Department of Physics
Date: 05/04/2023

To,
The Principal,
Tuljaram Chaturchand College of
Arts, Science & Commerce, Baramati

With ref notice no 456 dated 18/03/2023, we have arranged Physics BoS meeting on Saturday 8th April 2023 at 12.00 pm in the department of Physics in off-line as well as online mode.

This is for your kind information.

Head,
Department of Physics

Anekant Education Society's

Tuljaram Chaturchand College

of Arts, Science and Commerce, Baramati

(Autonomous Status)

(Affiliated to Savitribai Phule Pune University, Pune)

BOS Meeting Notice

The meeting of all the members of **Board of Studies in Physics** is arranged on **Saturday, 08/04/2023 at 12.00 p.m.** in the Department of Physics offline as well with online-mode. All the members are requested to attend and actively participate in the meeting.

AGENDA

1. Reading and confirmation of minutes of previous BOS meeting
2. To discuss and finalize syllabus for S.Y.B. Sc First semester
3. To discuss and finalise the syllabus for M. Sc. II first semester
4. Any other matter with the permission of the chairman.

Chairman
Board of Studies in Physics

Principal

Dr. AS Jagtap
13/4/

Anekant Education Society's

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MINUTES OF BOS MEETING

Meeting of Board of Studies in Physics was held on Saturday, 08/04/2023 at 12.00 p.m. in the Department of Physics offline as well with online-mode**. Chairman of BOS in Physics Prof. Dr. P.C. Pingale welcomed all the members present for the meeting. The meeting proceeded with the issues mentioned in the agenda.**

Following issues were discussed in the meeting and decisions were taken after the detailed discussion.

1. **To read and confirm the minutes of previous meeting.**
   The minutes of previous meeting were read and were unanimously confirmed by all the members.
2. **To design syllabus for S.Y.B.Sc. First semester class.**
   The syllabus of S.Y.B.Sc. First semester class designed by BOS members was discussed in meeting and finalized.
3. **To discuss and finalize the syllabus for M. Sc. II First semester**
   The members of BOS present for the meeting discussed and finalized the syllabus for M. Sc. II First semester
   Prof. Dr. K.R. Priolkar suggested reference book "Cryogenics And Measurement Of Properties Of Solids At Low Temperatures: S. Kasthurirengan R. Srinivasan, A.K. Raychaudhuri; Allied Publishers, 05-Apr-2008" for course Experimental Techniques in Physics
4. **Any other matter with the permission of the chairman.**
   All the subjects on the agenda were discussed in the meeting, so no issue was raised by any of BOS members.
5. **Students feedback on Syllabus were collected and appropriate suggestions were incorporated in the syllabus.**

Meeting was concluded with the vote of thanks by Dr. R.D. Mane.

Chairman
Board of Studies in Physics

Noted:

Coordinator
Internal Quality Assurance Cell
Tuljaram Chaturchand College of
Arts,Science and Commerce,
Baramati (Pune)-413102

IQAC Co-ordinator

Principal

Department of Physics

List of Physics BoS Members 2022-2025

Third Meeting 8th April 2023 at 12.00 pm

Sr. No.	Name	Designation	Signature
1	Prof. (Dr.) P. C. Pingale	Chainman BoS	
2	Prof. (Dr.) S. S. Veer	Member, Expert from SPPU, Pune	online.
3	Prof. (Dr.) K. Y. Rajpure	Member, Expert from Shivaji University, Kolhapur	—
4	Prof. (Dr.) K.R. Priolkar	Member, Expert from Goa University	
5	Mr. Subhash Zambare	Representative From Industry, Gaser Metacoat, Pune	online.
6	Mr. Swapnil Nardekar	Alumni and Research Scholar Jeju National University, South Korea	online.
7	Prof. (Dr.) A. E. Kalange	Member	
8	Dr. R. D. Mane	Member	
9	Dr. R. T. Sapkal	Member	
10	Dr. S. B. Kulkarni	Member	
11	Prof. (Dr.) S.H. Pawar	Member	—
12	Mr. S. B. Kakade	Member	
13	Dr. V. S. Mohite	Member	
14	Dr. S. J. Rajoba	Member	
15	Ms S E Bhosale	Member	
16	Dr. G. S. Lonkar	Member	
17	Mr.Mhaske .S.S	Member	
18	Mr.Malve .S.S	MSc-II	
19	Dhanashree Hole	TYBSc	
20	Adidtya Sorate	TYBSc	
21	Asmita Ghadge	MSc-II	

Pingale
HoD Physics
8.4.23

Anekant Education Society's

Tuljaram Chaturchand College

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Board of Studies in Physics

Names of BOS

1. Prof. Dr. Pandurang Pingale – Chairman
2. Prof. Dr. Ashok Kalange – Member
3. Dr. Ravindra Mane – Member
4. Dr. Ramchandra Sapkal – Member
5. Dr. Sachin Kulkarni – Member
6. Prof. Dr. Shivaji Pawar- Member
7. Mr. Sandip Kakade – Member
8. Dr. Vijay Mohite – Member
9. Dr. Swapnil Rajoba – Member
10. Ms. Shubhangi Bhosale - Member
11. Prof. Dr. Shivaji Veer- Member (Expert from SPPU, Pune)
12. Prof. Dr. Keshav Rajpure – Member (Expert from other university)
13. Prof. Dr. Priolkar – Member (Expert from other university)
14. Mr. Subhash Zambare - Member (Representative from Industry)
15. Mr. Swapnil Nardekar – Member (Alumni and Research Scholar)

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Faculty of Science

Department of Physics

Syllabus Submitted to Academic Council

For

M.Sc. in Physics

Academic Year 2022-2025

INDEX

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 Chaturchand 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. Physics and syllabus for M.Sc. II Physics Third semester as follows:

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M.Sc. II Course Structure

Semester-III

Course Number	Course Code	Course Name	Credit
1	PSPH 231	STATISTICAL PHYSICS	4
2	PSPH 232	SOLID STATE PHYSICS	4
3	PSPH 233	EXPERIMENTAL TECHNIQUES IN PHYSICS- I	4
4	PSPH 234	**CBCS Group I** A) NANO TECHNOLOGY I OR B) ENERGY STUDIES-I OR C) BIOPHYSICS-I OR D) PHYSICS OF THIN FILMS OR E) ELECTRONIC INSTRUMENTATION-I OR F) Density Functional Theory -I	4
5	PSPH 235	SPECIAL LAB– I	4
6	PSPH 236	SPECIAL LAB– II COMPUTATIONAL METHODS USING PYTHON	4
Total Credit			**24**

SYLLABUS (CBCS) FOR M.Sc. PHYSICS (W.E.F. June 2023)
Academic Year 2023-2024
M. Sc-II (Physics) Semester-III
PSPH 231: STATISTICAL PHYSICS

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

Learning Objectives:

- To do the calculation of macroscopic (bulk) properties of pure substances and mixtures from the microscopic properties of the molecules and their interactions.
- to derive the classical thermodynamics of materials in terms of the properties of their constituent particles and the interactions between them.
- To provide the information on the nature of statistical errors and variations of thermodynamic parameters.
- To evaluate the laws of classical thermodynamics for macroscopic systems using the properties of its atomic particles.

Learning Outcomes:

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

- Understand the relevant quantities used to describe macroscopic systems, thermodynamic potentials, and ensembles.
- Understand the concepts of statistical errors, partition functions by considering the different types of ensembles.
- Describe the consequences in classical and quantum statistics.
- Understand fermions, bosons and differentiate between FD statistics and BE statistics.
- Show an analytic ability to solve the statistical mechanics problems.

Unit 1: Statistical Description and Thermodynamics of Particles (15L)

Specification of the state of the system, Macroscopic and Microscopic states, Phase space, Statistical ensemble, Postulate of equal a priori probability, Probability calculations, Behaviour of density of states, Liouville's theorem(Classical)and constraints, Equilibrium conditions and constraints, Distribution of energy between systems in equilibrium, Approach to thermal equilibrium, Temperature, Heat reservoir, Sharpness of the probability distribution,

Dependence of the density of states on the external parameters, Equilibrium between interacting systems, Problems.

Unit 2: Classical Statistical Mechanics: (15L)

Ensembles,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, Grand-canonical ensemble, Physical interpretation of α, Chemical potential in the equilibrium state, Mean values and fluctuations in grand canonical ensemble, Thermodynamic functions in terms of the Grand partition function, Problems.

Unit 3: Applications of Statistical Mechanics and Quantum Distribution (18L)

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 Boltzmann statistics, B-E statistics, F-D statistics, comparison of M-B statistics, F-D statistics, and B-E statistics, Evaluation of the partition function, Partition function for diatomic molecules, Equation of state for an ideal gas, quantum mechanical paramagnetic susceptibility, Problems.

Unit 4: Ideal Bose and Fermi Systems: (12L)

Photon gas – i) Radiation pressure ii) Radiation density iii) Emissivity iv) Equilibrium number of photons in the cavity. Einstein derivation of plank's law, Bose-Einstein Condensation, Specific heat, Photon gas – Einstein and Debye's model of solids. Mean energy of fermions at absolute zero, Fermi energy as a function of temperature, Problems.

Reference books:

1. Fundamentals of Statistical and Thermal Physics, - F. Reif,
2. Fundamentals of Statistical Mechanics, B.B. Laud, New Age International Publication
3. Statistical Mechanics, R.K. Pathria, Bufferworgh Heinemann (2nd Edition)
4. Statistical Mechanics, K. Huang, John Willey and Sons (2nd Edition)
5. Statistical Mechanics, Satya Prakash and Kedar Nath Ram, Nath Publication (2008)

6. Statistical Mechanics by Loknathan and Gambhir

M. Sc-II (Physics) Semester-III

PSPH 232: SOLID STATE PHYSICS

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

Learning objectives:

The course gives an introduction to solid state physics, and will enable the student to employ classical and quantum mechanical theories needed to understand the physical properties of solids.

Learning outcomes:

- ✓ After successful completing this course, the student will able to
- ✓ Explain mechanical, electrical and magnetic properties of solid matter, and connect these to bond type.
- ✓ Explain simple theories for conduction of heat and electrical current in metals.
- ✓ Know the basic physics behind dia, para and ferromagnetism.
- ✓ Critically evaluate the approximations needed to build models to understand the solid state.

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.

The electrical conductivity at low temperature, The thermal conductivity of metals, Dielectric Properties of insulators. Macroscopic electrostatic Maxwell equations, Theory of Local Field, Theory of polarizability, Clausius- Mossotti relation, Long- wavelength optical modes in Ionic crystals.

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, Anti ferromagnetism: Neel temperature, Ferrimagnetism: Curie temperature, susceptibility of ferrimagnets.

Unit 4: Carbon and its oxides **(15L)**

Occurrence of carbon

Allotropes of carbon: Crystalline, Amorphous

Bonding in Carbon:

Carbon nanostructure: Fullerenes, Carbon Nanotube (CNTs), Carbon Nanofiber (CNFs), Graphene

Graphene: Applications

Reference Books:

1. Introduction to solid states Physics - Charles, Kittle 7th Edition
2. Introductory Solid States Physics – H. P. Myers
3. Solid States Physics - S.O. Pillai (latest edition)
4. Elementary Solid States Physics- M. Ali Omar
5. Problem in Solid State Physics – S.O. Pillai
6. Solid States Physics – A.J. Dekkar
7. Solid states Physics – Wahab
8. Solid State Physics: Neil W. Ashcroft, N. David Mermin
9. Solid States Physics – Ibach & Luth
10. Solid States Physics – C.M.Kacchawa
11. Wet Chemical Synthesis of Graphene for Battery Applications - Ida Johansen

M. Sc-II (Physics) Semester-III

PSPH 233: EXPERIMENTAL TECHNIQUES IN PHYSICS- I

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

Learning Objectives:

1. Mastered the assessment of reasonable experimental uncertainty in a variety of different measurements, and understood how to minimize that uncertainty.
2. Rigorously analyzed experimental data using accepted error analysis methodologies to verify theoretical predictions.

Learning Outcomes:

After completion of this course students will

1. Learn to operate and implement tools and techniques used by experimental physicists in their research.
2. Put the scientific process into practice by forming hypotheses, designing experiments, taking and analyzing data relevant to the experiment, and using this data to form concrete, well-supported conclusions.

Unit 1: Vacuum Physics (15L)

Important and fields applications of vacuum, kinetic theory of gases, impingement rate of molecules on a surface, average velocity of gas and mean free path, gas transport properties (thermal conductivity, viscosity and diffusion), various ranges of vacuum, gas conductance of a vacuum line, gas impedance of a vacuum line, pumping speed

Unit 2: Pumps for High Vacuum (HV) and Ultra High Vacuum (UHV) (15 L)

Principles of pumping concept, Types of vacuum pumps: Rotary, Molecular drag, Diffusion, Cryogenic, Getter, Titanium sublimation, Sputter ion, Orbitron

Unit 3: Vacuum Measurements and Low Temperature Technique (15 L)

Vacuum Gauges: Mc Leod, Thermocouple (Pirani), Penning, Hot cathode ionization (triode type), Bayard-Alpert leak detection: simple methods of LD, palladium barrier and halogen leak detectors.

Production of low temperatures: Adiabatic cooling, the Joule-Kelvin expansion, adiabatic demagnetization, 3He cryostat, the dilution refrigerator, principle of Pomerunchuk cooling, principle of nuclear demagnetization; measurement of low temperatures. (Throttling process)

Unit 4: Atomic Absorption Spectrometry (15 L)

Fundamentals: principle, basic equipment, operation, monochromator action, modulation; apparatus: double beam instrument, radiation sources, aspiration and atomization; interferences, control of AAS parameters, reciprocal sensitivity and detection limit techniques of measurement : routine procedure, matrix matching method

References:

1. Instrumentation: Devices and Systems, C.S. Rangan, G.R. Sarma and V.S.V. Mani, Tata Mc Graw Hill Publishing Co. Ltd.
2. Hand Book of Thin Film Technology, Maissel and Glange
3. Vacuum Physics and Techniques, T. A. Delchar, Chapman and Hall
4. Vacuum Technology, A. Roth, (North Holland, Elsevier Science B.V. 1990)
5. High Vacuum Techniques, J. Yarwood, (Chapman and Hall, Londong, 1967)
6. Experimental Principles and Methods below 1K, O. U. Lounasmaa, (Academic Press, Londonand, New York, 1974)
7. Thermometry at Ultra Low Temperatures, W. Weyhmann 10. Methods of Experimental Physics, Vol. II (R. V. Coleman, Academic Press, New York and London, 1974)
8. Cryophysics, K. Mendelssohn, Interscience (London, 1960)
9. Optical trapping and manipulation of neutral particles usingılasers, by Arthur Ashkin, Proceeding of National Academy of Sciences May 13, (1997) (4 (10) 4853-4860.
10. Atomic absorption spectroscopy - B.Welz (Verlag Chemie, New York) 1976.
11. Atomic absorption spectroscopy- R.J. Reynolds,K.Aldous & K.C. Thompson (CharlesGriffin and company Ltd. London) 1970.
12. Cryogenics and Measurement of Properties of Solids at Low Temperatures- R. Srinivasan, A.K. Raychaudhuri, S. Kasthurirengan (Allied Publishers) 2008

M. Sc-II (Physics) Semester-III

PSPH 234 (A): NANO TECHNOLOGY I

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

Learning objectives:

After completing this course students will be able to:

1. Learn about the background on Nanoscience
2. Understand the synthesis of nanomaterials and their application and the impact of nanomaterials on environment
3. Apply their learned knowledge to develop Nanomaterial's.

Learning outcomes:

After successful completing this course, the student will able to

- ✓ To understand the nature and properties of nanomaterials.
- ✓ To provide scientific understanding of application of nanomaterials and nanotechnology in agriculture, health and environmental conservation.
- ✓ To foundational knowledge of the Nanoscience and related fields.
- ✓ To make the students acquire an understanding the Nanoscience and Applications
- ✓ To help them understand in broad outline of Nanoscience and Nanotechnology
- ✓ Build models to understand the physical properties of different nano materials
- ✓ Critically evaluate the approximations needed to build models to understand the solid state.

Unit 1: Science at Nano scale **(15L)**

Nano and Nature:

Nanoscopic colours (Butterfly wings), Bioluminescence (fireflies), Tribology (Gec ko'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:

Vacuum Techniques (i) Thermal evaporation methods: Resistive heating, Electron Beam Evaporation, (ii) Sputtering system: Glow discharge, DC sputtering, Radio frequency sputtering, Magnetron sputtering, Ion beam sputtering.

Chemical Methods:

Chemical 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:

1 Nanotechnology principle and practices by Sulabha K. Kulkarni (2007).

2 Klabunde, K.J. (Ed.), "Nanoscale Materials in Chemistry", John Wiley & Sons Inc. 2001

3 Nalwa, H.S. (Ed.), "Encyclopedia of Nanoscience and Nanotechnology" 2004

4 Sergeev, G.B. Nanochemistry, Elsevier, B.V. 2010

5 Schmid, G. (Ed.), "Nanoparticles", Wiley-VCH Verlag GmbH & Co. KgaA.2004

6 Rao, C.N.R., Müller, A. and Cheentham, A.K. (Eds.),"Chemistry of Nanomaterials", Wiley – VCH. 2005

7 Carbon Nanotubes: Properties and Applications- Michael J. O'Connell.

8 Carbon Nanotechnology- Liming Dai.

9 Nanotubes and Nanowires- CNR Rao and A Govindaraj RCS Publishing.

M.Sc. II (Physics) Semester III

PSPH 234 (B): ENERGY STUDIES-I

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

Learning Objectives:

1. To create awareness about use of renewable energy sources.
2. To develop the technologies have low cost.
3. To create surrounding without pollution.
4. To use the hydrogen as clean source of energy.
5. To use storage devices like batteries and super capacitors.
6. To foster scientific attitude, provide in-depth knowledge of scientific and technological concepts of Physics.
7. To familiarize with recent scientific and technological developments.
8. To create foundation for research and development in Physics.
9. To help students to build-up a progressive and successful career in Physics.

Learning Outcomes:

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

1. Describe environmental impacts of renewable sources of energy
2. Describe hydrogen as clean sources of energy.
3. Understand the concept of superconductors and fuel cell energy resources.
4. Understand the batteries and super capacitors.

Unit 1:Environmental Impacts of Renewable Energy Sources (15L)

Energy flow diagram to the earth, Carbon cycle, Ecological Niche, Green house effect. Energy Consumption in India, Environmental degradation due to conventional energy production and utilization: Asian Brown Cloud Effect, Environmental impacts of Biomass energy, solar energy systems, wind energy and ocean thermal energy. Power co-generation.

Unit 2: Hydrogen as clean source of Energy (15L)

Sources of hydrogen, Thermodynamics of water splitting, Hydrogen production methods, Photoelectrolysis of water, Direct decomposition of water, Thermochemical production of hydrogen; Hydrogen storage methods: Conventional, Liquid Hydrogen storage, Metal Hydrides, and Cryo-adsorbing storage. \

Unit 3: Superconductors and Fuel Cell Technology (15L)

Cuprates and MgB_2 superconductors and their properties, superconducting wires, Role of superconductor in Electric generator, Magnetic energy storage devices and power transmission. Working principle of fuel cell, Components of fuel cell, EMF of fuel cell and polarization in fuel cells, Types of fuel cells, Advantages and disadvantages of fuel cell, Power generation with fuel cells.

Unit 4: Batteries and Supercapacitors (15L)

Energy storage systems, Faradaic and non-Faradaic processes, Types of capacitors and batteries, Comparison of capacitor and battery, Charge discharge cycles, experimental evaluation using Cyclic voltammetry and other techniques, Energy and entropy stored by capacitor, Electrochemical behavior of RuO_2, IrO_2 and mixed oxides, Energy density and power density, Applications for electric vehicle drive systems.

Reference Books :

1) Biological paths to self reliance- Russell E. Anderson.

2) Encyclopedia of Environmental Energy Resources- G.R. Chhatwal Vol. 1 & 2.

3) Renewable Energy Sources and their Environmental Impacts- S.A. Abbasi & N. Abbasi.

4) Electrochemical supercapacitors by B. E. Conway, Kluwer Academic Press.

5) Hydrogen as an Energy Carrier- T. Carl-Jochen Winter, Joachim Nitsch (eds.)

6) Advances in Renewable Energy Technologies- S.H. Pawar, and L. A. Ekal (eds.)

7) Handbook of Batteries and Fuel Cells- David Linden.

M. Sc-II (Physics) Semester-III

PSPH 234 (C): BIOPHYSICS-I

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

Learning Objectives:

The main aim of biophysics is to understand biological systems, while the aim of bioengineering is to make practical devices.

1. The perspective that biological processes can be understood from the interactions between and within the constituent molecules.
2. Students demonstrate the ability to analyze scientific problems, generate logical hypotheses, evaluate evidence, and tolerate ambiguity.
3. Students demonstrate the ability to apply knowledge of biophysics in one area to make appropriate intellectual connections and solve problems in other areas of biophysics or other fields.

Learning Outcomes:

1. **Foundations:** Examine biophysical scenarios using both a conceptual understanding of the core concepts of biology, chemistry, and physics, and calculations using the appropriate methods of mathematical, theoretical, and computational physics.
2. **Scientific Communication:** Effectively communicate biophysics content through both written reports and oral presentation.
3. **Experimental Methods:** Devise, implement, and refine an experiment to assess biophysics questions using appropriate statistical and computational methods to interpret the data and draw valid scientific conclusions.
4. **Applications:** Apply their physics and biophysics experience and knowledge to analyze new biophysical situations and to develop and refine experimental methods for new biophysical applications.

UNIT 1: Introduction of Biophysics (16L)

History of Biophysics, Concept of Biophysics and Physical properties applied to biology- Surface tension, Viscosity, adsorption, diffusion, osmosis, Definition for Biostatistics and Biometry, Cell: Animal and plant cell, types of cell, Functional aspects of cell membrane, cytoplasm, nucleus, mitochondria and chloroplast, Protein structure (Primary and Secondary), amino acid structure, Genetic code- symmetry, DNA structure, Photosynthesis process:- electron transport, Gibbs's free energy, Redox couple, Redox potential, Oxidation and reduction, Examples of redox potential in biological system.

UNIT 2: Bio-potentials (15L)

Bioelectric signals: structure of neuron, resting potential, action Potential, Nernst equation, Bioelectrodes- Half-cell potential, polarizable and non-polarizable electrodes,

Microelectrode- metal andglass electrode, Study of Cardiovascular system, Compound action potential of human body-ECG (Electrocardiography), Electrodes for ECG

UNIT 3: Bio-instruments (14L)

Basic principle, Construction and working of colorimeter, spectrophotometer, PH meter and Centrifuge measurement. Electron Microscope: SEM, TEM.

UNIT 4: Radiation Biophysics (15L)

Definition, Units of Radioactivity and radiation doses, Types of radiation (Ionizing and non- ionizing), radio immunoassays. Applications: PET (Positron Emission Tomography), NMR (Nuclear Magnetic Resonance), MRI(Magnetic Resonance Imaging Techniques), Ultrasonography, CT (Computed Tomography) Scan.

Reference books:

1. Introduction to Biophysics - by P. Narayanan.New Age P.
2. Medical Instrumentation - by Khandpur, TMH
3. Laboratory Manuals of Biophysics Instruments - by P.B. Vidyasagar
4. Biophysics -by Vatsala Piramal, Dominant Publisher and Distributors, New Delhi-110002
5. Textbook of Biophysics - by R.N. Roy
6. Photosynthesis - by Hall and Rao.
7. Introduction to Biomedical Equipment Technology (Fourth Edition) by-Joseph J.Carr
8. Text Book of Bio-medical Electronics-by S.S. Agrawal

M. Sc-II (Physics) Semester-III
PSPH 234 (D): PHYSICS OF THIN FILMS

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

Learning objectives:

1) This course introduces students to thin film growth methodologies, to the chemical and physical mechanisms that control thin film deposition and to the applications of thin film growth for the engineering of multilayer thin film structures.
2) Evaluate and use models for nucleating and growth of thin films

Learning Outcomes:

1) Acquire knowledge in processing of different thin film structures (elementary materials and compounds in crystalline, polycrystalline, nanocrystalline, and amorphous forms)
2) Develop and engineer thin film materials, and contribute in advancement of thin film technologies that are applicable in industry, research, and science
3) Develop ability to design various thin films and tailor their properties by controlling the deposition parameters of a selected deposition technique

Unit 1: Introduction to thin films **(15 L)**

Overview of vacuum techniques, Comparison of thin and thick films, Theory of growth of thin films: Nucleation, condensation, Frank-Van der Merwe model, Volmer-Weber model, Stranski-Krastanov model, Capillarity model, Atomistic model, comparison of models, various stages of film growth.

Unit 2: Deposition Techniques and Measurement of thickness **(15 L)**

Physical methods: Vacuum Techniques (i) Thermal evaporation methods: Resistive heating, Electron Beam Evaporation, (ii) Sputtering system: Glow discharge, DC sputtering, Radio frequency sputtering, Magnetron sputtering, Ion beam sputtering. Chemical Methods: Chemical vapor deposition system (CVD), Chemical bath deposition: Ionic and solubility products, Preparation of binary semiconductors, Electrochemical deposition: Deposition mechanism and Preparation of compound thin films, Spray pyrolysis: Deposition mechanism and preparation of compound thin films. Doctor blade technique, Dip coating and Spin coating, Photolithography, Electron–beam deposition, Pulsed Laser Ablation, Tolansky technique,

Talystep (styles) method, Quartz crystal microbalance, Stress measurement by optical method, Gravimetric method.

Unit 3: Properties of thin films **(15 L)**

Electrical Properties: Source of Resistivity in Metallic conductors, Influence of thickness on the resistivity of thin films, Hall Effect & Magnetoresistance in thin films, Fuch-Sondhemir theory, TCR and its effects. Mechanical properties: Adhesion & its measurement with mechanical and nucleation methods, stress measurement by using optical method. Optical properties: Absorption and transmission.

Unit 4: Applications of Thin Films **(15 L)**

Resistors, capacitors, Junction devices (Metal semiconductor junction) Solar cells, ICs, Optical coating, Thin film sensors (gas and humidity), Thin films for information storage, electro acoustics and telecommunication.

Reference books:

1. Hand book of Thin Film Technology: Maissel and Glang, (Mc Graw Hill)
2. Thin Film Phenomena: K. L. Chopra, (Mc Graw Hill)
3. Material Science of Thin Films: M. Ohring, (Academic Press)
4. Thin Film Process: J. L. Vossen and Kern, (Academic Press)
5. Vacuum Technology (2 nd revised edition), A. Roth, (North Hollad)

M. Sc-II (Physics) Semester-III

PSPH 234 (E): ELECTRONIC INSTRUMENTATION-I

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

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 (15L)

1.1 General configuration and functional description of measuring instruments with examples of instruments and their functional description. (Ref.1: #2.1 to 2.4).

1.2 Input output configuration of measuring instruments, and methods of correction of unwanted inputs. (Ref.1: #2.5)

1.3 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)

1.4 Errors in measurement, Types of errors, sources of errors (Ref.9)

References: 1, 3, 8

Unit 2: Transducers (15L)

2.1 Displacement Measurement: a) Resistive Transducers (variable resistance, Strain gauges, Electrical strain gauges), b) Inductive transducers (LVDT, variable reluctance), c) Capacitive transducers

2.2 Pressure Measurement: a) Non-Elastic pressure transducers (Barometer, Manometer) b) Elastic pressure transducers (Diaphragm, Bellows, Bourdon gauge), c) Electrical pressure transducers (Piezoelectric transducer)

2.3 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: 8

Unit 3: Signal Conditioners, Data acquisition and conversion (15L)

3.1 Signal conditioners: Op-amps, instrument amplifier, bridge, phase sensitive detector

3.2 Data Acquisition System (DAS): DAS, hardware, Single channel DAS, Multi channel DAS

3.3 Data Converters: D to A and A to D converters, Data loggers,

References: 8

Unit 4: Indicators, Display system and Oscilloscope (15L)

4.1 Digital display system and Indicators

4.2 Classification of Displays

4.3 Light Emitting Diodes (LED)

4.4 Liquid Crystal Display (LCD).
4.5 Printers: principle of Laser printers
4.6 Cathode Ray Oscilloscope (CRO)

References: 8

Reference Books:

1. Measurement systems- applications and design. 4th E. O. Doeblin.
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.
6. Process controlled instrumentation by C. D. Johnson.
7. Sensors and transducers. Patrabnis.
8. Electronics Instrumentation. Kalsi (Tata McGraw-Hill)

M.Sc. II (Physics) Sem-III
PSPH 234 (E): Density Functional Theory -I

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

Learning Objectives:

The students will be expected to: explain key concepts in density-functional theory, perform derivations involving density functional,

Learning Outcomes:

- The course is designed for materials scientists, chemists, physicists, and applied mathematicians, who are seeking to know both the basic concept and certain advanced topics in density functional theory.
- Density functional theory (DFT) is widely used nowadays in both industry and academia to simulate various properties of materials and molecules, such as electronic properties, crystal structures, and chemical reactions.
- In this course, Students will learn both the theoretical and numerical aspects of DFT.
- We will also learn how to perform DFT calculations on simple

Unit 1: Basics Of Solids State Physics (15L)

Bravais lattice, reciprocal space, Bloch theorem, and Brillouin zone, Pseudopotentials: norm-conserving pseudopotential, nonlinear core correction, and project-augmented wave technique, Numerical aspects of Kohn-Sham DFT: smearing, k-point sampling, Gaussian basis set, and plane-wave basis set, Geometry optimization: Hellmann-Feynman force, Pulay force, and stress, Ab initio molecular dynamics, Physical meaning of Kohn-Sham eigenvalues, and fractional number of electrons.

Unit 2: Basic concepts in Density Functional Theory (15L)

Hohenberg-Kohn theorem, Levy-Lieb constrained-search formulation of DFT, Kohn-Sham equation, and spin-polarized DFT.

Unit 3: Properties of exchange and correlation function (15L)

Exchange correlation functionals: local density approximation, hybrid exchange-correlation functional, self-interaction correction, Orbital-dependent exchange correlation functionals: optimized effective potential, exact exchange, and random phase approximation.

Unit 4. Applications

Installation of quantum espresso, Input file generation of simple material, Input file for k path finder , SCf calculation, NSCf calculation, Band calculations, Dos calculations, PDOS calculation

References:

1. “Density-Functional Theory of Atoms and Molecules” by Parr and Yang.
2. “The ABC of DFT”, by Kieron Burke, http://dft.uci.edu/doc/g1.pdf
3. “Modern Quantum Chemistry, Introduction to Advanced Electronic Structure Theory”, Szabo and Ostlund.
4. “A bird’s-eye view of density-functional theory” by K Capelle, Brazilian Journal of Physics 36, pp 1318 (2006).
5. “Challenges for Density Functional Theory”, Cohen et al., Chemical Review 112, pp 289 (2012).
6. “Iterative minimization techniques for ab initio total-energy calculations: molecular dy-namics and conjugate gradients”, Payne et al., Review of Modern Physics 64, pp 1045 (1992).
7. “Orbital-dependent density functionals: theory and applications” K¨ummel and Kronik, Review of Modern Physics, 80, pp 3 (2008)
8. “Random-phase approximation and its applications in computational chemistry and materials science”, Ren et al., Journal of Materials Science 47, pp 7447 (2012).

M. Sc-II (Physics) Semester-III

PSPH 234 (F): ASTROPHYSICS -I

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

Course Outcomes After learning this course student will be able to -

1. Apart from developing liking and inquisitiveness in this subject, students can take it up as a career in astronomy and astrophysics.
2. Provide the much-needed manpower for research in this field and contribute in major upcoming projects in Astronomy and Astrophysics.

UNIT 1: OVERVIEW OF THE UNIVERSE (15 L)

1.1 Qualitative description of interesting astronomical objects

1.2 Length, Mass and Timescales, Physical conditions in different objects,

1.3 Evolution of structures in the universe, red-shift.

1.4 Radiation in different bands, Brightness, Radiant Flux and Luminosity,

1.5 Measurement of Astronomical Quantities, Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature,

1.6 Celestial Sphere, Astronomical Coordinate Systems, Measurement of Time.

UNIT 2: THE STELLAR STRUCTURE AND EVOLUTION (15 L)

2.1 Solar Photosphere, Solar Atmosphere, Chromosphere, Corona, Solar Activity,

2.2 Basic Composition of Interstellar Medium, Formation of Protostar, Jeans Criterion Fragmentation of Collapsing Clouds from Protostar to Pre-Main Sequence

2.3 Hayashi Line, Cosmic Abundances, Stellar Nucleosynthesis, Evolution of Stars, Supernovae.

2.4 Basic Familiarity with Compact Stars, Equation of State and Degenerate Gas of Fermions.

2.5 Theory of White Dwarf, Chandrasekhar Limit, Neutron Star.

2.6 Stellar Spectra and classification: Spectral Types and their Temperature Dependence, Black Body Approximation.

UNIT 3: GALAXIES (15 L)

3.1 Galaxy Morphology, Milky Way Galaxy, Spiral and Elliptical galaxies,

3.2 Galaxies as self-gravitating systems; spiral structure, Supermassive black holes, Q

3.3 The Nature of the Central Engine, Unified Model of the Various Active Galaxies.

3.4 Nature of Rotation of the Milky Way,

3.5 Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy

3.6 Nature of the Spiral Arms, Stars and Star Clusters of the Milky Way,

UNIT 4: ASTRONOMY & ASTRONOMICAL INSTRUMENTS (15 L)

4.1 Concept of time, Magnitudes: apparent and absolute, constellations.

4.2 Observation of Sun, Eclipses, Moon, planets, meteor showers, transits, occultation's.

4.3 Optical telescopes, mounts, light gathering power, magnification, and resolution.

4.4 Spectroscopes, CCD camera, photometer, filters, photometry, Radio telescopes, interferometry UV, IR, X-ray and Gamma ray telescopes.

REFERENCE BOOKS:

1. Modern Astrophysics, B. W. Carroo and D. A. Ostlie, (Addison-Weseley).
2. The physical universe, F. Shu, (University Science books).
3. The Physics of Astrophysics, Volume I and II, F. Shu, (University Science books).
4. Astrophysics for Physicists, Arnab Rai Choudhari, (Cambridge University Press).
5. Astronomy and Astrophysics, A.B. Bhattacharya, S. Joardar, R. Bhattacharya (Overseas press)
6. Astrophysical Techniques, C.R. Kitchin, 6th Edition

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

PSPH 235: SPECIAL LAB– I / PSPH 245: SPECIAL LAB– III

Credit: 04 **No of practicals: 10**

List of Experiments: (Students must perform Any 8 Experiments)

(CB Group –I: PSPH 234 (A): NANO TECHNOLOGY-I &

CB Group –II: PSPH 244 (A): NANO TECHNOLOGY-II):

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

PSPH 235: SPECIAL LAB– I / PSPH 245: SPECIAL LAB– III

Credit: 04 **No of practicals: 10**

Learning objectives:

1) Understand the principle in measuring the thickness of thin films and to find a suitable method for measuring the thickness of thin films.

2) Understand, analyze and treating the Structural defects in thin films.

3) Understanding the mechanical behavior of thin films.

Learning Outcomes:

1) Students will have acquired necessary skills for working in research institutes.

2) Students will have acquired necessary skills and expertise to work in industry related to materials processing and quality control

List of Experiments:

(CB Group –I: PSPH 234 (D): PHYSICS OF THIN FILM-I &

CB Group –II: PSPH 244 (D): PHYSICS OF THIN FILM-II):

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

PSPH 235: SPECIAL LAB– I / PSPH 245: SPECIAL LAB– III

Credit: 04 **No of practicals: 10**

Learning Objectives:

1. To develop analytical abilities toward real life problems
2. To familiarize with recent scientific and technological developments
3. To enrich knowledge through problem-solving, hands-on training, study visits, projects etc

Learning Outcomes:

After successfully completing this laboratory course, the students will be able to do the following:

1. Demonstrate an ability to collect data through observation and/or experimentation and interpreting data.
2. Demonstrate a deeper understanding of abstract concepts and theories gained by experiencing and visualizing them as authentic phenomena.
3. Acquire the complementary skills of collaborative learning and teamwork in laboratory settings.

List of Experiments:

(CB Group –II: PSPH 234 (E): ELECTRONIC INSTRUMENTATION-I&

CB Group –IV: PSPH 244 (E): ELECTRONIC INSTRUMENTATION-III) :

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

Additional Activity (Any one Activity equivalent to two experiments)

Students must perform at least one additional activity out of two activities in addition to eight experiments mentioned above. Total Laboratory work with additional activities should be equivalent to ten experiments.

1. **Simulation/Demonstration/Mini Project**
2. **Industrial Visit / Study Tour / Field visit**

M. Sc-II (Physics) Semester-III

PSPH 236: SPECIAL LAB– II COMPUTATIONAL METHODS USING PYTHON

Credit: 04 **No of practicals: 10**

Course Objectives:

1. To understand the object-oriented concepts using Python in problem solving.
2. To understand the fundamentals of Python programming concepts and its applications.
3. To elucidate solving Physics problems using Python programming language
4. To train the students in solving computational physics problems

Course Outcomes:

1. Apply the knowledge of Physical science to solve complex real-life Physics problems.
2. Identify, formulate, review research literature, and analyze complex Physics problems and reaching substantiated conclusions.
3. Use research-based knowledge and research methods, including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusion.
4. Demonstrate knowledge and understanding of the Physics and Python programming principles and apply these to one's own project work.

List of Experiments:

1	Write a program of Bisection method of finding a root
2	Write a program of Newton's method of finding a root
3	Write a program that uses the trapezoid method to return the integral of a function over a given range
4	Write a program of Simpson's Method
5	Plot sine and cosine over the range $\{-\pi, \pi\}$
6	Write a program of Runge-Kutta Methods
7	Write a program to find prime number
8	Write simple Python program using operators: a) Arithmetic Operators b) Logical Operators
9	Write a Python program to print out the first N numbers in the Fibonacci sequence
10	A ball is thrown upwards with initial velocity vo = 5m/s and an initial height yo = 3 m. Write a Python program to plot y(t) from t = 0 until the ball hits the ground.
11	Program to plot the motion of a mass and spring on a horizontal surface with friction .

12	The number of radioactive atoms that decay in a given time period is proportional to the number of atoms in the sample. Write a program that uses Euler's method to plot N(t). Have your program also plot the exact solution, $N(t) = Noe^{-\lambda t}$, for comparison.
13	Program to plot the motion of a simple pendulum
14	Program to plot the motion of a spring pendulum
15	Use of Monte Carlo method
16	Program to plot the wave motion

Additional Activity (Any one Activity equivalent to two experiments)

Students must perform at least one additional activity out of two activities in addition to eight experiments mentioned above. Total Laboratory work with additional activities should be equivalent to ten experiments.

1. **Simulation/Demonstration/Mini Project**
2. **Industrial Visit / Study Tour / Field visit**