Faculty of Science

Department of Physics

Proposed Syllabus

For

M.Sc. in Physics

From Academic Year 2020-2021
PREAMBLE
Physics, a core discipline, is the fundamental and foremost to all natural sciences. It has been significant and influential through advances in its understanding that have translated into new technologies. Physics interact with the society and other discipline such as Medicine, Chemistry, Agriculture, Engineering etc. in many important ways. Physics department in Tuljaram Chatur Chand College has highly qualified faculty members and support staffs and is committed towards the development of innovative and handy ways of teaching at graduate, post graduate and developing a core research group for carrying out cutting edge research in various research fields like Condensed Matter Physics, Solid State Physics, Electronics, Theoretical Physics, Atomic & Molecular Physics and Nuclear Physics. The department also offers Doctoral Programme in order to nurture young minds towards embracing various scientific challenges. Extra care is taken to pay individual attention to the students in their laboratory work and tutorial sessions. Project work and problem sessions are encouraged to develop innovative and analytical approach to physics learning.

GOALS
The goal of the Physics education is to provide the student with a broad understanding of the physical principles of the universe, to help them develop critical thinking and quantitative reasoning skills, to empower them to think creatively and critically about scientific problems and experiments. It’s provide training for students and planning careers in physics including research, teaching, industrial jobs, government jobs or other sectors of our society.

OBJECTIVES
1. To endow with a conducive and friendly environment that nurtures excellence and high standards of professionalism in teaching, learning and research.
2. To augment the level of participation in research, dissemination and preservation of knowledge for both academic and social development.
3. Prepare the student in assets of Physics and the principles of analytical methods required for the conclusion of physical tests.
4. Provide an opportunity for students to deepen his/her knowledge in the branches of Physics so that views on the outskirts of contemporary science.
5. Training the students on the way of scientific research and enable it to contribute to it under the supervision.
6. Continued development of faculty members by sending them for training courses so as to maintain a high degree of efficiency and performance.
7. Support and encourage the scientific cooperation between faculty members in the department and co-operation with other departments in the field of multi-purpose research.
8. Spread the spirit of competition and encouragement and give the opportunity to all members.
9. Preparation of national cadres by basic physics and knowledge that contribute to community service.
10. To establishes collaborations with other eminent institution.

Proposed Structure of M.Sc. degree in Physics and syllabus for first year degree in Physics as follows:
## M.Sc. II Course Structure
### Semester-III

<table>
<thead>
<tr>
<th>Course Number</th>
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<td>A) Physics of thin films-I</td>
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<td>B) Nano-technology-I</td>
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<td>D) Microcontroller– I</td>
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### Semester-IV

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<td><strong>Total Credit</strong></td>
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Unit 1: Statistical Description and Thermodynamics of Particles (15L)
Revision of laws of thermodynamics, statistical ensemble, postulates of equal a priori probability, behavior of density of states, Liouville’s theorem (classical), Equilibrium conditions and constraints, Distribution of energy between systems in equilibrium, Approach to thermal equilibrium, Sharpness of the probability distribution, Dependence of the density of states on the external parameters, Equilibrium between interacting systems, Thermodynamical laws and basic statistical relations (Revision)

Unit 2: Classical Statistical Mechanics: (15L)
Micro-canonical ensemble, System in contact with heat reservoir, Canonical ensemble, Applications of canonical ensembles (Paramagnetism, Molecule in an ideal gas, Law of atmosphere), System with specified mean energy, Calculation of mean values and fluctuations in a canonical ensemble, Connection with thermodynamics, Grand-canonical ensemble, Chemical potential in the equilibrium state, Mean values and fluctuations in grand canonical ensemble, Thermodynamic functions in terms of the Grand partition function

Unit 3: Applications of Statistical Mechanics and Quantum Distribution (15L)
Calculations of thermodynamic quantities, Ideal monoatomic gas, Gibbs paradox, Equipartition theorem and its Simple applications. i) Mean kinetic energy of a molecule in a gas ii) Brownian motion iii) Harmonic Oscillator iv) Specific heat of solid, Maxwell velocity distribution, Related distributions and mean values Symmetry of wave functions, Quantum distribution functions, Boltzmann limit of Boson and Fermions gases, Maxwell Boltzman statistics, B-E statistics, F-D statistics, Evaluation of the partition function, Partition function for diatomic molecules, Equation of state for an ideal gas, quantum mechanical paramagnetic susceptibility

Unit 4: Ideal Bose and Fermi Systems: (15L)

Reference books:
1. Fundamentals of Statistical and Thermal Physics, - F. Reif,
2. Fundamentals of Statistical Mechanics, B.B. Laud, New Age International Publication
4. Statistical Mechanics, K. Huang, John Willey and Sons (2nd Edition)
6. Statistical Mechanics by Loknathan and Gambhir
Unit 1: Band Theory of Solids (15L)

Introduction, Nearly free electron model, DC and AC electrical conductivity of metals, Bloch theorem (with proof), Kronig-Penney model, Motion of electron in 1-D according to band theory, Distinction between metals, insulators and intrinsic semiconductors, Reduced, periodic & extended zone schemes, Cyclotron resonance, Quantization of electronic orbit in a magnetic field.


Unit 2: Diamagnetism and Paramagnetism (15L)

Introduction, Classical theory of diamagnetism, Langevin theory of Paramagnetism, Quantum theory of Paramagnetism, Paramagnetic susceptibility of conduction electron, Magnetic properties of rare earth ions & iron group ions with graphical representation, Crystal field splitting, Quenching of orbital angular momentum.

Unit 3: Ferromagnetism, Antiferromagnetism and Ferrimagnetism (15L)

Introduction, Ferromagnetism: Wiess theory, Curie point, Exchange integral, saturation magnetization and its temperature dependence, Saturation magnetization at absolute zero, ferromagnetic domains, Anisotropy energy, Bloch wall, Quantum theory of ferromagnetism Magnetic resonance, Nuclear magnetic resonance (NMR), The resonance condition, Antiferromagnetism: Neel temperature, Ferrimagnetism: Curie temperature, susceptibility of ferrimagnets.

Unit 4: Carbon based materials (15L)

Allotropes of carbon: Diamond, Graphite, Graphene, Amorphous carbon, Glassy carbon
Carbon nanostructure: Fullerenes, Carbon Nanotube (CNTs), Carbon Nanofiber (CNFs), Graphene
Synthesis methods of graphene oxide: Original Hummers method, modified Hummers method
Graphene oxide reduction: Thermal reduction mechanism, Thermal reduction in various atmospheres
Graphene: Applications
Reference Books:

1. Introduction to solid states Physics - Charles, Kittle 7th Edition
2. Introductory Solid States Physics – H. P. Myers
7. Solid states Physics – Wahab
10. Solid States Physics – C.M.Kacchawa
11. Wet Chemical Synthesis of Graphene for Battery Applications - Ida Johansen
M. Sc-II (Physics) Semester-III

CB Group –I: 1. PHY 5303: PHYSICS OF THIN FILM-I

Credit: 04 Total No. of Lectures: 60

Unit 1: Introduction to thin films

Unit 2: Deposition Techniques and Measurement of thickness

Unit 3: Properties of thin films

Unit 4: Applications of Thin Films
   Resistors, capacitors, Junction devices (Metal semiconductor junction) Solar cells, ICs, Optical coating, Thin film sensors (gas and humidity), Thin films for information storage, electroacoustics and telecommunication.

Reference books:
5. Vacuum Technology (2nd revised edition), A. Roth, (North Hollad)
Unit 1: Science at Nano scale (15L)

Nano and Nature: Nanoscopic colours (Butterfly wings), Bioluminescence (fireflies), Tribology (Gecko’s Sticky Feet, Nasturtium Leaf-Lotus effect etc) in nature.

Classification of nano materials:
0D,1D,2D and 3D and types of nano materials (QDs, QW, CNT’s, Bucky Balls, Nano composites etc)

Nano science:
Quantum mechanics, Brownian motion, surface forces, surface to volume ratio

Making of nanostructures:
Top down Overview of top down nano fabrication processes. Mechanical grinding (ball milling)

Making of nano structures:
Bottom up, overview of bottom up nanofabrication processes Solid state phase synthesis

Unit 2: Physical Properties of Nano materials (15L)

Surface Properties:
Surface energy – chemical potential as a function of surface curvature-Electrostatic stabilization- surface charge density-electric potential at the proximity of solid surface-Van der Waals attraction potential

Mechanical properties
Melting point and lattice constants, Electrical conductivity (Surface scattering, Change of electronic structure, quantum transport).

Magnetic properties of Nano materials
Origin of magnetism in materials, Classification into Dia-, Para- and Ferro-magnetic materials, Hysteresis in ferromagnetic materials, domains, soft and hard magnetic materials, Coercivity vs particle size

Unit 3: Nano structured materials (15L)

Nano ceramics:
Dielectrics, ferroelectrics and magneto ceramics, Magnetic properties

Nano polymers:
Preparation and characterization of di block Copolymer based Nano composites, Nanoparticles polymer ensembles; Applications of Nano polymers

Nano composites:
Metal-Metal nano composites, Polymer-Metal nano composites, Ceramic nano composites
Special Nano materials:

- Graphene, Carbon nano tubes and Types (CNT), Fullerenes, Aerogels, Core Shell Nanostructures

Unit 4: Synthesis techniques of Nano materials   (15L)

Physical methods:


Chemical Methods:

- 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.

Reference books:

M. Sc-II (Physics) Semester-III  
CB Group –I: 3. PHY 5303: BIOMEDICAL INSTRUMENTATION-I

Credit: 04                                                        Total No. of Lectures: 60
Unit 1: Fundamentals to Biomedical Instrumentation and patient safety (15L)
1.1 Basic medical instrumentation system.
1.2 System configuration
1.3 basic characteristics of measuring system
1.4 Problems faced when measuring a human body
1.5 Essentials of biomedical instrumentation.
1.6 Electric shock hazards-Gross shock-Micro current shock
1.7 Precautions to minimize electric shock hazards

Unit 2: Electrodes and physiological transducers: (15L)
3.1 Electrode Theory
3.2 Biopotential Electrodes
3.3 Electrodes for ECG, EEG, EMG.
3.4 Introduction to physiological transducers
3.5 Classification of Transducer
3.6 Performance characteristic of transducer.
3.7 Displacement, position and motion transducer.
3.8 Pressure transducer
3.9 Transducer for Body temperature measurement
3.10 Biosensors

Unit 3: Recording Systems and Signal Analysis: (15L)
3.1 Basic recording system.
3.2 General consideration for signal conditioners
3.3 Pre amplifiers, Differential, Instrumentation, Isolation amplifier.
3.4 Source of noise in low level measurement.
3.5 Biomedical signal analysis techniques
3.6 Fourier Transform, FFT and Wavelet Transform
3.7 Signal processing techniques.

Unit 4: Cardiovascular System and Measurements: (15L)
4.1 The Heart.
4.2 The Heart and Cardiovascular system
4.3 Blood Pressure
4.4 Heart Sounds.
4.5 Block diagram of electrocardiograph
4.6 The ECG leads
4.7 Effect of Artifacts on ECG recording
4.8 Introduction to pacemakers
4.9 Types of pacemakers
4.10 Need for pacemakers
4.11 Pacemaker system and its functioning

Reference Books:
1. Biomedical Instrumentation and Measurements (Second edition)  
   By Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer Pearson education.
2. Handbook of Biomedical Instrumentation (Second Edition) by R. S. Khandpur (Tata  
After successful completion of this course the students will be able to-
- Understand the principles and functions of different instruments.
- Use different instruments for measurement of various parameters.
- Design experiments using sensors.

**Unit 1: General Background and Measurements**

1. General configuration and functional description of measuring instruments with examples of instruments and their functional description. (Ref.1: #2.1 to 2.4).
2. Input output configuration of measuring instruments, and methods of correction of unwanted inputs. (Ref.1: #2.5)
3. Qualities of measurements (Ref.9 Ch# 1)
   I] Static characteristics II] Dynamic characteristics: Generalized mathematical model of measurement System, III] Order of instruments: zero, first and second order. (Ref.1: #3.3 94 to 115 & 123 to131)
4. Errors in measurement, Types of errors, sources of errors (Ref.9)

**References:** 1, 3, 9

**Unit 2: Transducers**

1. Displacement Measurement: a) Resistive Transducers (variable resistance, Strain gauges, Electrical strain gauges), b) Inductive transducers (LVDT, variable reluctance ), c) Capacitive transducers
2. Pressure Measurement: a) Non-Elastic pressure transducers (Barometer, Manometer)  
   b) Elastic pressure transducers (Diaphragm, Bellows, Bourdon gauge), c) Electrical pressure transducers (Piezoelectric transducer)
3. Temperature Measurement: a) Electrical Method (RTD, Platinum resistance thermometer, Thermistor), b) Thermocouple EMF measuring Circuit, c) Non-contact Type (Semiconductor temperature sensors, Radiation pyrometers)

**References:** 9

**Unit 3: Signal Conditioners, Data acquisition and conversion**

1. Signal conditioners: Op-amps, instrument amplifier, bridge, phase sensitive detector
2. Data Acquisition System (DAS): DAS, hardware, Single channel DAS, Multi channel DAS
3. Data Converters: D to A and A to D converters, Data loggers

**References:** 9

**Unit 4: Indicators, Display system and Oscilloscope**

1. Digital display system and Indicators
2. Classification of Displays
3. Light Emitting Diodes (LED)
4. Liquid Crystal Display (LCD)
5. Printers: principle of Laser printers
6. Cathode Ray Oscilloscope (CRO)
7. Cathode Ray Tube (CRT)
4.8 Digital Storage Oscilloscope (DSO)

**References:** 9

**Reference Books:**

2. Measurement system – applications and design by E.O. Doblin and Manik.
3. Instrumentation, measurement and systems. Nakra and Chaudhary.
4. Electronic Instrumentation and measurement techniques by A.D. Helfrick and W. D. Cooper. (Pearson.)
5. Instrumentation, devices and systems. Rangan, Mani and Sarma Prentice Hall of India. 186.
M. Sc-II (Physics) Semester-III
CB Group –II: 2. PHY 5304: LASER-I

Credit: 04                                     Total No. of Lectures: 60

Unit 1: Basic of Lasers                     (15L)
Introduction, Historical background of laser, Einstein coefficients and stimulated light amplification, population inversion, Creation of population inversion in three level & four level lasers, Problem Solving.

Unit 2: Types of Lasers Systems            (15L)

Unit 3: Laser Beam Propagation             (15L)
Introduction, Laser beam propagation, properties of Gaussian beam, resonator, stability, various types of resonators, resonator for high gain and high energy lasers, Gaussian beam focusing.

Unit 4: Detection and some applications of laser (15L)
Detection of optical radiation: Human eye, thermal detector (bolometer, pyro-electric), photon detector (photoconductive detector, photo voltaic detector and photoemissive detector), p-i-n photodiode, APD photodiode
Holography:Importance of coherence, Principle of holography and characteristics, Recording and reconstruction, classification of hologram and application, non-destructivetesting, injection laser diode (double heterostructure , distributed feedback)

Reference Book:
1. Principles of lasers- O Svelto
2. Solid State Laser Engineering- W Koechner
3. Laser- B A Labgyel
4. Gas laser- A J Boom
7. Handbook of Nonlinear Optics- R L Sautherland
8. Laser and electro optics- C C Davis
9. Fibre optic communication- Joseph C Palais
10. Fundamentals of light sources and lasers – Mark csele
Unit 1: Energy and Thermodynamics


Unit 2: Solar Energy for Clean Environment


Unit 3: Wind Energy

Origin and classification of winds, Aerodynamics of windmill: Maximum power, and Forces on the Blades and thrust on turbines; Wind data collection and field estimation of wind energy, Site selection, Basic components of wind mill, Types of wind mill, Wind energy farm, Hybrid wind energy systems: wind + PV; The present Indian Scenario. Concept of wind form & project cycle, Cost economics & viability of wind farm

Unit 4: Biomass Energy and Biogas Technology

Importance of biogas technology, Different Types of Biogas Plants, Aerobic and anaerobic bioconversion processes, various substrates used to produce Biogas (cow dung, human and other agricultural waste, municipal waste etc.) Individual and community biogas operated engines and their use. Removal of CO₂ and H₂O, Application of Biogas in domestic, industry and vehicles, Bio-hydrogen production, Isolation of methane from Biogas and packing and its utilization

Reference Books
6. Advances in Energy systems and technology- Peter Auer.
M. Sc-II (Physics) Semester-III
CB Group –II: 4. PHY 5304: MICROCONTROLLER– I

Credit: 04                                                                 Total No. of Lectures: 60

Unit 1: ARCHITECTURE OF 8051: [10L]
Comparison of Microprocessor and Microcontroller, Overview of the 8051 family, Blockdiagram of Microcontroller, Functions of each block, Pin details of 8051, A and B CPU registers, Flags and Program status word (PSW), Program Counter and Data Pointer, PSW register, Memory Organization of 8051, Internal RAM, Stack and Stack Pointer, Special function registers, Internal ROM, I/O Ports, Oscillator and Clock

Unit 2: 8051 ASSEMBLY LANGUAGE PROGRAMMING: [10L]
Introduction to 8051 Assembly programming, Assembling and running an 8051 program, 8051 data types and directives, Intel hex file, Jump, loop, and call instructions, 8051 I/O Programming, Addressing modes

Unit 3: ARITHMETIC & LOGIC INSTRUCTIONS AND PROGRAMS: [10L]
Arithmetic instructions, Signed number concepts and arithmetic operations, Logic AndCompare instructions, Rotate instruction, BCD, ASCII, and other application programs.

Unit 4: TIMER AND INTERRUPTS PROGRAMMING IN ASSEMBLY/C: [10L]
Timers. Programming 8051 timers, counter programming, Programming timers 0 and 1 in8051, 8051 interrupts, Interrupt priority in the 8051

Unit 5: SERIAL COMMUNICATION: [10L]
Basics of Serial programming, RS 232 Standards, 8051 connection to RS 232, 8051 SerialCommunication Programming.

Unit 6: INTERFACING TECHNIQUES [10L]
LCD and Keyboard interfacing, ADC, DAC, and sensor interfacing (LM35)

Reference Books:
1. 8051 Microcontroller by Kenneth J.Ayala.
4. Programming customizing the 8051 Microcontroller by MykePredko, Tata McGraw Hill
M. Sc-II (Physics) Semester-IV
PHY 5401: NUCLEAR AND PARTICLE PHYSICS
Credit: 04 Total No. of Lectures: 60

Unit 1: General Properties and concepts of Nuclei

Unit 2: Radiation Detectors and Nuclear Models
(15L) Detectors: NaI(Tl) Scintillation Detector, Si(Li) and Ge(Li) Detectors, High Purity Germanium Detector, Bubble Chamber, Cloud Chamber, Spark Chamber, Nuclear Models: Liquid drop model and empirical mass formula, Shell Model with details of magic numbers, Predictions of the Shell Model, Achievements & Failures of shell Model, Fermi Gas Model, Collective Model.

Unit 3: Reaction Dynamics, Nuclear Reactors and Accelerators

Unit 4: Elementary Particle Physics
(15L) Classification of Elementary Particles and their Quantum Numbers (Charge, Spin, Parity, Iso-Spin, Strangeness, Baryon number, Hypercharge etc.), conservation laws, Classification of Quarks, Their masses and spins, Quark contents of particles, CPT invariances, Parity non conservation in weak interactions, Gell-Mann-Nishijima formula.

Reference Books:
5. S.N.Ghoshal, Atomic and Nuclear Physics, S.Chand.
6. E.Segre, Nuclei and Particles
11. Frauenfelder and Henley, Subatomic Physics, Prentice Hall.
Unit 1: Properties of Materials and Defects in Solids (15L)
(a) Mechanical, electrical, magnetic, thermal and structural properties (in brief – 2L only)
(b) **Point defects** - Vacancies, interstitials, non-stoichiometry, substitution, Schottky and Frenkel defects with proofs
(c) **Line defects** - Edge and screw dislocations, properties of dislocations – force on dislocation, energy of dislocation, pinned dislocation (These properties with derivation), dislocation density, interaction between dislocations, motion of a dislocation (cross-slip and climb), dislocation generator (Frank Read source)
(d) **Surface defects** – grain boundaries with explanation of high angle, low angle, tilt and twist boundaries, stacking fault
(e) **Volume defect**- twin boundary
(f) **Solid Solution** - Types of solid solutions (Substitutional and Interstitial), Factors governing solid solubility (Hume - Rothery rule), Atomic size and size factor in solid solutions, Vegard’s law

Unit 2: Diffusion in Solids (15L)
Introduction, types of diffusion, Diffusion mechanism, Fick’s first and second laws of diffusion, solution to Fick’s second law (without proof, introduction of error function), Factors governing diffusion, Factors affecting diffusion coefficient (D), Experimental determination of D, Diffusion in oxides and ionic crystals, Applications of diffusion: Corrosion resistance of duralumin, Decarburization of steel, Doping of semiconductors

Unit 3: Metallurgical Thermodynamics (15L)
Revision of laws of thermodynamics, Auxiliary thermodynamic functions, measurement of changes in enthalpy and entropy, Richard’s rule, Trouton’s rule, Chemical reaction equilibrium, Thermodynamic properties of solutions (mixing processes – Rault’s law, activity coefficient; regular solution behavior – Henry’s law), Gibb’s phase rule: proof, explanation and application to single component (H2O) and binary phase diagram

Unit 4: Alloy systems, Phase diagrams and Phase transformations (15L)
**Alloy:** Introduction, Alloy systems, Families of engineering alloys
**Phase diagrams:** Thermodynamic origin of phase diagrams, Lever rule, Type I (Cu-Ni) phase diagram, Type II (explanation only) phase diagram, Type III (Pb-Sn) phase diagram, Maxima and
minima in two-phase regions, Miscibilitygaps, Topology of binary phase diagrams (Explanation in short of eutectic, peritectic, Monotectic, eutectoid, peritectoid, syntactic reaction, extension rule), Applications of phase diagrams

**Phase transformation**: Introduction, Mechanism of Phase Transformation, The kinetics of Solid state reaction, Nucleation and Growth, Applications of phase transformations

**Reference books:**

2. Materials Science and Engineering - V. Raghvan
4. Introduction to Materials Science for Engineers (6th edition) - J.F.Shaekel ford and M.K.Murlidhara - Pearson Education
5. Materials Science – Kodgire and Kodgire
6. Materials Science – S L Kakani, AmitKakani
M. Sc-II (Physics) Semester-IV
CB Group –III: 1. PHY 5403: PHYSICS OF THIN FILM-II

Credit: 04 Total No. of Lectures: 60

Unit 1: Radiation Sources, Detectors and Sensors(15L)

Sources of Electromagnetic Radiations: Different types of radiations (x-rays, rays, UV-VIS, IR, microwaves and nuclear) and their sources
Detectors: $\gamma$-rays, X-rays, UV-VIS, IR, microwaves and nuclear detectors
Sensors: Sensor’s characteristics, Classification of sensors, Operation principles of sensors such as electric, dielectric, acoustic, thermal, optical, mechanical, pressure, IR, UV, gas and humidity with examples

Unit 2: Structural Characterization and Thermal Analysis (15L)

X-ray Diffraction – Production of X-rays, Types (continuous and characteristics), Bragg’s diffraction condition, principle, instrumentation (with filters) and working. Techniques used for XRD – Laue’s method, Rotating crystal method, Powder (Debye Scherrer) method, Derivation of Scherrer formula for size determination
Neutron Diffraction: Principle, Instrumentation and Working
Thermal analysis: Principle, Instrumentation and Working: Thermo-gravimetric (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC), Graphical analysis affecting various factors, Numericals

Unit 3: Morphological and Magnetic Characterization (15L)

Optical Microscopy: Principle, Instrumentation and Working of optical microscope
Probe Microscopy: Principle, Instrumentation and Working of Scanning Tunneling Microscope (STM) and Atomic Force Microscope (AFM)

Unit 4: Spectroscopic Analysis (15L)

Spectroscopic characterization (principle, instrumentation and working): InfraRed (IR), Fourier Transform Infra-Red (FTIR), Ultraviolet-Visible (UV-VIS), Diffused Reflectance
Spectroscopy (DRS), X-ray Absorption (XPS), Electron Spin Resonance (ESR), Nuclear Magnetic Resonance (NMR). Numericals.

**Reference Books:**

Unit 1: Optical and electrical Properties of Nano materials

Electronic Properties of Nano materials
- Electronic Structure of Nanoparticles, Zero dimensional, one-dimensional and two-dimensional nanostructures, Fundamentals of electrical conductivity in nano tubes and nano rods, carbon nano tubes, Photo conductivity of nano rods, electrical conductivity of nano composites

Optical properties of Nano materials
- Absorption: direct and in direct band gap transitions, Emission: photoluminescence and Raman scattering,
- Emission: chemiluminescence and electroluminescence, shape dependent optical properties

Unit 2: Nano structured Applications

Solar cells:
- Generations of Solar cells, Dye sensitized solar cells, Advantages and disadvantages, Quantum dot sensitized solar cells, Perovskite solar cells

Batteries and Supercapacitors:
- Basics of electrochemical cell, Primary batteries, Rechargeable batteries, Battery parameters (Battery capacity, Battery voltage, Battery life cycle, Discharge/charge rate), 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, Pseudo capacitance, Origin, Kinetic theory, Regon plot, Energy density and Power density, Various oxides as pseudocapacitors.

Fuel cell –
- Principle, construction, types and applications

Unit 3: Characterizations of Thin Films

Thickness Measurement Methods: Weight Difference Method

Characterization Methods: X-ray diffraction (XRD), Scanning Electron Microscopy (SEM) and Energy, Field emission scanning electron microscopy (FESEM), Transmission electron microscopy (TEM), dispersive analysis of X-rays (EDAX), UV-VIS spectroscopy, X-ray photoelectron spectroscopy (XPS), Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM)

Unit 4: Nano toxicology and Bio safety
Introduction, source of nanoparticles, epidemiological evidences, entry routes for nanoparticles in human body: lungs, intestinal tract and skin

**Mechanisms of nano material toxicity:** oxidative stress, eco toxicity, genotoxicity, hemolytic toxicity, mutagenicity and immunotoxicity

**References:**

2. Handbook of Nanotoxicology, Nanomedicine and Stem Cell Use in Toxicology. Saura C Sahu, Daniel A Casciano.
4. Biointeractions of Nanomaterials. Vijaykumar B. Sutariya, Yashwant Pathak
CB Group – III: 3. PHY 5403: BIOMEDICAL INSTRUMENTATION-II

Credit: 04  Total No. of Lectures: 60

Unit 1: Fundamentals to Biomedical Instrumentation and patient safety (15L)
1.1 Basic medical instrumentation system.
1.2 System configuration
1.3 Basic characteristics of measuring system
1.4 Problems faced when measuring a human body
1.5 Essentials of biomedical instrumentation.
1.6 Electric shock hazards-Gross shock-Micro current shock
1.7 Precautions to minimize electric shock hazards

Unit 2: Electrodes and physiological transducers: (15L)
3.1 Electrode Theory
3.2 Biopotential Electrodes
3.3 Electrodes for ECG, EEG, EMG.
3.4 Introduction to physiological transducers
3.5 Classification of Transducer
3.6 Performance characteristic of transducer.
3.7 Displacement, position and motion transducer.
3.8 Pressure transducer
3.9 Transducer for Body temperature measurement
3.10 Biosensors

Unit 3: Recording Systems and Signal Analysis: (15L)
3.1 Basic recording system.
3.2 General consideration for signal conditioners
3.3 Preamplifiers, Differential, Instrumentation, Isolation amplifier.
3.4 Source of noise in low level measurement.
3.5 Biomedical signal analysis techniques
3.6 Fourier Transform, FFT and Wavelet Transform
3.7 Signal processing techniques.

Unit 4: Cardiovascular System and Measurements: (15L)
4.1 The Heart.
4.2 The Heart and Cardiovascular system
4.3 Blood Pressure
4.4 Heart Sounds
4.5 Block diagram of electrocardiograph
4.6 The ECG leads
4.7 Effect of Artifacts on ECG recording
4.8 Introduction to pacemakers
4.9 Types of pacemakers
4.10 Need for pacemakers
4.11 Pacemaker system and its functioning

Reference Books:
1. Biomedical Instrumentation and Measurements (Second edition)
   By Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer Pearson education.
2. Handbook of Biomedical Instrumentation (Second Edition) by R. S. Khandpur
   (TataMcGraw Hill).
M. Sc-II (Physics) Semester-IV

CB Group –IV: 1. PHY 5404: ELECTRONIC INSTRUMENTATION-II

Credit: 04  Total No. of Lectures: 60

Unit 1: Introduction to Process Control (15L)
1.1 Introduction, Control systems
1.2 Process control block diagram
1.3 Control system Evaluation and Control system Objective
1.4 Evaluation Criteria, Damped response, Cyclic response
1.5 Process Control Drawing and symbols with their meaning
1.6 Discrete Process Control : Introduction, definitions of discrete state process control
1.7 Characteristics of the systems , relay, controllers and ladder diagrams
1.8 PLC’s, interfacing with LAN, SCADA systems

References: 1

Unit 2: Controller Principles (15L)
2.1 Introduction of controller
2.2 Process Characteristics- Process Load, Transient, Process Lag
2.3 Control System Parameters, Error, Variable Range, Control Parameter Range, Control Lag, Dead Time, Cycling
2.4 Controller Modes, Reverse And Direct Action, Discontinuous Controller Modes Two Position Neutral Zone (Examples) Applications
2.5 Multi position controller floating control mode- (eliminate single speed and multiple speed) Continuous controller modes, Proportional Control Mode, Integral Control Mode, Derivative Control Mode, Composite Control , PI Control, PD Control Mode, Three Mode Controller (PID)

References: 1

Unit 3: Controllers (15L)
3.1 Analog Controllers: Electronic controller with design considerations: Proportional (P), Integral (I), Derivatives (D) PI, PD and PID
3.2 Digital Control: Introduction two position controls and multivariable alarms.

References: 1

Unit 4: Modeling, Simulation and Programming (15L)
4.1 Introduction to modeling and simulation: Mathematical model, equivalent circuit model, Empirical Model, methodology, concept and need of simulation and its applications.
4.2 Introduction to MATLAB/ SciLab

References: 2 and References: 3

References Books:
2. Computer based industrial controls  K. Kant PHI publications.
3. MATLAB an introduction and applications”, by Amos Gilat, Wiley Students Edition
M. Sc-II (Physics) Semester-IV

CB Group –IV: 2. PHY 5404: LASER-II

Credit: 04

Total No. of Lectures: 60

Unit 1: Laser characteristics and Resonators

Principles, Properties of laser radiation, Light amplification, Threshold condition for laser oscillations, Homogeneous and inhomogeneous broadening, Laser rate equations for 2,3 and 4 level, variation of laser power around threshold, optimum output coupling, Open planar resonator, Quality Factor ,ultimate line width of the laser, Transverse and Longitudinal mode selection.

Unit 2: Non linear optics

Techniques for Q-switching, Mode Locking, Hole burning and Lamb dip in Doppler broadened Gas laser, Non linear oscillator model, Non linear polarization and wave equation, perturbative solution of the Nonlinear oscillator equation, Harmonic generation, Second harmonic generation, Phase matching third harmonic generation, Optical wave mixing, parametric generation of light, parametric oscillation, tuning of parametric oscillators, Non-Linear susceptibilities, non-linear susceptibility tensor, non-linear materials.

Unit 3: Applications of Laser Systems

Laser in industry, Lasers in Medicine, Lasers in Communications, Lasers in Science and Technology, Lasers in defense

Unit 4: Spectroscopic Instrumentation and applications

Raman scattering, photoacoustic Raman Spectroscopy, Raman Amplification and Raman laser, special techniques in non linear spectroscopy, polarization spectroscopy, multi-photon spectroscopy, photofluorescence excitation spectroscopy, Spatial Frequency filtering, optical computers, Laser ablation, Laser in Biomedicine.

References:

4. Yariv, Optical Electronics in Modern Communications, Oxford University Press (1997),
5. Laser Spectroscopy Basic concepts and instrumentation by Demtroder (ed. 3, Springer)
6. Laser: Svelto
M. Sc-II (Physics) Semester-IV
CB Group –IV: 3. PHY 5404: ENERGY STUDIES-II

Credit: 04  Total No. of Lectures: 60
Unit 1: Photovoltaic converters  (15L)

Interaction of solar radiations with semiconductors, photovoltaic effect, types of solar cell, equivalent circuit diagram of a solar cell, determination of series resistance (Rs) and shunt resistance (Rsh), ideal properties of semiconductor for use its solar cell, carrier generation and recombination, dark and illuminated characteristics of solar cell, solar cell output parameters: RL, Voc, Isc, Pm, FF, efficiency, performance dependence of a solar cell on band gap energy, diffusion length and carrier life time, Types of heterojunction, construction of energy band diagram of heterojunctions, origin of capacitance in a heterojunction, expression for junction capacitance, Mott – Schottky relation, problems.

Unit 2: Materials and Solar cell Technology  (15L)

Fabrication technology of solar cell, Single, poly – and amorphous silicon, GaAs, CdS, Cu₂S, CuInSe₂, CdTe etc. technologies for fabrication of single and polycrystalline silicon solar cells, amorphous silicon solar cells and tandem cells, solar cell modules, photovoltaic systems, spacequality solar cells, dye synthesized solar cell, perovskite solar cell, Different materials used in solar cells, problems

Unit 3: Photochemical Converters  (15L)

Semiconductor – electrolyte interface, Helmholtz double layer,Gouy-Chapman model,Stern model,Principle of photoelectrochemical solar cells,conversion efficiency in relation to different material properties, photoelectrolysis cell, driving force of photoelectrolysis, alkaline fuel cell, semiconductor- septum storage cell,concept of photocatalysis and photoelectrocatalysis process, problems.

Unit 4: Thermoelectric Converters  (15L)

Thermoelectric effects, solid state description of thermoelectric effect, Kelvin’s thermodynamic relations, analysis of thermoelectric generators, basic assumptions, temperature distribution and thermal energy transfer for generator, co-efficient of performance for thermoelectric cooling, problems.

Reference Books:
2. Photoelectrochemical solar cells – Suresh Chandra
4. Solar cells – Martin A.Green
M. Sc-II (Physics) Semester-IV
CB Group –IV: 4. PHY 5404: MICROCONTROLLER– II

Credit: 04                                                                 Total No. of Lectures: 60

Unit 1: Introduction to processors: (15L)
Introduction of Microprocessors and Microcontrollers, Introduction of Arduino Microcontrollers

Unit 2: Introduction to architecture: (15L)
Atmega328: Basics and Architecture, Instruction Set

Unit 3: Arduino programming: (15L)
Arduino programming basics, Analog/Digital components and its application with Arduino, IDE for Arduino

Other utilities in Arduino: Timers, Analog comparators and hardware interrupts

Unit 4: Interfacing with peripherals: (15L)
Communication buses, Interfacing of I/O devices

Case studies: Case studies of a few projects using Arduino boards and Shields

References:

M. Sc-II (Physics) Semester-III& IV
PHY 5305: SPECIAL LAB– I /PHY 5405: SPECIAL LAB– II

Credit: 04

List of Experiments:

(CB Group –I: 1. PHY 5303: PHYSICS OF THIN FILM-I &
CB Group –III: 1. PHY 5403: PHYSICS OF THIN FILM-II):

Students have to perform minimum 5 Experiments in each Semester:

<table>
<thead>
<tr>
<th>No.</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Deposition of metallic thin films by vacuum evaporation method</td>
</tr>
<tr>
<td>2</td>
<td>Deposition of thin films by spray pyrolysis method and thickness measurement by gravimetric method</td>
</tr>
<tr>
<td>3</td>
<td>Thin film formation by Electro-chemical deposition technique.</td>
</tr>
<tr>
<td>4</td>
<td>Deposition of thin films by spin coating method and resistance measurement.</td>
</tr>
<tr>
<td>5</td>
<td>Deposition of thin film by Dip Coating method and thickness measurement.</td>
</tr>
<tr>
<td>6</td>
<td>Thickness measurement of thin film by Tolansky method.</td>
</tr>
<tr>
<td>7</td>
<td>Study of optical absorption of thin film (UV-visible spectroscopy) and determination of particle size</td>
</tr>
<tr>
<td>8</td>
<td>Determination of particle size of thin film from X-ray diffraction.</td>
</tr>
<tr>
<td>9</td>
<td>Determination of grain size of thin film from SEM</td>
</tr>
<tr>
<td>10</td>
<td>Resistivity measurement of thin film by two probe method.</td>
</tr>
<tr>
<td>11</td>
<td>Band gap energy of thin film</td>
</tr>
<tr>
<td>12</td>
<td>Crystal structure of thin film</td>
</tr>
<tr>
<td>13</td>
<td>Electron Spin Resonance (ESR)</td>
</tr>
<tr>
<td>14</td>
<td>Development of microstructures by photolithography.</td>
</tr>
</tbody>
</table>
M. Sc-II (Physics) Semester-III & IV  
**PHY 5305: SPECIAL LAB– I /PHY 5405: SPECIAL LAB– II**

Credit: 04

**List of Experiments:**

**(CB Group –I: 2. PHY 5303: NANO TECHNOLOGY-I)**

**(CB Group –III: 2. PHY 5403: NANO TECHNOLOGY-II):**

Students have to perform minimum 5 Experiments in each Semester:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Synthesis of Fe$_2$O$_3$ by sol-gel method</td>
</tr>
<tr>
<td>2</td>
<td>Preparation of Mn$_3$O$_4$ thin film by SILAR method</td>
</tr>
<tr>
<td>3</td>
<td>Synthesis of metal oxides by spray pyrolysis method</td>
</tr>
<tr>
<td>4</td>
<td>Synthesis of metal nanoparticles using green route</td>
</tr>
<tr>
<td>5</td>
<td>Band gap energy Measurement of thin films by UV-Visible spectrophotometer</td>
</tr>
<tr>
<td>6</td>
<td>Use of FT-IR for functional group identification (in CNT, graphene etc.)</td>
</tr>
<tr>
<td>7</td>
<td>Data plotting using Origin 8 software</td>
</tr>
<tr>
<td>8</td>
<td>Photoluminescence study of nanomaterials</td>
</tr>
<tr>
<td>9</td>
<td>Thickness measurement of thin film by weight difference method</td>
</tr>
<tr>
<td>10</td>
<td>Electro-deposition of Cu nano particle</td>
</tr>
<tr>
<td>11</td>
<td>Deposition of thin films by CBD method</td>
</tr>
<tr>
<td>12</td>
<td>Synthesis of ferrites by Co-precipitation method</td>
</tr>
<tr>
<td>13</td>
<td>Preparation of film by Doctor Blade method</td>
</tr>
<tr>
<td>14</td>
<td>Resistivity measurement of thin film by two probe method</td>
</tr>
<tr>
<td>15</td>
<td>Contact angle measurement of thin films</td>
</tr>
<tr>
<td>16</td>
<td>Structural properties of nanomaterials by XRD</td>
</tr>
<tr>
<td>17</td>
<td>Analysis of surface morphology by TEM</td>
</tr>
<tr>
<td>18</td>
<td>Morphological study by SEM</td>
</tr>
</tbody>
</table>
List of Experiments:

(CB Group –I: 3. PHY 5303: BIOMEDICAL INSTRUMENTATION-I &

CB Group –III: 3. PHY 5403: BIOMEDICAL INSTRUMENTATION-II):

Students have to perform minimum 5 Experiments in each Semester:

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Active filters for Bio-signals: Design and Filtering (Low pass and High pass filter)</td>
</tr>
<tr>
<td>2</td>
<td>Design and build a Notch filter (To reduce noise of 50 Hz).</td>
</tr>
<tr>
<td>3</td>
<td>ECG preamplifier-Instrumentation amplifier and testing.</td>
</tr>
<tr>
<td>4</td>
<td>Use of sphygmomanometers for measurement of blood pressure.</td>
</tr>
<tr>
<td>5</td>
<td>Concept of ECG, system and placement of electrodes ECG signal recording with surface Electrodes</td>
</tr>
<tr>
<td>6</td>
<td>Design and build a Wide/ Narrow band pass filters for measurement for Bio-signals</td>
</tr>
<tr>
<td>7</td>
<td>To study LVDT Characteristics.</td>
</tr>
<tr>
<td>8</td>
<td>Measurement of physical parameter using embedded system</td>
</tr>
</tbody>
</table>
**M. Sc-II (Physics) Semester-III & IV**

**PHY 5306: SPECIAL LAB– I /PHY 5406: SPECIAL LAB– II**

Credit: 04

**List of Experiments:**

**(CB Group –II: 1. PHY 5304: ELECTRONIC INSTRUMENTATION-I &**

**(CB Group –IV: 1. PHY 5404: ELECTRONIC INSTRUMENTATION-III)**:

Students have to perform minimum 5 Experiments in each Semester:

<table>
<thead>
<tr>
<th>No.</th>
<th>Experiment Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Application of ultrasonic pressure transducer.</td>
</tr>
<tr>
<td>2</td>
<td>Temperature Characteristic of Thermistor</td>
</tr>
<tr>
<td>3</td>
<td>D to A converter circuit (R-2R &amp; binary weighted).</td>
</tr>
<tr>
<td>4</td>
<td>V to F, converter as basic concept of ADC.</td>
</tr>
<tr>
<td>5</td>
<td>Op-amp as Instrumentation amplifier.</td>
</tr>
<tr>
<td>6</td>
<td>Characteristics and applications of photoelectric devices, LED, Photodiode</td>
</tr>
<tr>
<td>7</td>
<td>Study of Sample and Hold Circuits</td>
</tr>
<tr>
<td>8</td>
<td>F to V Converter using OP-AMP</td>
</tr>
<tr>
<td>9</td>
<td>Study of Data Acquisition System</td>
</tr>
<tr>
<td></td>
<td>Measurement of temperature by thermocouple</td>
</tr>
<tr>
<td>10</td>
<td>Measurement of displacement using LVDT</td>
</tr>
<tr>
<td>11</td>
<td>Temperature Characteristic of strain gauges and its Application</td>
</tr>
<tr>
<td>12</td>
<td>Logarithmic amplifier using op-amp 741</td>
</tr>
<tr>
<td>13</td>
<td>Measurement of load using strain gauge based load cell</td>
</tr>
<tr>
<td>14</td>
<td>Measurement of temperature by RTD</td>
</tr>
<tr>
<td>15</td>
<td>Study of storage oscilloscope and determination of transient response of RLC Circuit</td>
</tr>
<tr>
<td>16</td>
<td>Determination of characteristics of a fiber-optic sensor</td>
</tr>
<tr>
<td>17</td>
<td>Study of data acquisition system using “lab view” software and test all signal points</td>
</tr>
<tr>
<td>18</td>
<td>Measurement of water level using strain gauge based water level transducer</td>
</tr>
<tr>
<td>19</td>
<td>Study of P, PI and PID controllers</td>
</tr>
</tbody>
</table>
Credit: 04

List of Experiments:

(CB Group –II: 2. PHY 5304: LASER-I &

CB Group –IV: 2. PHY 5404: LASER-II):

Students have to perform minimum 5 Experiments in each Semester:

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>To study the diffraction patterns of single and double slit using laser source and measure its intensity variation using photo sensor and compare with incoherent source- Na light</td>
</tr>
<tr>
<td>2</td>
<td>Determine the wavelength of laser.</td>
</tr>
<tr>
<td>3</td>
<td>Thickness of sharp blade by LASER diffraction.</td>
</tr>
<tr>
<td>4</td>
<td>Study of laser beam diversity.</td>
</tr>
<tr>
<td>5</td>
<td>Determine of angle of divergence of a laser beam using He-Ne laser.</td>
</tr>
<tr>
<td>6</td>
<td>Determine of particle of size of lycopodium powder using semiconductor laser.</td>
</tr>
<tr>
<td>7</td>
<td>Determine the wavelength of laser light using semiconductor laser diffraction.</td>
</tr>
<tr>
<td>8</td>
<td>Determine the thickness of thin wire using LASER</td>
</tr>
<tr>
<td>9</td>
<td>Determine the wavelength of laser and calculate velocity and frequency of light.</td>
</tr>
<tr>
<td>10</td>
<td>Diffraction grating.</td>
</tr>
</tbody>
</table>
Credit: 04

List of Experiments:

(CB Group –II: 3. PHY 5304: ENERGY STUDIES-I &
CB Group –IV: 3. PHY 5404: ENERGY STUDIES-II):
Students have to perform minimum 5 Experiments in each Semester:

<table>
<thead>
<tr>
<th>No.</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Solar Cell Characteristics</td>
</tr>
<tr>
<td>2</td>
<td>Recording the amount of sunlight receives throughout a day using Sunshine Recorder</td>
</tr>
<tr>
<td>3</td>
<td>Measure the solar radiation flux density using Pyrometer</td>
</tr>
<tr>
<td>4</td>
<td>Determining efficiency of lighting system/loads</td>
</tr>
<tr>
<td>5</td>
<td>Air mass Ratio</td>
</tr>
<tr>
<td>6</td>
<td>Bio-gas Production from Kitchen waste.</td>
</tr>
<tr>
<td>7</td>
<td>Energy Content in Wind.</td>
</tr>
<tr>
<td>8</td>
<td>Utilizing the latent heat released by the condensing water steam using Solar Still</td>
</tr>
<tr>
<td>9</td>
<td>Study of solar hot air collector/ solar dryer</td>
</tr>
<tr>
<td>10</td>
<td>Performance evaluation of box type and concentrating type solar cooker</td>
</tr>
<tr>
<td>11</td>
<td>Flat Plate Collector</td>
</tr>
<tr>
<td>12</td>
<td>PV – IV Characteristics</td>
</tr>
<tr>
<td>13</td>
<td>Find out the kinetics of photocatalytic reaction</td>
</tr>
<tr>
<td>14</td>
<td>Electrodeposition method</td>
</tr>
</tbody>
</table>
M. Sc-II (Physics) Semester-III & IV

PHY 5306: SPECIAL LAB– I /PHY 5406: SPECIAL LAB– II

Credit: 04

List of Experiments:

(CB Group –II: 4. PHY 5304: MICROCONTROLLER– I &

Students have to perform minimum 5 Experiments in each Semester:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Use of Keil/Pinacle software.</td>
</tr>
<tr>
<td>2</td>
<td>Addition of two 16 bit numbers</td>
</tr>
<tr>
<td>3</td>
<td>Multiplication of two 8 bit numbers.</td>
</tr>
<tr>
<td>4</td>
<td>Write a program to find largest/smallest number in given block</td>
</tr>
<tr>
<td>5</td>
<td>Write a program to toggle bits of port 1 with delay which depends on value of number in R0</td>
</tr>
<tr>
<td>6</td>
<td>Memory block transfer from one location to another.</td>
</tr>
<tr>
<td>7</td>
<td>Find two’s complement of given number.</td>
</tr>
<tr>
<td>8</td>
<td>LCD Interfacing</td>
</tr>
<tr>
<td>9</td>
<td>Keyboard Interfacing</td>
</tr>
<tr>
<td>10</td>
<td>ADC Interfacing</td>
</tr>
<tr>
<td>11</td>
<td>Temperature Sensor Using LM 35</td>
</tr>
</tbody>
</table>
M. Sc-II (Physics) Semester-III

PHY 5306: PROJECT– I

The student will have to perform the project course for the both semesters III and IV. The continuous evaluation of the project will be done during each semester. Student must complete 50% project work in semester III and evaluation will be done at the end of semester and credit will be assigned to the students according to their performance.

M. Sc-II (Physics) Semester-IV

PHY 5406: PROJECT– II

The final evaluation of the project work will be done at the end of semester IV. Student should submit the dissertation of the project work and face the vivo-vice of the project.