Anekant Education Society's

TULJARAM CHATURCHAND COLLEGE OF ARTS, SCIENCE AND COMMERCE, BARAMATI

(Autonomous Status)

(Affiliated to Savitribai Phule Pune University, Pune)

Faculty of Science

Department of Physics

Proposed Syllabus

For

M.Sc. in Physics

Semester-IV

2019 PATTERN

From Academic Year 2019-2020

Anekant Education Society's

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M. Sc. II

2019 Pattern

Semester-IV Course Structure

Course Number		Course Name	Credit
17	PHY5401	Nuclear & Particle Physics	4
18	PHY5402	Material Science	4
19	PHY5403	CB Group –III A) Physics of thin films-II B) Nano-technology-II C) Biomedical Instrumentation-II	4
20	PHY5404	CB Group –IV A) Electronic Instrumentation-II B) Laser-II C) Energy Studies-II D) Microcontroller– II	4
21	PHY5405	Special Lab-II	4
22	PHY5406	Project-II	2
Total Credit			**22**

Programme Outcomes (POs)

PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the discipline that forms a part of a postgraduate Programme. Execute strong theoretical and practical understanding generated from the specific Programme in the area of work.
PO2	**Critical Thinking and Problem solving:** Exhibit the skill of critical thinking and understand scientific texts and place scientific statements and themes in contexts and also evaluate them in terms of generic conventions. Identify the problem by observing the situation closely, take actions and apply lateral thinking and analytical skills to design the solutions.
PO3	**Social competence:** Exhibit thoughts and ideas effectively in writing and orally; communicate with others using appropriate media, build effective interactive and presenting skills to meet global competencies. Elicit views of others, present complex information in a clear and concise way and help reach conclusions in group settings.
PO4	**Research-related skills and Scientific temper :** Infer scientific literature, build a sense of enquiry and able to formulate, test, Analyse, interpret and establish hypothesis and research questions; and to identify and consult relevant sources to find answers. Plan and write a research paper/project while emphasizing on academics and research ethics, scientific conduct and creating awareness about intellectual property rights and issues of plagiarism.
PO5	**Trans-disciplinary knowledge:** Create new conceptual, theoretical and methodological understanding that integrates and transcends beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence:** Perform independently and also collaboratively as a part of a team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics:** Demonstrate empathetic social concern and equity centered national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability:** Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	**Self-directed and Life-long learning:** Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

M. Sc-II (Physics) Semester-IV

PHY 5401: NUCLEAR AND PARTICLE PHYSICS

Credit: 04 **Total No. of Lectures: 60**

Course Outcomes: On successful completion of this course students will be able to

CO1: Can express the basic concepts of nuclear physics.

CO2: Can tell a chronology of some of the major events in nuclear physics.

CO3: Can express the radioactive decays.

CO4: Can state some quantities characterizing the decay such as half-life, decay constant.

CO5: Can list the types of decay.

CO6: Can express the alpha decay.

CO7: Can express reaction equation and Q values and Energy of alpha particles.

CO8: Can explain the alpha process by using quantum theory.

CO9: Can calculate the half-times based on quantum theory.

Unit 1: General Properties and concepts of Nuclei (15L)

General Properties of nuclei :Charge, Nuclear mass, Nuclear binding energy, Mass defect, Nuclear radius, Angular momentum, Nuclear spin ,Parity, Magnetic dipole moments &Electric quadrupole moments of nuclei, Radioactivity and Unit of radiation, Different types of decays: Alpha Decay: Velocity of Alpha Particles, Disintegration Energy, Range-Energy Relationship, Geiger-Nuttal Law, Beta Decay: Conditions for Spontaneous Emission of β^-& β^+ Particles, Selection Rules, Origin of Beta Spectrum-Neutrino Hypothesis, Gamma Decay: Decay Scheme of ^{137}Cs &^{60}Co Nuclei, Internal Conversion, Internal Pair Creation.

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 (15L)

Reaction Dynamics: Types of Nuclear Reactions, Conservation Laws in Nuclear Reactions, Q-value and threshold energy of nuclear reactions, Compound Nucleus Hypothesis, Reactors: Fission Chain Reaction, Four Factor Formula, Multiplication Factor, General Properties and Concepts of Nuclear Reactors, Reactor Materials, Types of Reactors, List of Different Types of Reactors Developed in India, Accelerators: Van de Graff, Microtron, Electron & Proton Synchrotron, Pelletron, Cyclotron.

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:

1. K. S. Krane, 1988, Introductory Nuclear Physics, Wiley, India.
2. D. C. Tayal, Nuclear Physics, Himalaya Publishing House.
3. B. L. Cohen, Concepts of Nuclear Physics, Tata McGraw Hill.
4. I. Kaplan, 1989, Nuclear Physics, 2nd Edition, Narosa, New Delhi.
5. S. N. Ghoshal, Atomic and Nuclear Physics, S.Chand.
6. E. Segre, Nuclei and Particles
7. R. D. Evans, The Atomic Nucleus, Tata McGraw Hill.
8. G. F. Knoll, Radiation Detection and Measurement, 3rd edition, Wiley India.
9. S. S. Kapoor and V. S. Ramamurthy, Nuclear Radiation Detectors, Wiley eastern Limited.
10. R. R. Roy, B. P. Nigam, Nuclear Physics-Theory and Experiment,Wiley eastern Limited.
11. Frauenfelder and Henley, Subatomic Physics, Prentice Hall.
12. S. Sharma, Atomic & Nuclear Physics, Pearson education 2008
13. S. B. Patel, Nuclear Physics An Introduction, (New Age International Limited)

Mapping of Program Outcomes with Course Outcomes

Course Outcomes	Programme Outcomes								
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8	PO9
CO 1	3								2
CO 2		2							2
CO 3		3				2			2
CO 4		3							2
CO 5				2					2
CO 6									2
CO7				3					2

Justification

PO1: Disciplinary Knowledge

CO1: Can express the basic concepts of nuclear physics. Weightage: 3

This CO directly aligns with the objective of developing disciplinary knowledge in nuclear physics.

PO2: Critical Thinking and Problem Solving

CO2: Can tell a chronology of some of the major events in nuclear physics. Weightage: 2

Understanding the chronological sequence in nuclear physics requires critical thinking skills to analyze and interpret historical events.

CO3: Can express the radioactive decays. Weightage: 3

Expressing radioactive decays involves critical thinking and problem-solving skills related to understanding complex processes.

CO4: Can state some quantities characterizing the decay, such as half-life, decay constant. Weightage: 3

Calculating quantities like half-life and decay constant involves critical thinking and problem-solving skills.

PO4: Research-related Skills and Scientific Temper

CO5: Can list the types of decay. Weightage: 2

Listing types of decay requires knowledge of research findings and contributes to scientific temper.

CO7: Can express reaction equation and Q values and Energy of alpha particles. Weightage: 3

Expressing reaction equations and understanding Q values involve research-related skills and scientific temper.

PO6: Personal and Professional Competence

CO3: Can express the radioactive decays. Weightage: 2

Expressing radioactive decays contributes to personal and professional competence by building a foundational understanding of nuclear physics.

PO9: Self-directed and Life-long Learning

All COs can be related to this PO to some extent, as they contribute to building a foundation for continuous learning. Weightage: 2

Each CO requires a level of self-directed learning, and the knowledge gained contributes to lifelong learning.

M. Sc-II (Physics) Semester-IV

PHY 5402: MATERIAL SCIENCE

Credit: 04 **Total No. of Lectures: 60**

Course Outcomes: On successful completion of this course students will be able to do the following:

CO1: Qualitatively describe the bonding scheme and its general physical properties, as well as possible applications.

CO2: Describe physical origin of defects and its effects on various mechanical, electrical, thermal and other properties of the materials.

CO3: Describe resultant elastic properties in terms of its 1D and 2D defects.

CO4: Understand diffusion mechanisms and solve problems related to diffusion processes.

CO5: Understand alloy systems, families of engineering alloys.

CO6: Understand thermodynamic origin of phase diagrams, draw phase diagrams.

CO7: Understand phase diagrams and apply their knowledge of phase diagrams for various applications.

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 secondlaws 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:

1. Elements of Materials Science and Engineering (5^{th} edition) - Lawrence H. Van Vlack, Addison - Wesley Publishing Co.
2. Materials Science and Engineering - V. Raghvan
3. Physical Metallurgy (PartI) R. W. Cahn and P. Hassen, North Holland Physics Publishing, New York
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, Amit Kakani

Mapping of Program Outcomes with Course Outcomes

Course Outcomes	Programme Outcomes								
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO8**	**PO9**
CO 1	3								
CO 2		3							
CO 3				2					
CO 4				2					
CO 5					2				
CO 6					2				
CO7						2			

Justification

PO1: Disciplinary Knowledge

CO1: Qualitatively describe the bonding scheme and its general physical properties, as well as possible applications. Weightage: 3

This directly aligns with acquiring disciplinary knowledge in materials science and bonding schemes.

PO2: Critical Thinking and Problem Solving

CO2: Describe the physical origin of defects and its effects on various mechanical, electrical, thermal, and other properties of materials. Weightage: 3

Critical thinking is required to understand the complex relationship between defects and material properties.

PO4: Research-related Skills and Scientific Temper

CO3: Describe resultant elastic properties in terms of its 1D and 2D defects.

CO4: Understand diffusion mechanisms and solve problems related to diffusion processes.

Weightage: 2

Justification: While these outcomes involve research-related skills, they might not directly align with the entire spectrum of scientific temper.

PO5: Trans-disciplinary Knowledge

CO5: Derive various metallurgical thermodynamics equations and functions.

CO6: Understand and apply Gibb's phase rule to various systems of materials.

Weightage: 2

These outcomes involve knowledge that spans multiple disciplines within materials science.

PO6: Personal and Professional Competence

CO7: Understand alloy systems, families of engineering alloys.

Weightage: 2

Understanding alloy systems contributes to professional competence in materials engineering.

M. Sc-II (Physics) Semester-IV

CB Group –III: 1. PHY 5403: PHYSICS OF THIN FILM-II

Credit: 04 **Total No. of Lectures: 60**

Course Outcomes:

CO1: To understand the principle, differences and similarities, advantages, and disadvantages of different thin film deposition Techniques.
CO2: To understand and evaluate and use models for understanding nucleation and growth of thin films.
CO3: To understand about different instrumentation techniques and to analyze thin film properties to apply for various applications.
CO4: To improve problems solving skills related to evaluation of different properties of thin films.
CO5: Problem solving ability
CO6: Critical analysis
CO7: Discuss the differences and similarities between different vacuum based deposition techniques
CO8: Evaluate and use models for nucleating and growth of thin films
CO9: Asses the relation between deposition technique, film structure, and film properties

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: γ-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 Electron Microscopy: Principle, Instrumentation and Working of Scanning Electron Microscope (SEM), Field Emission Scanning Electron Microscope (FESEM) – Advantages over SEM, Transmission Electron Microscope (TEM), Selected Area Electron Diffraction (SAED) Probe Microscopy: Principle, Instrumentation and Working of Scanning Tunneling Microscope (STM) and Atomic Force Microscope (AFM)

Magnetic Characterization: Principle, Instrumentation and Working of Vibrating Sample Magnetometer (VSM), Analysis of Hysteresis loop, SQUID Technique: Principle, Instrumentation and Working. Numericals

Unit 4: Spectroscopic Analysis (15L)

Spectroscopic characterization (principle, instrumentation and working): Infra Red (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:

1. Nuclear Radiation Detectors, S.S. Kapoor, V. S. Ramamurthy, (Wiley-Eastern Limited, Bombay)
2. Instrumentation: Devices and Systems, C.S. Rangan, G.R. Sarma and V.S.V. Mani, Tata Mc Graw Hill Publishing Co. Ltd.
3. Instrumental Methods of Chemical Analysis, G. Chatwal and S. Anand, Himalaya Publishing House
4. Instrumental Methods of Analysis by H.H. Willard, L.L. Merritt, J.A. Dean, CBS Publishers
5. Characterization of Materials, John B. Wachtman & Zwi. H. Kalman, Pub. Butterworth Heinemann (1992)
6. Elements of X-ray diffraction, Bernard Dennis Cullity, Stuart R. Stock, (Printice Hall, 2001 - Science - 664 pages)

Mapping of Program Outcomes with Course Outcomes

Course Outcomes	Programme Outcomes								
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**
CO 1	3			2					
CO 2	3					2			
CO 3	3					2	3	2	
CO 4									
CO 5		2							
CO 6									
CO7			2		2				
CO8		3		2					2
CO9		3							

Justification

PO1: Disciplinary Knowledge

CO1: To understand the principle, differences and similarities, advantages, and disadvantages of different thin film deposition Techniques. Weightage: 3

Acquiring technical skills in a laboratory setting is fundamental to building disciplinary knowledge.

CO2: To understand and evaluate and use models for understanding nucleation and growth of thin films. CO3: To understand about different instrumentation techniques and to analyze thin film properties to apply for various applications. Weightage: 3

Creating experimental models for better understanding involves disciplinary knowledge and direct application, indicating a strong relationship. Weightage: 3

Visualizing and experiencing abstract concepts directly contribute to disciplinary knowledge.

PO2: Critical Thinking and Problem Solving

CO8: Evaluate and use models for nucleating and growth of thin films: 3

CO9: Asses the relation between deposition technique, film structure, and film properties. Weightage3

Critical thinking is essential in use models for nucleating and growth of thin films and interpreting Assess the relation between deposition technique, film structure, and film properties

CO4: To improve problems solving skills related to evaluation of different properties of thin films.

CO5: Problem solving ability Weightage: 2

Applying knowledge in project work involves problem-solving skills, but the link may not be as direct as in other cases.

PO3: Social Competence

CO7: Discuss the differences and similarities between different vacuum based deposition techniques. Weightage: 3

Collaborative learning and teamwork in a laboratory setting directly contribute to social competence.

PO4: Research-related Skills and Scientific Temper

CO1: To understand the principle, differences and similarities, advantages, and disadvantages of different thin film deposition Techniques. Weightage: 2

Acquiring technical skills can be part of research-related skills, but the link may not be as direct.

CO8: Evaluate and use models for nucleating and growth of thin films. Weightage: 2

Evaluate and use models can be part of developing a scientific temper, but the link may not be as strong.

PO5: Trans-disciplinary Knowledge

CO7: Discuss the differences and similarities between different vacuum based deposition techniques. Weightage: 2

Collaborative learning and teamwork contribute to trans-disciplinary knowledge, but the link may not be as strong.

PO6: Personal and Professional Competence

CO2: To understand and evaluate and use models for understanding nucleation and growth of thin film Weightage: 2

Collaborative learning and teamwork contribute to personal and professional competence, though the link may not be as direct.

CO3: To understand about different instrumentation techniques and to analyze thin film properties to apply for various applications.

Collaborative learning and teamwork contribute to personal and professional competence, though the link may not be as direct.

PO7: Effective Citizenship and Ethics

CO2: To understand and evaluate and use models for understanding nucleation and growth of thin films. Weightage: 3

Understanding laboratory procedures, especially safety and scientific methods, directly contributes to effective citizenship and ethics.

PO8: Environment and Sustainability

CO3: To understand about different instrumentation techniques and to analyze thin film properties to apply for various applications. Weightage: 2

Adhering to laboratory safety procedures can indirectly contribute to considerations of environment and sustainability.

PO9: Self-directed and Life-long Learning

CO8: Evaluate and use models for nucleating and growth of thin film. Weightage: 2

Applying knowledge in project work is relevant to self-directed and life-long learning, though the link may not be as direct.

M. Sc-II (Physics) Semester-IV

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

Credit: 04 **Total No. of Lectures: 60**

Course Outcomes:

After successful completing this course, the student will able to
CO1: To understand the nature and properties of nanomaterials.
CO2: To provide scientific understanding of application of nanomaterials and nanotechnology in agriculture, health and environmental conservation.
CO3: To foundational knowledge of the Nanoscience and related fields.
CO4: To make the students acquire an understanding the Nanoscience and Applications
CO5: To help them understand in broad outline of Nanoscience and Nanotechnology
CO6: Build models to understand the physical properties of different nano materials
CO7: Critically evaluate the approximations needed to build models to understand the solid state.

Unit 1: Optical and electrical Properties of Nano materials (15L)

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 (15L)

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 (15L)

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 (15L)

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:

1. Nanotechnology principle and practices by Sulabha K. Kulkarni (2007).
2. Handbook of Nanotoxicology, Nanomedicine and Stem Cell Use in Toxicology. Saura C Sahu, Daniel A Casciano.
3. Nanotoxicology - Interactions of Nanomaterials with Biological Systems. Yuliang Zhao and Hari Singh Nalwa.
4. Biointeractions of Nanomaterials. Vijaykumar B. Sutariya, Yashwant Pathak
5. New Technologies for Toxicity Testing. Michael Balls DPhil, Robert D. Combes PhD, Nirmala Bhogal.

Mapping of Program Outcomes with Course Outcomes

Course Outcomes	Programme Outcomes								
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO8**	**PO9**
CO 1	3								
CO 2					2				
CO 3	3								
CO 4	3								
CO 5	3								
CO 6		3							
CO7		3							

Justification

PO1: Disciplinary Knowledge
CO1: To understand the nature and properties of nanomaterials.
CO3: To foundational knowledge of Nanoscience and related fields.
CO4: To make the students acquire an understanding of Nanoscience and Applications.
CO5: To help them understand the broad outline of Nanoscience and Nanotechnology.
Weightage: 3
All these course outcomes directly contribute to acquiring disciplinary knowledge in the field of Nanoscience.

PO2: Critical Thinking and Problem Solving
CO6: Build models to understand the physical properties of different nanomaterials.
CO7: Critically evaluate the approximations needed to build models to understand the solid state.
Weightage: 3
Building models and critically evaluating approximations involve critical thinking and problem-solving skills, especially in the context of nanomaterials and solid-state physics.

PO5: Trans-disciplinary Knowledge
CO2: To provide a scientific understanding of the application of nanomaterials and nanotechnology in agriculture, health, and environmental conservation.
Weightage: 2
Understanding the application of nanomaterials in diverse fields contributes to trans-disciplinary knowledge.

M. Sc-II (Physics) Semester-IV

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

Credit: 04 **Total No. of Lectures: 60**

Course Outcomes:

After completion of the course, the student should be able to:

CO1: Explain the different medical imaging systems, compare advantages and disadvantages, understand the limitations and find the best suitable method for different pathological diagnoses.

CO2: Explain and describe different diagnostic measurement methods for identification of human biopotentials and their necessary instrumentation.

CO3: Explain the principles behind the operation of common biomedical instruments.

CO4: Identify and describe the components of biomedical instruments.

CO5: Understand basic signal processing techniques applied in biomedical instrumentation.

CO6: Analyze and process signals from biological systems.

CO7: Identify different types of sensors and transducers used in biomedical applications.

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

4.11Pacemaker system and its functioning

Reference Books:

1. 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 McGraw Hill).
3. Biomedical Instrumentation and Measurement by Carr and Brown-Pearson.

Mapping of Program Outcomes with Course Outcomes

Course Outcomes	Programme Outcomes								
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO8**	**PO9**
CO 1	3	3	2						
CO 2	3	3			1				
CO 3	3								
CO 4	3								
CO 5	3	2							
CO 6	3	3							
CO7	3								

Justification

CO1: Explain the different medical imaging systems, compare advantages and disadvantages, understand the limitations and find the best suitable method for different pathological diagnoses.

PO1: Disciplinary Knowledge: 3 (strong or direct relation)

Justification: This course outcome directly aligns with the development of disciplinary knowledge in the field of biomedical instrumentation, particularly in understanding medical imaging systems and their applications.

PO2: Critical Thinking and Problem Solving: 3 (strong or direct relation)

Justification: Analyzing advantages, disadvantages, and limitations of medical imaging systems requires critical thinking and problem-solving skills.

PO5: Trans-disciplinary Knowledge: 2 (moderate or partial relation)

Justification: While primarily focused on biomedical instrumentation, understanding medical imaging systems may involve knowledge from other disciplines, but to a lesser extent.

CO2: Explain and describe different diagnostic measurement methods for identification of human biopotentials and their necessary instrumentation.

PO1: Disciplinary Knowledge: 3 (strong or direct relation)

Justification: Understanding diagnostic measurement methods for biopotentials is a direct application of disciplinary knowledge in biomedical instrumentation.

PO2: Critical Thinking and Problem Solving: 3 (strong or direct relation)

Justification: Describing and explaining diagnostic measurement methods involves critical thinking and problem-solving skills.

PO5: Trans-disciplinary Knowledge: 1 (weak or low relation)

Justification: This outcome is more discipline-specific and doesn't involve significant trans-disciplinary knowledge.

CO3: Explain the principles behind the operation of common biomedical instruments.
PO1: Disciplinary Knowledge: 3 (strong or direct relation)
Justification: Understanding the principles of common biomedical instruments is foundational disciplinary knowledge.

CO4: Identify and describe the components of biomedical instruments.
PO1: Disciplinary Knowledge: 3 (strong or direct relation)
Justification: Recognizing and describing components directly contributes to disciplinary knowledge in biomedical instrumentation.

CO5: Understand basic signal processing techniques applied in biomedical instrumentation.
PO1: Disciplinary Knowledge: 3 (strong or direct relation)
Justification: Signal processing is a core aspect of biomedical instrumentation knowledge.
PO2: Critical Thinking and Problem Solving: 2 (moderate or partial relation)
Justification: Understanding signal processing involves some level of critical thinking and problem-solving skills.

CO6: Analyze and process signals from biological systems.
PO1: Disciplinary Knowledge: 3 (strong or direct relation)
Justification: Signal analysis from biological systems directly falls within the domain of disciplinary knowledge in biomedical instrumentation.
PO2: Critical Thinking and Problem Solving: 3 (strong or direct relation)
Justification: Analyzing and processing signals requires critical thinking and problem-solving skills.

CO7: Identify different types of sensors and transducers used in biomedical applications.
PO1: Disciplinary Knowledge: 3 (strong or direct relation)
Justification: Recognizing sensors and transducers is fundamental to disciplinary knowledge in biomedical instrumentation.

M. Sc-II (Physics) Semester-IV

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

Credit: 04 **Total No. of Lectures: 60**

Course Outcomes: After successful completion of this course the students will be able to-

CO1: Understand the principles and functions of different instruments.
CO2: Use different instruments for measurement of various parameters.
CO3: Design experiments using sensors.
CO4: Recognize the importance of instrumentation in various engineering and scientific applications.
CO5: Study various types of sensors and transducers.
CO6: Understand the working principles and characteristics of different sensor.
CO7: Learn techniques for conditioning and processing electrical signals from sensors.

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: Modelling, 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:

1. Process Control Instrumentation Technology, Curtis D. Johnson, 7th Edition, Prentice Hall India Pvt. Ltd.
2. Computer based industrial controls K. Kant PHI publications.
3. MATLAB an introduction and applications", by Amos Gilat, Wiley Students Edition

Mapping of Program Outcomes with Course Outcomes

Course Outcomes	Programme Outcomes								
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3								
CO 2	3								
CO 3		3	2						
CO 4	3			3					
CO 5				3					
CO 6		3		3					
CO7	3								

Justification

PO1: Disciplinary Knowledge

CO1: Understand the principles and functions of different instruments.
CO2: Use different instruments for measurement of various parameters.
CO4: Develop the knowledge of theoretical and mathematical principles of electrical measuring instruments.
CO7: Develop the knowledge of theoretical and mathematical principles of electrical measuring instruments.
Weightage: 3
These outcomes directly contribute to acquiring disciplinary knowledge in the field of instrumentation and electrical measurements.

PO2: Critical Thinking and Problem Solving

CO3: Design experiments using sensors.
CO6: Set up testing strategies to evaluate performance characteristics of different types of sensors and transducers and develop professional skills in acquiring and applying the knowledge outside the classroom through the design of a real-life instrumentation system.
Weightage: 3
Designing experiments and setting up testing strategies involve critical thinking and problem-solving skills in the context of instrumentation and sensor applications.

PO3: Social Competence

CO3: Design experiments using sensors.
Weightage: 2 (moderate or partial relation)
Justification: While CO3 primarily focuses on the technical aspect of designing experiments using sensors, it indirectly contributes to social competence by fostering collaborative and communicative skills when working in a team setting.

PO4: Research-related Skills and Scientific Temper
CO4: Recognize the importance of instrumentation in various engineering and scientific applications.
CO5: Study various types of sensors and transducers.
CO6: Understand the working principles and characteristics of different sensors.
Weightage: 3 (strong or direct relation)
Justification: CO4 emphasizes the recognition of instrumentation's significance in scientific applications, while CO5 and CO6 delve into research-related skills by studying various types of sensors and understanding their working principles.

M. Sc-II (Physics) Semester-IV

CB Group –IV: 2. PHY 5404: LASER-II

Credit: 04 **Total No. of Lectures: 60**

Course Outcomes: After successful completion of this course the students will be able to-

CO1: Explain the fundamental principles of laser operation, including population inversion, stimulated emission, and amplification of light.

CO2: Describe different types of lasers, such as solid-state lasers, gas lasers, semiconductor lasers, and fiber lasers, and understand their applications.

CO3: Demonstrate knowledge of laser safety protocols, including the hazards associated with laser use and appropriate safety measures.

CO4: Identify and describe the components of a laser system, including gain medium, pump source, cavity, and optical elements.

CO5: Explain the principles of optical resonators and laser cavities and their role in laser emission.

CO6: Explore how lasers interact with different materials, including absorption, reflection, and transmission, and their applications in cutting, welding, and ablation.

CO7: Discuss various applications of lasers in science, technology, medicine, communication, and industry.

Unit 1: Laser characteristics and Resonators (15L)

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 (15L)

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 **(15L)**

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

Unit 4: Spectroscopic Instrumentation and applications **(15L)**

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

References:

1. B. Laud, Laser and Non linear optics, Wiley Eastern Ltd., (1991)
2. A.K. Ghatak and K. Thyagarajan, optical electronics, Cambridge University Press S.C Gupta Optoelectronic devices and systems, Prentice Hall of India.
3. (WH) Wilson and Hawkes: Optoelectronics, Prentice Hall of India.
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
7. Optical electronics: Wariv.
8. Laser spectroscopy: Demtroder.
9. Non-linear spectroscopy: Etekhov.
10. Introduction to modern optics: G. R. Flowles.

Mapping of Program Outcomes with Course Outcomes

Course Outcomes	Programme Outcomes								
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**
CO 1	3	2							
CO 2	3	2							
CO 3							3		
CO 4	3								
CO 5	3								
CO 6	3	2							
CO7					3				

Justification

CO1: Explain the fundamental principles of laser operation, including population inversion, stimulated emission, and amplification of light.

PO1: Disciplinary Knowledge: 3 (strong or direct relation)

Justification: Understanding the fundamental principles of laser operation directly contributes to disciplinary knowledge in laser technology.

PO2: Critical Thinking and Problem Solving: 2 (moderate or partial relation)

Justification: Explaining these principles involves critical thinking, but it may not be as extensive as in some other topics.

CO2: Describe different types of lasers, such as solid-state lasers, gas lasers, semiconductor lasers, and fiber lasers, and understand their applications.

PO1: Disciplinary Knowledge: 3 (strong or direct relation)

Justification: Describing different types of lasers and their applications contributes significantly to disciplinary knowledge in laser technology.

PO2: Critical Thinking and Problem Solving: 2 (moderate or partial relation)

Justification: Understanding the applications of different types of lasers requires critical thinking.

CO3: Demonstrate knowledge of laser safety protocols, including the hazards associated with laser use and appropriate safety measures.

PO7: Effective Citizenship and Ethics: 3 (strong or direct relation)

Justification: Demonstrating knowledge of laser safety protocols aligns with ethical considerations and responsible citizenship.

CO4: Identify and describe the components of a laser system, including gain medium, pump source, cavity, and optical elements.

PO1: Disciplinary Knowledge: 3 (strong or direct relation)

Justification: Identifying and describing components directly contributes to disciplinary knowledge in laser technology.

CO5: Explain the principles of optical resonators and laser cavities and their role in laser emission.
PO1: Disciplinary Knowledge: 3 (strong or direct relation)
Justification: Explaining the principles of optical resonators directly contributes to disciplinary knowledge in laser technology.

CO6: Explore how lasers interact with different materials, including absorption, reflection, and transmission, and their applications in cutting, welding, and ablation.
PO1: Disciplinary Knowledge: 3 (strong or direct relation)
Justification: Exploring laser-material interactions directly contributes to disciplinary knowledge in laser technology.
PO2: Critical Thinking and Problem Solving: 2 (moderate or partial relation)
Justification: Understanding the applications of laser-material interactions involves critical thinking.

CO7: Discuss various applications of lasers in science, technology, medicine, communication, and industry.
PO5: Trans-disciplinary Knowledge: 3 (strong or direct relation)
Justification: Discussing various applications of lasers involves knowledge beyond the discipline, contributing to trans-disciplinary knowledge.

M. Sc-II (Physics) Semester-IV

CB Group –IV: 3. PHY 5404: ENERGY STUDIES-II

Credit: 04 **Total No. of Lectures: 60**

Course Outcomes:

After completion of the course, the student should be able to:

CO1: Describe environmental impacts of renewable sources of energy.

CO2: Describe hydrogen as clean sources of energy.

CO3: Understand the concept of superconductors and fuel cell energy resources.

CO4: Understand the batteries and super capacitors.

CO5: Understand the challenges and solutions for integrating renewable energy sources into existing energy grids.

CO6: Explore the role of energy storage and grid management in facilitating renewable energy integration.

CO7: Explore methods for promoting energy literacy and awareness.

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, Cu_2S, $CuInSe_2$, CdTe etc. technologies for fabrication of single and polycrystalline silicon solar cells, amorphous silicon solar cells and tandem cells, solar cell modules, photovoltaic systems, space quality 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, drivingforce 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:

1. Solar energy conversion: The solar cell, by Richard C. Neville.
2. Photoelectrochemical solar cells – Suresh Chandra
3. Solar energy conversion – A. E. Dixon and J. D. Leslie.
4. Solar cells – Martin A. Green
5. Heterojunction and metal – semiconductor junctions – A.G. Milnes and D. L.Feucht.
6. Solid state electronic devices - B.G. Streetman.
7. Principles of solar engineering – Frank Kreith and Janf Kreider.
8. Direct energy conversion (4th edition) – Stanley W Angrist

Mapping of Program Outcomes with Course Outcomes

Course Outcomes	Programme Outcomes								
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO8**	**PO9**
CO 1	3								
CO 2	3								
CO 3	3								
CO 4	3								
CO 5		3							
CO 6		3							
CO7	3								

Justification

PO1: Disciplinary Knowledge
CO1: Describe environmental impacts of renewable sources of energy.
CO2: Describe hydrogen as clean sources of energy.
CO3: Understand the concept of superconductors and fuel cell energy resources.
CO4: Understand the batteries and supercapacitors.
CO7: Explain the field applications of solar energy.
Weightage: 3
All these course outcomes directly contribute to acquiring disciplinary knowledge in the field of renewable energy.
PO2: Critical Thinking and Problem Solving
CO5: Perform an initial design of a renewable energy system.
CO6: Use laboratories and emulators of renewable energy systems to analyze relevant issues.
Weightage: 3
Performing a design and analysing issues related to renewable energy systems involve critical thinking and problem-solving skills.
PO8: Environment and Sustainability
CO1: Describe environmental impacts of renewable sources of energy.
Weightage: 2
Describing environmental impacts aligns with the environmental and sustainability aspect of PO8.

M. Sc-II (Physics) Semester-IV

CB Group –IV: 4. PHY 5404: MICROCONTROLLER– II

Credit: 04 **Total No. of Lectures: 60**

Course Outcomes: After successful completion of this course the students will be able to-

CO1: Explain the architecture of microcontrollers, including the CPU, memory, input/output ports, and peripherals.

CO2: Write and debug programs for microcontrollers using a high-level programming language.

CO3: Interface microcontrollers with various peripherals such as sensors, actuators, displays, and communication modules.

CO4: Design and implement real-time systems using microcontrollers for applications with time-critical requirements.

CO5: Develop embedded systems using microcontrollers for specific applications, considering constraints such as power, memory, and processing speed.

CO6: Utilize debugging tools and techniques to identify and rectify errors in microcontroller programs.

CO7: Implement interrupt-driven programming for handling events and improving system responsiveness.

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:

1. Brian Evans, “Beginning Arduino Programming”, Springer, 2011
2. Michael J. Pont , “Embedded C”, Pearson Education, 2nd Edition, 2008
3. Raj Kamal, “ Embedded Systems – Architecture: Programming and Design”, TMH
4. Frank Vahid and Tony Givargis, “Embedded System Design”, Wiley

Mapping of Program Outcomes with Course Outcomes

Course Outcomes	Programme Outcomes								
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO8**	**PO9**
CO 1	3								
CO 2	3	3							
CO 3	3								
CO 4	3	3							
CO 5	3	3							
CO 6		3							
CO7		3							

Justification

CO1: Explain the architecture of microcontrollers, including the CPU, memory, input/output ports, and peripherals.

PO1: Disciplinary Knowledge: 3 (strong or direct relation)

Justification: Understanding microcontroller architecture is fundamental to disciplinary knowledge in microcontroller systems.

CO2: Write and debug programs for microcontrollers using a high-level programming language.

PO1: Disciplinary Knowledge: 3 (strong or direct relation)

Justification: Writing and debugging programs contribute directly to disciplinary knowledge in microcontroller programming.

PO2: Critical Thinking and Problem Solving: 3 (strong or direct relation)

Justification: Writing and debugging programs require critical thinking and problem-solving skills.

CO3: Interface microcontrollers with various peripherals such as sensors, actuators, displays, and communication modules.

PO1: Disciplinary Knowledge: 3 (strong or direct relation)

Justification: Interfacing microcontrollers with peripherals is a core aspect of disciplinary knowledge in microcontroller systems.

CO4: Design and implement real-time systems using microcontrollers for applications with time-critical requirements.

PO1: Disciplinary Knowledge: 3 (strong or direct relation)

Justification: Designing and implementing real-time systems directly contribute to disciplinary knowledge in microcontroller applications.

PO2: Critical Thinking and Problem Solving: 3 (strong or direct relation)

Justification: Designing real-time systems involves critical thinking and problem-solving skills.

CO5: Develop embedded systems using microcontrollers for specific applications, considering constraints such as power, memory, and processing speed.

PO1: Disciplinary Knowledge: 3 (strong or direct relation)

Justification: Developing embedded systems aligns with disciplinary knowledge in microcontroller applications.

PO2: Critical Thinking and Problem Solving: 3 (strong or direct relation)

Justification: Considering constraints and designing embedded systems require critical thinking and problem-solving skills.

CO6: Utilize debugging tools and techniques to identify and rectify errors in microcontroller programs.

PO2: Critical Thinking and Problem Solving: 3 (strong or direct relation)

Justification: Debugging programs involves critical thinking and problem-solving skills.

CO7: Implement interrupt-driven programming for handling events and improving system responsiveness.

PO2: Critical Thinking and Problem Solving: 3 (strong or direct relation)

Justification: Implementing interrupt-driven programming requires critical thinking and problem-solving skills.

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 must perform minimum 5 Experiments in each Semester:

1. Students will be able to understand the synthesis of nano materials and their application.
2. Students will be able to explain different physical and chemical properties of material.
3. Students will be able to explain relation between nanotechnology and biology.
4. Students will be able to discuss the various applications that can be expected from nanotechnology.
5. Students will be able to determine the characterization techniques for nano materials and nano thin films can classify different techniques depending on application area.

1	Deposition of metallic thin films by vacuum evaporation method
2	Deposition of thin films by spray pyrolysis method and thickness measurement by gravimetric method
3	Thin film formation by Electro-chemical deposition technique.
4	Deposition of thin films by spin coating method and resistance measurement.
5	Deposition of thin film by Dip Coating method and thickness measurement.
6	Thickness measurement of thin film by Tolansky method.
7	Study of optical absorption of thin film (UV-visible spectroscopy) and determination of particle size
8	Determination of particle size of thin film from X-ray diffraction.
9	Determination of grain size of thin film from SEM

10	Resistivity measurement of thin film by two probe method
11	Band gap energy of thin film
12	Crystal structure of thin film
13	Electron Spin Resonance (ESR)
14	Development of microstructures by photolithography.

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 must perform minimum 5 Experiments in each Semester:

1	Synthesis of Fe_2O_3 by sol-gel method
2	Preparation of Mn_3O_4 thin film by SILAR method
3	Synthesis of metal oxides by spray pyrolysis method
4	Synthesis of metal nanoparticles using green route
5	Band gap energy Measurement of thin films by UV-Visible spectrophotometer
6	Use of FT-IR for functional group identification (in CNT, graphene etc.)
7	Data plotting using Origin 8 software
8	Photoluminescence study of nano materials
9	Thickness measurement of thin film by weight difference method
10	Electro-deposition of Cu nano particle
11	Deposition of thin films by CBD method
12	Synthesis of ferrites by Co-precipitation method
13	Preparation of film by Doctor Blade method
14	Resistivity measurement of thin film by two probe method

15	Contact angle measurement of thin films
16	Structural properties of nano materials by XRD
17	Analysis of surface morphology by TEM
18	Morphological study by SEM

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: 3. PHY 5303: BIOMEDICAL INSTRUMENTATION-I &

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

Students must perform minimum 5 Experiments in each Semester:

1	Active filters for Bio-signals: Design and Filtering (Low pass and High pass filter)
2	Design and build a Notch filter (To reduce noise of 50 Hz).
3	ECG preamplifier-Instrumentation amplifier and testing.
4	Use of sphygmomanometers for measurement of blood pressure.
5	Concept of ECG, system and placement of electrodes ECG signal recording with surface Electrodes
6	Design and build a Wide/ Narrow band pass filters for measurement for Bio-signals
7	To study LVDT Characteristics.
8	Measurement of physical parameter using embedded system

M. Sc-II (Physics) Semester-III & IV

PHY 5305: SPECIAL LAB– I /PHY 5405: 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 must perform minimum 5 Experiments in each Semester:

1	Application of ultrasonic pressure transducer.
2	Temperature Characteristic of Thermistor
3	D to A converter circuit (R-2R & binary weighted).
4	V to F, converter as basic concept of ADC.
5	Op-amp as Instrumentation amplifier.
6	Characteristics and applications of photoelectric devices, LED, Photodiode
7	Study of Sample and Hold Circuits
8	F to V Converter using OP-AMP
9	Study of Data Acquisition System
	Measurement of temperature by thermocouple
11	Measurement of displacement using LVDT
12	Temperature Characteristic of strain gauges and its Application
13	Logarithmic amplifier using op-amp 741
14	Measurement of load using strain gauge based load cell

15	Measurement of temperature by RTD
16	Study of storage oscilloscope and determination of transient response of RLC Circuit
17	Determination of characteristics of a fiber-optic sensor
18	Study of data acquisition system using “lab view” software and test all signal points
19	Measurement of water level using strain gauge based water level transducer
20	Study of P, PI and PID controllers

M. Sc-II (Physics) Semester-III & IV

PHY 5305: SPECIAL LAB– I /PHY 5405: SPECIAL LAB– II

Credit: 04

List of Experiments:

(CB Group –II: 2. PHY 5304: LASER-I &

CB Group –IV: 2. PHY 5404: LASER-II):

Students must perform minimum 5 Experiments in each Semester:

1	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
2	Determine the wavelength of laser.
3	Thickness of sharp blade by LASER diffraction.
4	Study of laser beam diversity.
5	Determine of angle of divergence of a laser beam using He-Ne laser.
6	Determine of particle of size of lycopodium powder using semiconductor laser.
7	Determine the wavelength of laser light using semiconductor laser diffraction.
8	Determine the thickness of thin wire using LASER
9	Determine the wavelength of laser and calculate velocity and frequency of light.
10	Diffraction grating.

M. Sc-II (Physics) Semester-III & IV

PHY 5305: SPECIAL LAB– I /PHY 5405: SPECIAL LAB– II

Credit: 04

List of Experiments:

(CB Group –II: 3. PHY 5304: ENERGY STUDIES-I &
CB Group –IV: 3. PHY 5404: ENERGY STUDIES-II):

Students must perform minimum 5 Experiments in each Semester:

1	Solar Cell Characteristics
2	Recording the amount of sunlight receives throughout a day using Sunshine Recorder
3	Measure the solar radiation flux density using Pyrometer
4	Determining efficiency of lighting system/loads
5	Air mass Ratio
6	Bio-gas Production from Kitchen waste.
7	Energy Content in Wind.
8	Utilizing the latent heat released by the condensing water steam using Solar Still
9	Study of solar hot air collector/ solar dryer
10	Performance evaluation of box type and concentrating type solar cooker
11	Flat Plate Collector
12	PV – IV Characteristics
13	Find out the kinetics of photocatalytic reaction
14	Electrodeposition method

M. Sc-II (Physics) Semester-III & IV

PHY 5305: SPECIAL LAB– I /PHY 5405: SPECIAL LAB– II

Credit: 04

List of Experiments:

(CB Group –II: 4. PHY 5304: MICROCONTROLLER– I &
CB Group –IV: 4. PHY 5404: MICROCONTROLLER– II):

Students must perform minimum 5 Experiments in each Semester:

1	Use of Keil/Pinacle software.
2	Addition of two 16 bit numbers
3	Multiplication of two 8 bit numbers.
4	Write a program to find largest/smallest number in given block
5	Write a program to toggle bits of port 1 with delay which depends on value of number in R0
6	Memory block transfer from one location to another.
7	Find two's complement of given number.
8	LCD Interfacing
9	Keyboard Interfacing
10	ADC Interfacing
11	Temperature Sensor Using LM 35

M. Sc-II (Physics) Semester-III

PHY 5306: PROJECT– I

The student will have to perform the project course for 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.