.

UNIT II SECOND HARMONIC GENERATION (SHG) AND PARAMETRIC OSCILLATION


UNIT III THIRD ORDER NONLINEARITIES

Intensity dependent refractive index – Nonlinearities due to molecular orientation – Self-focusing of light and other self-action effects - Optical phase conjugation – Optical bistability and switching - Pulse propagation and temporal solitons.

UNIT IV ELECTRO –OPTIC AND PHOTOREFRACTIVE EFFECTS


UNIT V STIMULATED SCATTERING PROCESSES


TOTAL: 60 PERIODS
OUTCOMES
- The students will understand how the nonlinear effects affect the properties and dynamics of light-matter interaction.
- The students will gain knowledge in the field of second harmonic generation and parametric oscillation.
- The students will be introduced to the theory and applications of third order nonlinearities.
- The students will understand easily the physical principles of planar wave guides.
- The students will learn about stimulated Raman scattering and its applications.

REFERENCES

PX5015 LASER THEORY AND APPLICATIONS

OBJECTIVES
- To learn about the fundamentals of Laser Theory and its process dynamics
- To learn about the different types of laser resonators and switching theory
- To learn about the different types of Gas lasers, configurations and liquid lasers
- To learn about the high power solid state lasers and semiconductor lasers
- To learn about Speckle and Holographic applications, Material processing applications and Medical applications

UNIT I LASER THEORY
Absorption - Spontaneous and stimulated emission - Einstein’s coefficients - threshold conditions for laser action - Line broadening, Mechanism - Lorentzian and Doppler line shapes - Small signal gain - Gain coefficient - gain saturation - Rate equations for 3 and 4 level systems - Pulsed and CW lasers.

UNIT II RESONATORS AND SWITCHING THEORY
Resonant cavity - Fox and Li - Boyd and Gorden’s theory on resonators - modes - Spot size - Types of resonators - Mode selection - Q switching theory and technique - Mode locking theory and technique.

UNIT III GAS AND LIQUID LASERS
Lasers: He-Ne, Argon Ion, Carbon dioxide, Nitrogen - Metal vapour - Gas dynamics - Excimer - Free electron lasers - Dye lasers organic dyes - Threshold conditions - Pumping configurations.

UNIT IV SOLID STATE AND SEMICONDUCTOR LASERS

UNIT V APPLICATIONS
Speckle, speckle interferometry - Holography - Holographic interferometry - Material processing - Surface treatment - welding, drilling and cutting - Laser ranging - Laser Doppler Velocimetry - Pollution monitoring - Medical and communication applications.

TOTAL: 60 PERIODS

Attested

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OUTCOMES

- Students would gain knowledge on the fundamentals of Laser theory and its process dynamics
- Students would gain knowledge on the different types of laser resonators and switching applications
- Students would gain knowledge on the different types of configurations used in Gas lasers and liquid lasers
- Students would gain knowledge on the high power solid state lasers and semiconductor lasers
- Students would gain knowledge on the various types of laser applications

REFERENCES


UNIT I BASIC PROBABILITY, STATISTICS AND RANDOM NUMBERS


UNIT II NUMERICAL INTERPOLATION, DIFFERENTIATION AND INTEGRATION

Newton’s forward and backward interpolation formulae - Lagrange’s interpolation formula for unequal intervals - Error in polynomial interpolation and Newton’s interpolation formula - Numerical differentiation - Maximum and minimum of a tabulated function – Numerical integration - Trapezoidal rule - Romberg’s method- Simpson’s rule - Practical applications of Simpson’s rule.

UNIT III NUMERICAL SOLUTION OF ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS


UNIT IV EMPRICAL LAWS AND CURVE FITTING

Linear law and laws reducible to linear law - Graphical method - method of group averages - principle of least squares - Fitting of straight line and parabola.

UNIT V MONTE CARLO METHODS


TOTAL: 60 PERIODS
OUTCOMES
After completing this course, the students should able to
- understand probability, statistics and random numbers.
- understand numerical interpolation, differentiation and integration.
- Solve differential equations
- use curve fitting methods.
- Understand Monte Carlo methods.

REFERENCES

OBJECTIVES
- To introduce the alternative energy sources and utilization.
- To impart knowledge on the fundamentals of electrochemistry and electrode kinetics.
- To introduce the students to hydrogen as a renewable energy source.
- To familiarize the students to various batteries and super capacitors.
- To expose the students to biomass utilization and nuclear energy.

UNIT I INTRODUCTION TO ALTERNATIVE ENERGY SOURCES AND UTILIZATION 12

UNIT II FUNDAMENTALS OF ELECTROCHEMISTRY AND ELECTRODE KINETICS 12

UNIT III HYDROGEN AS A RENEWABLE ENERGY SOURCE 12

UNIT IV BATTERIES AND SUPER CAPACITORS 12
Introduction to Primary and Secondary batteries- Principle- Battery materials - anode, cathode and electrolyte materials - Concepts of Rechargeable batteries – Applications of Lithium batteries, Lithium ion and polymer batteries. — Super-capacitors: principles and working, electrode materials synthesis process, fabrication of the devices and their applications.

UNIT V BIOMASS UTILIZATION AND NUCLEAR ENERGY 12

TOTAL: 60 PERIODS
OUTCOMES
- The students would have learnt the basic aspects of alternative energy sources and utilization.
- Gained knowledge on the fundamentals of electrochemistry and electrode kinetics.
- Learnt about hydrogen as a renewable energy source.
- The students acquired knowledge about the various batteries and super capacitors.
- The students are familiar with various biomass utilization and nuclear energy.

REFERENCES

UNIT I GENERAL
Linear waves-ordinary differential equations (ODEs)-Partial differential equations (PDEs)-Methods to solve ODEs and PDEs- Numerical methods – Linear and Nonlinear oscillators-Nonlinear waves-Qualitative features.

UNIT II COHERENT STRUCTURES

UNIT III BIFURCATIONS AND ONSET OF CHAOS

UNIT IV CHAOS THEORY AND CHARACTERISTION
UNIT V  APPLICATIONS


TOTAL: 60 PERIODS

OUTCOMES

- Students will gain knowledge about the available analytical and numerical methods to solve various nonlinear systems.
- The students will understand the concepts of different types of coherent structures and their importance in science and technology.
- The students will learn about simple and complex bifurcations and the routes to chaos.
- The students will acquire knowledge about various oscillators, characterization of chaos and fractals.
- The students will be well trained in the applications of solutions in telecommunication, applications of chaos in cryptography, computations and that of fractals.

REFERENCES


UNIT I  INFRARED SPECTROSCOPY


UNIT II  RAMAN SPECTROSCOPY


UNIT III  SEM –EDX AND FT-IR MICROSCOPIC SPECTROSCOPY

UNIT IV  NMR and ESR SPECTROSCOPY  
Origin of electron spin resonance and resonance condition – quantum mechanical theory of ESR – design of ESR spectrometer – Hyperfine structure study – ESR study of anisotropic systems – Triplet states study of ESR – application of ESR to transition metal ions – ENDOR.

UNIT V  NQR AND MOSSBAUER SPECTROSCOPY  
General principles of NQR – energy levels of quadruple transitions for half-integral spins – design of NQR Spectrometer – Application of NQR (Molecular Structure). Principle of Mossbauer Effect – Schematic arrangement of Mossbauer spectrometer – Isomer shift – Quadruple interaction – magnetic hyperfine interactions – applications of Mossbauer spectroscopy (Biological applications)

OUTCOMES
• The students would gain knowledge on the infrared spectroscopy.
• Understand the experimental aspects of Raman spectroscopy.
• Gained knowledge on SEM – EDX and FT-IR microscopy.
• The students would be able to analyze about NMR – ESR spectroscopy.
• Apply their knowledge gained on characterizing the materials properties by using NQR and Mossbauer spectroscopy.

REFERENCES

PX5020  SUPERCONDUCTIVITY AND ITS APPLICATIONS  
OBJECTIVES
• To introduce the basic experimental aspects of the superconductivity
• To know about superconducting materials and its alloys
• To make the students to understand the experimental studies of superconducting materials
• To inspire the theoretical aspects of superconductivity
• To progress the students with various application in superconductivity

UNIT I  BASIC EXPERIMENTAL ASPECTS  

UNIT II  SUPERCONDUCTING MATERIALS  
Elemental superconductors – superconducting compounds and its alloys – A15 compounds – chevrals phase compounds
UNIT III
HIGH TEMPERATURE SUPERCONDUCTORS 12

UNIT IV
THEORETICAL ASPECTS 12
Isotope effect – BCS theory – Role of electrons and phonons – applications of electron band structure results to calculate electron – Phonon coupling constant, McMillan’s formula – GlaG theory – recent theories on high Tc materials, Coherence length, expression for critical temperature Tc, critical field Hc, critical current Jc – heavy fermion superconductivity.

UNIT V
APPLICATIONS 12

TOTAL: 60 PERIODS

OUTCOMES
• The students will understand the basic concepts of superconductivity
• Keen knowledge in superconducting materials.
• Crack the experimental studies of superconducting materials
• Apply the theoretical aspects of superconductivity
• The students will able to understand various technological application of the superconductivity

REFERENCES