M.Sc. Degree

IN

Physics

SYLLABUS

FOR

CREDIT BASED CURRICULUM

(From the academic year 2014-15 onwards)

DEPARTMENT OF PHYSICS

National Institute of Technology, Tiruchirappalli – 620015

TAMILNADU, INDIA
THE INSTITUTE

Vision
To provide valuable resources for industry and society through excellence in technical education and research.

Mission
- To offer state-of-the-art undergraduate, postgraduate and doctoral programmes.
- To generate new knowledge by engaging in cutting-edge research.
- To undertake collaborative projects with academia and industries.
- To develop human intellectual capability to its fullest potential.

THE DEPARTMENT

Vision
- Provide a world class scientific platform for scientists and engineers.

Mission
- Establish the department as a global player in Science and Technology.
- Excel in scientific R&D and consultancy.
- Create an environment for society aimed at knowledge enhancement.
# CURRICULUM

Total minimum credits required for completing M.Sc. Programme in Physics is **66**.

## SEMESTER I

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LIST OF ELECTIVES *

Odd Semester

PH611  DIGITAL SIGNAL AND IMAGE PROCESSING
PH613  BASICS OF ENGINEERING MATERIALS
PH671  WAVEGUIDES AND MODERN OPTICS
PH673  SOLAR PHOTOVOLTAIC TECHNOLOGY
PH675  ADVANCED ELECTROMAGNETIC THEORY
PH677  FIBER OPTIC SENSORS
PH679  SENSORS AND TRANSDUCERS
PH681  PHYSICS AND TECHNOLOGY OF THIN FILMS
PH683  MAGNETISM AND SUPERCONDUCTING LEVITATION
PH685  MICRO-ELECTRO-MECHANICAL SYSTEMS

Even Semester

PH610  ELECTRICAL, MAGNETIC AND OPTOELECTRONIC MATERIALS
PH672  MICROPROCESSORS
PH674  COMPUTER APPLICATIONS IN PHYSICS
PH676  NON-DESTRUCTIVE TESTING
PH678  LASERS AND APPLICATIONS
PH680  ADVANCED STATISTICAL METHODS AND PHASE TRANSITION
PH682  SEMICONDUCTOR PHYSICS
PH684  NANOSCIENCE AND TECHNOLOGY & APPLICATIONS

* Electives are not limited to the given list. Courses from other PG programmes can also be chosen as subjects of study. The courses will be offered based on convenience of the faculty concerned.
I SEMESTER

PH651 – MATHEMATICAL PHYSICS - I

Objective: To introduce basic mathematical topics necessary to understand and appreciate various physical laws of nature.

Unit – I: Vector Analysis

Unit – II: Curved coordinates, Tensors

Unit – III: Linear Algebra

Unit – IV: Ordinary Differential Equations

Unit-V: Probability

Text Books

Reference Books
Outcome: Students will be capable of handling variety of courses on mechanics and electromagnetic theory.

PH653 – CLASSICAL MECHANICS

Objectives:
1. To learn and use Newton’s laws of motion to solve advanced problems involving the dynamic motion of classical mechanical systems.
2. To introduce differential calculus and other advanced mathematical techniques pertaining to the development of Lagrangian and Hamiltonian formulations of classical mechanics.
3. To solve the dynamical problems using conservation laws.

Unit – I: Lagrangian Formulation

Unit – II: Central Force Problem

Unit – III: Rigid Body and Oscillating System

Unit – IV: Hamiltonian Formulation
Legendre transformation – Hamiltonian equations of motion – cyclic coordinates – phase space and Liouville's theorem – Poisson brackets.

Unit – V: Special Theory of Relativity

Text Books


**Reference Books**


**Outcome:** Effective learning of items 1, 2 and 3 will enable the students to understand the complicated classical dynamical problems and find possible solutions for these problems.

**PH655 – QUANTUM MECHANICS**

**Objectives:**

1. To introduce the mechanics of mater-waves necessary for uncovering the mysteries of matter at atomic scale.
2. To understand the spectrum of hydrogen.
3. To introduce various approximate methods useful for more complex problems.

**Unit – I: Schrödinger Equation**

**Unit – II: Operators and Eigenfunctions**

**Unit – III: Solvable Problems**

**Unit – IV: Angular Momentum and Spin**

**Unit – V: Approximation Methods**

**Text Books**

**Reference Books**

**Outcome:** Intriguing probabilistic nature of matter at atomic scale will be understood. Students will be capable of handling courses like Statistical Mechanics, Solid State Physics, Spectroscopy and Nuclear Physics.

**PH 657 – ELECTRONICS**

**Objective:** To impart a diversified knowledge on circuit analysis, the semiconductor devices, FETs, operational amplifiers and digital circuits and their applications.

**Unit – I: Circuit Theorems and Special Diodes**

**Unit – II: Bipolar Transistor Amplifiers and FETs**
Biasing characteristics of junction transistors – analysis using re model-fixed bias-voltage divider bias-emitter bias – direct coupled transistor amplifiers – single stage transistor amplifier – frequency response – feed back in amplifiers – effect of negative feedback in amplifiers – FETs – different types-low and high frequency FETs, frequency response of FET – applications

**Unit-III: Oscillators**
Unit – IV: Operational Amplifiers
Basis of operational amplifier – characteristics – CMRR – inverting and non-inverting modes- sum and difference amplifiers – integrating and differentiating circuits – feedback types – current to voltage (ICVS) and voltage to current (VCIS) conversion — op-amp application – instrumentation amplifiers – low pass and high pass active filters.

Unit – V: Digital Circuits

Text Books

Reference Books

Outcome: On successful completion of this course, students would be able i) to understand the construction, working function, characteristics and applications of various semiconductor devices and ii) to describe the design and applications of various digital circuits.

PH659 – GENERAL PHYSICS LABORATORY

Objective: To introduce the basic concepts of physics through hands on experience and impart experimental skill to students.

List of Experiments
1. Hall Effect in Semiconductor
2. Non-Destructive Testing – Ultrasonics
3. Two Probe Method for Resistivity Measurement
5. Numerical Aperture of an Optical Fiber
6. Electron Spin Resonance
7. Specific Heat Capacity of Solids
8. Half Shade Polarimeter and Strain Viewer
9. Michelson Interferometer
10. Acoustic Diffraction
11. Vacuum Pumps – Low Pressure Measurement and Determination of Pumping Speed
12. Zeeman effect
13. Hydrogen Spectra and Rydberg Constant
14. Forbe’s Method – Thermal Conductivity of Metal
15. Kundt’s Tube
16. Solar-Cell Characteristics
17. Magnetic Susceptibility of Liquids – Quincke’s Method
18. Curie Temperature of Magnetic Materials
19. Dielectric Constant and Curie Temperature of Ferroelectric Ceramics
20. Hysteresis (B – H Curve)
21. Helmholtz Galvanometer
22. Faraday Effect
23. Millikan Oil Drop Experiment – e/m of Electron
24. Determination of Planck’s Constant
25. Cornu’s Method – Determination of Elastic Constants of Transparent Materials

Text Books
1. General Physics Laboratory Manual, Department of Physics, NITT.

Reference Books

Outcome: The student will be able to understand the fundamental physics behind many scientific discoveries through hands on experience.

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II SEMESTER

PH652 – MATHEMATICAL PHYSICS - II

Objective: To introduce basic mathematical topics necessary to understand and appreciate various physical laws of nature.

Unit – I: Infinite Series

Unit – II: Complex Analysis

Unit – III: Integral Transforms

Unit – IV: Group Theory
Introduction to group theory – generators of continuous groups – rotation groups and angular momentum – SU(2)-SO(3) homomorphisms – orbital angular momentum – discrete groups – character table – irreducible representation.

Unit – V: Partial Differential Equations

Text Books

Reference Books

Outcome: Students will acquire enough mathematical skills to handle variety of equations, appear in various physical situations, with ease.
PH654 – ELECTROMAGNETIC THEORY

Objective: To understand the nature of electric and magnetic force fields and the intricate connection between them.

Unit – I: Electrostatics

Unit – II: Magnetostatics

Unit – III: Maxwell’s Equations

Unit – IV: Electromagnetic Waves

Unit – V: Waves in Bounded Region
Reflection and refraction at the boundary of non-conducting media – Fresnel’s coefficients – Brewster’s angle and critical angle – reflection from a conducting plane – wave guide – TE and TM waves – rectangular wave guide.

Text Books

Reference Books
Outcome: Electromagnetic nature of radiation and its propagation in media will be understood.

PH656 – STATISTICAL MECHANICS

Objectives:
1. To learn the connection between macroscopic and microscopic state of a system of large number of particles.
2. To understand thermal equilibrium of a system in statistical sense.

Unit – I: Thermodynamics
Ideal gas law – exact differentials – first law, internal energy, heat capacity – second law, Carnot’s cycle, Carnot’s theorem, absolute temperature – Clausius theorem, entropy – thermodynamic potentials, Maxwell’s relations – chemical potential – third law.

Unit – II: Theory of Ensembles

Unit – III: Maxwell-Boltzmann Statistics

Unit – IV: Bose-Einstein Statistics

Unit – V: Fermi-Dirac Statistics

Text Books

Reference Books

Outcome: Students will be able to understand various properties of matter and radiation in thermal equilibrium through appropriate statistics. Students will be prepared to understand Solid State Physics.

PH658 – INSTRUMENTATION

Objectives:
1. Students will study the major characteristics of measurement systems and errors involved in them.
2. Students will gain an understanding related to production and measurement of low temperatures and high pressure.
3. Student will read various spectroscopic techniques and detectors.

Unit – I: Generalized Characteristics of Instruments

Unit – II: Vacuum Systems

Unit – III: Thermal Systems

Unit – IV: Detectors and Spectroscopy
Unit – V: Electronics and Experimental Methods


Text Books

Reference Books

Outcomes:
1. To fully appreciate the various techniques involved in production of vacuum, low temperatures which will benefit them to handle various instruments in a better way.
2. To really understand the characteristics of instruments and analysis of errors will help them in interpreting the obtained data more efficiently.

PH660 – ELECTRONICS LABORATORY

Objective: To introduce the various concepts of basic electronics and circuits through hands on experience.

List of Experiments
1. Solving Simultaneous Equations
2. Voltage Controlled Oscillator
3. Op-Amp Arithmetic Operations
4. Op-Amp Square, Ramp Generator and Wien Bridge Oscillator
5. Op-Amp Precision Full Wave Rectifier
6. Multiplexer and De-multiplexer
7. Regulated Power Supply using IC 723
8. UJT-Characteristics of Relaxation Oscillator
9. Logarithmic and Anti-logarithmic Amplifier
10. Phase Shift Oscillator
11. Astable and monostable Multivibrator using IC555
12. Combinational Logic Circuit Design
13. IC 555 timer – Schmitt Trigger
14. Wien’s Bridge oscillator using operational amplifier
15. Characteristics of Photo Diode, Photo Transistor, LDR, LED
16. Series and Parallel Resonant Circuits
17. Silicon Diode as a Temperature Sensor
18. RC Coupled CE amplifier – Two stages with feedback – Frequency response and voltage gain
20. Active filters – low pass and high pass-first and second order frequency response and roll off rate.

**Text Books**
1. Electronics Laboratory Manual, Department of Physics, NITT.

**Reference Books**

**Outcome:** The student will be able to understand the fundamental physics behind electronic circuits used in many modern devices through hands on experience.

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III SEMESTER

PH661 – SOLID STATE PHYSICS

Objective: Students will have an appreciation on the physics and properties of different types of materials such as conductors, semiconductors, dielectric, magnetic and superconducting.

Unit – I: Introduction

Unit – II: Conductors, Semiconductors and Dielectrics

Unit – III: Transport and Thermodynamic Studies

Unit – IV: Magnetism

Unit – V: Superconductivity

Text Books

Reference Books

Outcome: Grasping the significance of transport and thermodynamic properties of materials will enable students to understand the basics in physics of condensed matter.

PH663 – ATOMIC AND MOLECULAR SPECTROSCOPY

Objective: To understand in detail the structure of atoms and molecules.

Unit – I: Atomic Spectra

Unit – II: Atoms in External Fields and Resonance Spectroscopy

Unit – III: Microwave Spectroscopy and IR Spectroscopy

Unit – IV: Raman Spectroscopy
Raman effect – quantum theory of Raman effect – rotational Raman spectra – vibrational

**Unit – V: Electronic Spectroscopy**

**Text Books**

**Reference Books**

**Outcome:** The student will be able to gain sufficient knowledge on most common atomic and molecular spectroscopic methods and properties derived from them.

**PH 665 – NUCLEAR AND PARTICLE PHYSICS**

**Objectives:**
1. Introduce students to the fundamentals of nuclear and particle physics.
2. To understand the applications of nuclear and particle physics.

**Unit – I: Nuclear Properties and Forces**

**Unit – II: Nuclear Models**
Unit – III: Radioactivity

Unit – IV: Nuclear Reactions

Unit – V: Elementary Particles

Text Books

Reference Books

Outcome:
1. The students would have understood the fundamentals of nuclear and particle physics.
2. The role of nuclear and particle physics in applications such as radioactivity and nuclear reactions shall be understood.

PH667 – NUMERICAL AND COMPUTATIONAL METHODS

Objective: To introduce various numerical and computational techniques useful to handle complex problems.

Unit – I: Roots of Equations
Unit – II: Interpolation and Integration

Unit – III: Linear Algebra

Unit – IV: Ordinary Differential Equations

Unit – V: Advanced Methods

Text Books

Reference Books

Outcome: Students will be equipped with necessary numerical and computational techniques to handle various physical problems, where exact solutions are not possible.

PH669 – ADVANCED PHYSICS LABORATORY

Objective: To introduce the basic concepts of various advanced experimental techniques used in research through hands on experience.

List of Experiments
1. MATLAB-1: Matrix operations
2. MATLAB-2: Digital Signal Processing
3. MATLAB-3: Solving Ordinary Differential Equations
4. Microprocessor-1: Stepper Motor Interface
5. Microprocessor-2: Traffic Control
6. Microprocessor-3: Interfacing Display
7. Microprocessor-4: Interfacing with Voltmeter
8. Labview-1: Operational Amplifier Circuits
9. Labview-2: Simulation of Diode characteristics
10. Labview-3: Design of Op-Amp AC Characteristics
11. Labview-4: Construction of OPAMP
12. Labview-5: Design of 555 Timer Chip Astable Circuit
14. UV-Vis Spectrophotometer – Determination of absorption coefficient and bandgap
15. FTIR Spectrometer – Determination of vibration levels in a compound
16. Superconductivity – Determination of transition temperature
17. Contact Angle Measurement
18. G.M. Counter
19. Thin Film Deposition and Measurement of Electrical Conductivity
   – Four Probe Method
20. Ellipsometer – Determination of $n$ and $k$ of a material.

Reference Books

Outcome: The student will be able to understand the fundamental physics behind modern scientific equipment used in research through hands on experience.

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IV SEMESTER
PH662 – PROJECT WORK AND VIVA-VOCE

In this course, students are required to do a project work on a research problem and submit their findings as a report followed by a presentation in front of viva-voce committee.

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ELECTIVES

Odd Semester

PH611 – DIGITAL SIGNAL AND IMAGE PROCESSING

Objective: To introduce some signal processing concepts, algorithms and their application for data analysis, image analysis, signal detection and classification. To create a broad awareness of the set of available signal processing methods for specific real world problems.

Unit – I: Discrete Time Signal and Systems

Unit – II: Transform Analysis of Linear time Invariant systems

Unit – III: Filter Design Techniques and Fast Fourier Transform

Unit – IV: Continuous and Digital Image Characterization

**Unit – V: Linear Image Processing and Image Enhancement**


**Text Books**

**Reference Books**

**Outcome:** The student will be able to
1. identify, select and apply appropriate signal processing techniques to analyze signals for specific real-world applications and judge the image quality.
2. understand the advantages and limitations of advanced signal and image processing techniques for specific applications.
3. apply proper processing tools for a better quality of images.

**PH613 – BASICS OF ENGINEERING MATERIALS**

**Objectives:** This introductory course is aimed to obtain basic exposure to the concepts of crystalline solids, its imperfections and basics of various advance engineering materials finding wide spread application in several industries. Understanding these material systems are vital for investigating the defects and their nature on these class of materials.

**Unit – I: Structure of Metals**

Unit – II: Mechanical Behavior of Materials
Elements of elastic and plastic deformation – stress-strain relation-work hardening, recovery, re-crystallization and grain growth, types of fractures in materials and their identification - Mechanical testing of metals - Tensile, Hardness, Fatigue, Creep tests and their interpretation. Mechanical testing on composites – compression, tension, ILSS, flexural.

Unit – III: Steel and Heat Treatment of Steels
The Iron-carbon system - structural changes on slow and rapid cooling - martensitic transformation - concept of hardenability - TTT and CCT diagrams. Effects of carbon and alloying elements - Classification of steels.
Heat Treatment of Steels: Annealing (various types), normalizing, quenching and tempering - Case hardening, Austempering and martempering - Solidification of Metals and alloys - Nucleation and crystal growth from the liquid phase - Ingot structure dendrite freezing - Segregation effects and grain size control – strength mechanisms – solute, dispersion and precipitation hardening.

Unit – IV: Non-Ferrous Metals & Ceramics

Unit – V: Composites

Text Books

Reference Books

**Outcome:** Upon completion of the course, the student will be able to:
- Select different materials and emphasis the need of modern materials other than conventional metals and alloys for specific engineering applications.
- Understand the heat treatment of steels using TTT and CCT diagrams.
- Analyze the various metallurgical factors influencing the performance of materials for different structural engineering applications.
- Define various mechanical properties of materials and their importance in materials selection criteria.
- Classify different mechanical properties and how they can influence the materials behaviour with respect to applied load.

**PH671 – WAVEGUIDES AND MODERN OPTICS**

**Objective:** The course aims at to expose students to applications of electromagnetic theory concepts in developing wave guides for communication, optical applications. Advanced technologies such as optical image processing, non-linear optics are covered in modern optics for students learning latest technologies.

**Unit – I: Electromagnetic Fields and Waves**
Maxwell’s equations and boundary conditions – energy density and poynting vector – monochromatic filed and complex function formalism – wave equation and monochromatic plane waves – chromatic dispersion and group velocity.

**Unit – II: Guided Wave in Dielectric Slabs**

**Unit – III: Crystals Optics and Electromagnetic Propagation in Anisotropic Media**
Plane wave in homogeneous media and normal surface – orthogonality of normal modes (eigenmodes) – classification of media – the index ellipsoid – plane waves in uniaxially anisotropic media phase retardation.

**Unit – IV: Nonlinear Optics**
Unit – V: Fourier Optics

Text Books

Outcome: Student will be able to understand design concepts in optical wave guides as well as generation of stimulated lights, optical non-linear phenomena.

PH673 – SOLAR PHOTOVOLTAIC TECHNOLOGY

Objectives: To introduce the basic physics and technology of photovoltaic science and systems for solar energy harnessing.

Unit – I: The Sun Light

Unit – II: Semiconductors

Unit – III: Semiconductors for Solar Cell
Unit – IV: Characterization and Analysis

Unit – V: Design of Solar Cells

Text Books

Reference Books

Outcome: Students will be able to understand the science and technology of solar cells and its design. Students can also appreciate various material properties which are used in photovoltaic devices.

PH675 – ADVANCED ELECTROMAGNETIC THEORY

Objectives:
1. To introduce elementary ideas of plasma, method of solving inhomogeneous wave equation, basics of radiating source and field equations in different inertial frames.
2. To understand optical dispersion of radiation in a media.

Unit – I: Physics of Plasmas
Electrical neutrality in plasma – particle motion in electric field – Larmor radius – particle in crossed electric and magnetic fields – hydromagnetic equation – plasma oscillations and waves.
Unit – II: Optical Dispersion

Unit – III: Potentials and Fields
Maxwell’s equation – scalar and vector potentials – gauge invariance – Coulomb gauge and Lorentz gauge – solution of inhomogenous wave equation – retarded potentials.

Unit – IV: Radiating System
Radiation from an arbitrary source – special cases: oscillating dipole, accelerated point charge – radiation damping – Thomson cross section.

Unit – V: Special Theory of Relativity
Lorentz transformation and Einstein’s postulates – geometry of space-time – Lorentz transformation as orthogonal transformation – covariant form of electromagnetic equations – transformation laws for electromagnetic fields – field of a moving point charge.

Text Books

Reference Books

Outcome: Optical properties of a media, basics of antennas and relativistic nature of EM-field will be understood.

PH677 – FIBER OPTIC SENSORS

Objective: Fiber optics sensors are widely used and students are exposed to fundamentals, design principles, characteristics and applications of fiber optic sensors.

Unit – I
Unit – II

Unit – III

Unit – IV

Unit – IV

Reference Books

Outcome: Students will be able to propose new design of sensors for various applications.

PH679 – SENSORS AND TRANSDUCERS

Objective: To introduce the basic concepts and technology of modern sensors used in industrial applications and in scientific equipments.

Unit – I: Temperature Sensors
temperature sensors – interferometric sensors – thermochromic solution sensor – acoustic
temperature sensor – piezoelectric temperature sensors.

**Unit – II: Position and Displacement Detectors**
Ultrasonic sensors – microwave motion detectors – capacitive occupancy detectors – tribo
electric detectors – optoelectronic motion detectors – visible and near-infrared light motion
detectors – far-infrared motion detectors – potentiometric sensors – gravitational sensors –
capacitive sensors – inductive and magnetic sensors – LVDT and RVDT - eddy current
sensors – transverse inductive sensor – Hall effect sensors – magnetoactive sensors –
magnetostrictive detector – optical sensors – optical bridge-proximity detector with
polarized light – fiber optic sensors – radar sensors – thickness and level Sensors – liquid-
level sensors.

**Unit – III: Acceleration and Pressure Sensors**
Accelerometer characteristics – capacitive accelerometers – piezo-resistive accelerometers
– piezoelectric accelerometers – thermal accelerometers – heated plate accelerometer –
heated gas accelerometer – gyroscopes – rotor gyroscope - monolithic silicon gyroscopes –
optical gyroscopes – piezoelectric cables. Strain Gauges - tactile sensors – piezoelectric
force sensors – pressure gauges: mercury pressure sensor – bellows, membranes and thin
plates – piezo-resistive sensors – capacitive sensors – VRP Sensors – optoelectronic
sensors.

**Unit – IV: Flow, Acoustic and Humidity Sensors**
Basics of flow dynamics – pressure gradient technique – thermal transport sensors –
ultrasonic sensors – electromagnetic sensors – microflow sensors – breeze sensor – coriolis
mass flow sensors – drag force flow sensors. Acoustic sensors: resistive microphones –
condenser microphones – fiber optic microphone – piezoelectric microphones – electric
microphones – solid state acoustic detectors – humidity and moisture sensors – concept of
humidity – capacitive sensors – electrical conductivity sensors – thermal conductivity
sensor.

**Unit – V: Chemical Sensors and Smart Sensors**
Chemical sensor characteristics – classification of chemical-sensing mechanisms-direct
sensors – metal-oxide chemical sensors – chemfet – electrochemical sensors –
potentiometric sensors – conductometric sensors – amperometric sensors – enhanced
catalytic gas sensors – thermal sensors – optical chemical sensors – biochemical sensors –
enzyme sensors – smart sensors – MEMS sensors – nano sensors.

**Text Books**
2. Jacob Fraden, Handbook of Modern Sensors: Physics, Design, and Application, 3rd

**Reference Books**

**Outcome:** Students will be able to understand many modern devices and technologies used in sensors. Student can also appreciate various material properties which are used in engineering applications and devices.

**PH681 – PHYSICS AND TECHNOLOGY OF THIN FILMS**

**Objective:** To cater the post graduate students about fundamental and applications of thin films.

**Unit – I: Preparation of Thin-films**

**Unit – II: Kinetics of Thin films**
Nucleation Kinetics: types of nucleation – kinetic theory of nucleation – energy formation of a nucleus – critical nucleation parameters; spherical and non spherical (cap, disc and cubic shaped). Growth Kinetics: Kinetics of binary (GaAs, InP, etc.), ternary (Al$_{1-x}$Ga$_x$As, Ga$_{1-x}$In$_x$P, InAs$_{1-x}$P$_x$, etc.) and quaternary (Ga$_{1-x}$In$_x$As$_{1-y}$P$_y$, etc.) semiconductors – derivation of growth rate and composition expressions.

**Unit – III: Characterization**

**Unit – IV: Properties of Thin films**
Dielectric properties – experimental technique for the determination of dielectric properties – optical properties – experimental technique for the determination of optical constants – mechanical properties – experimental technique for the determination of mechanical properties of thin films – magnetic and superconducting properties.

**Unit – V: Applications**
Text Books

Reference Books

Outcome: Students are moulded to do high level research in thrust areas like LEDs, Laser, solar cells, storage devices etc.

PH683 – MAGNETISM AND SUPERCONDUCTING LEVITATION

Objective: To understand the magnetic behaviour of superconducting materials. To learn the fundamentals of magnetism, superconductivity and materials used for superconducting levitation applications.

Unit – I: Fundamentals of Magnetism

Unit – II: Types of Magnetism

Unit – III: Magnetic Phenomena

Unit – IV: Superconducting Materials
Superconductivity basics – physical properties below Tc – duration of persistent currents – Magnetic field effects on superconductors – high Tc Superconductors – cuprate superconductors – wires and tapes – MgB₂ – iron and carbon based superconductors – superconducting magnets.

Unit – V: Superconducting Levitation
Text Books

Reference Books

Outcome: The fundamentals of magnetism, superconductivity and superconducting materials shall be understood. Student will acquire basic knowledge on science and technology of superconducting levitation.

PH685 – MICRO-ELECTRO-MECHANICAL SYSTEMS

Objective: To introduce the basic concepts of Micro-system and micro-sensors and their applications in modern scientific equipments and industrial products.

Unit – I: Introduction

Unit – II: Bulk micro machining

Unit – III: Surface micro machining
Introduction – sacrificial layer technology – material systems in sacrificial layer technology – plasma etching – combined IC technology and anisotropic wet etching.

Unit – IV: Microstereolithography

Unit – V: MEMS Devices
Electronic interfaces – design, simulation and layout of MEMS devices using CAD tools.

Text Books
Reference Books

Outcome: The student will be able to understand the fundamentals of various technologies involved in the fabrication of mems sensor, which are used in many common applications.

Even Semester

PH610 – ELECTRICAL, MAGNETIC AND OPTOELECTRONIC MATERIALS

Objectives: To understand the fundamentals of electrical, magnetic and optical properties of materials for various applications.

Unit – I: Electrical and Dielectric Materials
Review of electrical conduction – discussion on specific materials used as conductors (OFHC, Ag, Al, other alloys) – temperature dependent resistivity of Copper and CuNi alloy – Nordheim rule – CuAu alloy – dielectric phenomena – concept of polarization – effects of composition, frequency and temperature on these properties – discussion on specific materials used as dielectrics (ceramics and polymers) – BaTiO3 – dielectric loss, dielectric breakdown – ferro electricity – piezo and pyro electricity.

Unit – II: Magnetic Materials

Unit – III: Superconducting and Semiconducting Materials

Unit – IV: Production of Electronic Materials
Binary alloy phase diagram (PbSn and CuNi) – homogeneous and heterogeneous nucleation – methods of crystal growth for bulk single crystals – Czochralski – Bridgman – low and high temperature solution growth – floating zone method – synthesis of epitaxial
films by LPE, VPE, PVD, MBE and MOCVD techniques – lithography – production of silicon – applications.

**Unit – V: Optical and Optoelectronic Materials**

**Text Books**

**Reference Books**

**Outcome:** The students would have obtained knowledge about the electrical, magnetic and optoelectronic materials, their properties and applications.

**PH672 – MICROPROCESSORS**

**Objective:** To impart the basic knowledge on 8085 processor and its applications and gain an overview on its peripheral devices and its advancements

**UNIT – I**
Basic components of a digital computer – CPU-ALU – timing and control unit memory – bus architecture – I/O devices – 8085 microprocessor architecture, various registers, stacks

**UNIT – II**
UNIT – III
Interrupt structure in 8085 – hardware and software interrupt, I/O Ports – DMA principles – Serial I/O: Basic concepts, asynchronous and synchronous communication.

UNIT – IV

UNIT – V

Text Books

Reference Books

PH674 – COMPUTER APPLICATIONS IN PHYSICS

Objective: To introduce Programming tools in C language, MATLAB and LABView.

Unit – I: C programming

Unit – II: Introduction to MATLAB
Unit – III: Applications of MATLAB

Unit – IV: Introduction to LABVIEW
Introduction to LABVIEW tools palette, controls & functions palette, data types, conversion – front panel, block diagram construction, parallel data flow, create indicators/controls/constants math operations, booleans, arrays, case structures, sequences – for loops, while loops – I/O reading and writing to files, paths, graphing, timed loops, signal generation/processing, waveform types, connecting to hardware, DAQ, serial, GPIB, TCP/IP and USB interface

Unit – V: Computational Techniques

Text Books

Reference Books
2. Ross L. Spencer and Michael Ware, Introduction to MATLAB, Brigham Young University (2010).

Outcome: Students will be familiarized with computational tools available in MATLAB and LABView and COMSOL for simulating variety of physical problems.

PH676 – NON-DESTRUCTIVE TESTING

Objective: It is one of the applied physics subjects and conventional NDT techniques are widely practiced in industries.
Unit – I: Liquid Penetrant Testing

Unit – II: Ultrasonic Testing

Unit – III: Radiography

Unit – IV: Eddy Current
Generation of eddy currents – effect of created fields – effect of change of impedance on instrumentation – properties of eddy currents – eddy current sensing elements, probes, type of arrangement – a) absolute b) differential lift off, operation, applications, advantages, limitations – through encircling or around coils – type of arrangements a) absolute b) differential fill factor, operation, application, advantages, limitations.

Unit – V: Advanced NDT

Reference Books
**Outcome:** Students are taught working principles of different NDT methods and exposed to instrumentation.

**PH678 – LASERS AND APPLICATIONS**

**Objective:** To introduce basics and usage of laser in science and industry.

**Unit – I: Properties and Types of Lasers**

**Unit – II: Holography**

**Unit – III: Fibre Optics**

**Unit – IV: Lasers in Science**

**Unit – V: Lasers in Industry**

**Text Books**

**Reference Books**

**Outcome:** Students will understand wide applications of lasers in opto-electronic, non destructive testing, materials processing industry and its potential use as a scientific tool.
PH680 – ADVANCED STATISTICAL METHODS AND PHASE TRANSITION

Objectives:
1. To introduce the statistical methods and numerical tools needed to solve phase transitions of various kinds.
2. To learn the methods of constructing model systems and finding analytical solutions to these models to understand the phase transitions and critical phenomena around these transition points.

Unit – I: Probability and Random Process

Unit – II: Phase Transition Theories
Examples of first order and continuous phase transitions – mean field (van der Waals and Weiss molecular field) theories – fluid-magnet analogy – correlations – classical (Ornstein-Zernicke) theory.

Unit – III: Statistical Mechanical Models

Unit – IV: Critical Phenomena

Unit – V: Renormalization Group Theory
Elements of re-normalization group approach to continuous phase transitions – flows in parameter space, fixed points, epsilon expansion, real-space re-normalization – connection with Euclidean field theories – elementary ideas on percolation.

Text Books

Reference Books

**Outcome:** Students will gain confidence to pursue research careers in any areas of theoretical condensed matter physics.

**PH682 – SEMICONDUCTOR PHYSICS**

**Objective:** To introduce the basic properties of semiconductors and modern devices based on semiconductor materials.

**Unit – I: Properties of Semiconductors**

**Unit – II: Carrier Transport Phenomena**

**Unit – III: Nonequilibrium Excess Carriers**

**Unit – IV: The p-n Junction**

**Unit – V: Semiconductor Devices**

**Text Books**
References Books

Outcome: Students will be able to understand and appreciate the functionality of modern semiconductor devices.

PH684 – NANOSCIENCE AND TECHNOLOGY & APPLICATIONS

Objective: To impart the basic knowledge on nanoscience and technology which includes the exotic properties of materials at nanoscale, various techniques available for the processing and characterization of nanostructured materials, applications in selected fields such as magnetic recording technology, electronics and biomedical field

Unit – I: Nanomaterials and Structures

Unit – II: Characterization Tools

Unit – III: Nanomagnetism
Mesoscopic magnetism – magnetic measurements: miniature Hall detectors, integrated DC SQUID Microsusceptometry – magnetic recording technology, biological magnets.

Unit – IV: Nanoelectronics and Integrated Systems

Unit – V: Biomedical Applications of Nanotechnology

Text Books
Reference Books

Outcome: On successful completion of this course, students would be able to
1. describe important experimental tools in the fields of nano-science
2. understand the quantum mechanical tunnelling of electrons, oscillatory coupling GMR effect and related applications in devices and MEMs
3. familiarize with the applications of nano-technology in magnetic recording, quantum computation, drug delivery, nanofluidics and biological devices.