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

Syllabus Submitted to Academic Council

For

M.Sc. in Physics

From Academic Year 2022-2023

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. I Physics second semester as follows:

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M.Sc. I & II Course Structure

M.Sc.-I

Semester-I

Course Number	Course Code	Course Name	Credit
1	PSPH 111	Mathematical Methods in Physics	4
2	PSPH 112	Classical Mechanics	4
3	PSPH 113	Quantum Mechanics-I	4
4	PSPH 114	Electronics	4
5	PSPH 115	Electronics Laboratory-I	4
6	PSPH 116	Basic Physics Laboratory-I	4
Total Credit			**24**

Semester-II

Course Number	Course Code	Course Name	Credit
7	PSPH 121	Physics of Semiconductor Devices	4
8	PSPH 122	Atoms, Molecules & Laser	4
9	PSPH 123	Quantum Mechanics-II	4
10	PSPH 124	Classical Electrodynamics	4
11	PSPH 125	Electronics Laboratory-II	4
12	PSPH 126	Basic Physics Laboratory-II	4
Total Credit			**24**

SYLLABUS (CBCS) FOR M.Sc. PHYSICS (W.E.F. June 2022)

Academic Year 2022-2023

M. Sc-I (Physics) Semester-II

PSPH 121: Physics of Semiconductor Devices

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

Learning Objectives

To understand the students how the semiconductor behaves when doped with trivalent and penta-valent impurities.

1. To understand what direct and indirect band gap materials is.
2. To understand how the energy bands behaves in forward and reverse bias PN junctions.
3. What's happens when semiconductor material is kept in contacts with metal.
4. What's happens when semiconductor material is kept in contacts with metal oxides.

Learning outcomes:

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

1. The students should able to utilize semiconductor models to analyze carrier densities and carrier transport.
2. The students should able to understand and utilize the basic governing equations to analyze semiconductor devices.
3. The students should able to understand and analyze the inner working of semiconductor p-n diodes, Schottky barrier diodes and new semiconductor devices.
4. The students should able to explain how the metal-semi conductor contacts will occur.
5. The students should able to explain the working principle of a junction transistor.
6. The students should able to discuss conduction in semiconductors – charge carriers, intrinsic/extrinsic, p-type, n-type.
7. The students should able to Know the physics of semiconductor junctions, metal-semiconductor junctions and metal-insulator-semiconductor junctions.
8. The students should able to apply the knowledge of semiconductors to illustrate the functioning of basic electronic devices.

Unit 1: Properties of Semiconductors **(15L)**

An introduction to semiconductors, their crystal structure and their band structure, Intrinsic and extrinsic semiconductors, Charge carriers and their effective masses. Carrier concentration at thermal equilibrium for intrinsic and doped semiconductors, Carrier energy distribution, applications of Fermi factor to semiconductors, Density of available states, Excess carriers, carrier transport phenomena, Recombination Process, Basic equation for semiconductor device operation.

Unit 2: PN Junction (15L)

Basic device technology, Depletion region and depletion capacitance, Current Voltage Characteristics: Ideal case, Shockley Equation, Generation recombination process. High injection condition, Diffusion capacitance, Narrow base diode, Junction breakdown.

Unit 3: Metal–Semiconductor and Semiconductor Heterojunctions Devices (15L)

The Schottky Barrier Diode, Qualitative Characteristics, Ideal Junction Properties, Nonideal Effects on the Barrier Height, Current–Voltage Relationship, Comparison of the Schottky Barrier Diode and the P-N Junction Diode, Metal–Semiconductor Ohmic Contacts, Ideal Nonrectifying Barrier, Tunneling Barrier, Specific Contact Resistance, Heterojunctions Heterojunction Materials, Energy-Band Diagrams, Current–Voltage Characteristics

Unit 4: Metal Insulator Semiconductor Devices (15L)

Schottky effect, Energy Band relation at metal semiconductor contact, Ideal condition and surface states depletion Layer, General expression for barrier height Current, Transport Theory in Schottky barrier, Thermionic Emission Theory, Diffusion theory, Measurement of Schottky barrier height current voltage measurement

Reference Books:

1. Physics of Semiconductor Devices – S.M. Sze
2. Physics Solid State Devices – Streetman B.B.
3. Semiconductor Physics and Devices- Donald A Neamen 4e
4. Semiconductor Physics – Smith
5. Fundamentals of Semiconductor Devices – J. Lindmayer and C.Y. Wrigley
6. Physics of Semiconductor Devices – Michael shur
7. Introduction to Semiconductor devices – K.J.M. Rao

M. Sc-I (Physics) Semester-II

PSPH 122: Atoms, Molecules & Laser

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

Learning Objectives:

1. **At the end of the session, the student should be able to know** Rotational and vibrational spectra.
2. **At the end of the session, the student should be able to know** Quantum numbers associated with vector atom model.
3. **At the end of the session, the student should be able to know** Zeeman, Paschen and Stark effect.
4. **At the end of the session, the student should be able to know** features of Laser, Einstein coefficients and possibility of amplification and different types of lasers.

Learning outcomes:

On successful completion of this course student will be able to do the followings.

1. Understand the concept of atomic spectra origin of spectral line, fine and hyperfine structure, Zeeman Paschen and stark effect.
2. Describe the coupling scheme metastable state, types of pumping and different applications of laser.
3. Understand the concept of Frank Condon principle, ESR, NMR etc.
4. Understand the concept of different types of lasers
5. Determine the parameters of a laser for a specific application.
6. Demonstrate quantitative problem-solving skills in all the topics covered.

Unit 1: Atoms **(15)**

Introduction, Atomic structure and spectra, quantum states of an electron in an atom, [Exclusion principle and electronic configuration, electron spin, Hund's rule, Maximum multiplicity], Coupling scheme, origin of spectral lines, spectrum of He and alkali atoms, fine and hyperfine structure, isotropic shift, Zeeman and Paschen effect, Stark effect, Selection rule, Problem solving.

Unit 2: Molecules **(15)**

Bonding mechanism in molecules, Molecular orbital methods, Valence band method, Molecular Spectra – Rotational and vibrational spectra for diatomic molecules, Electronics spectra of diatomic molecules, vibration course structure, vibrational analysis of band system, Frank – Condon principle, Dissociation energy and dissociation products, rotational fine structure of electronic vibration transitions, electronic angular momentum in diatomic molecules, Problem solving.

Unit 3: Resonance Spectroscopy (15)

(a)ESR- Principles of ESR, ESR spectrometer, total Hamiltonian, hyperfine structure.
(b)NMR-Magnetic properties of nucleus, resonance condition, NMR instrumentation, relaxation process, chemical shift, applications of NMR.

Unit 4: Lasers and its applications. (15)

Introduction, Basic of LASERs (Absorption, spontaneous & Stimulated emission, population inversion), metastable state, Types of Pumping, Gain, Einstein's coefficient, threshold condition, Different types of lasers, He-Ne laser, CO_2 laser, Nd-YAG, Ruby, Excimer laser, Dye laser, semiconductor laser, Applications of Lasers: 1. Industrial applications- Cutting, moulding, melting, welding, drilling, 2. Medical applications-Skin therapy, Laser eye surgery, 3. Holography- principle & construction, Problem solving.

Reference Books

1. Molecular structure and spectroscopy, G. Aruldas
2. Fundamentals of molecular spectroscopy, Collin N, Banwell & Elaine M.
3. Atomic and molecular Physics, J. B. Rajam
4. Principles of Laser and their applications, Rhods
5. An introduction to laser theory and application, M. N. Avdhanulu-S. Chand Publication
6. Lasers, A. G. Sigman-Oxfaord University Press 1986.
7. An Introduction to Lasers Theory and Applications, M N Avadhanulu

M. Sc-I (Physics) Semester-II

PSPH 123: Quantum Mechanics-II

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

Learning Objectives:

1. Students should learn a systematic introduction to fundamental non-relativistic quantum mechanics.
2. Students should learn about partial wave analysis.
3. Students should learn approximate methods for solving the Schrödinger equation (the variational method, perturbation theory, Born approximations)
4. Students apply principles of quantum mechanics to calculate observables on known wave functions

Learning outcomes:

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

1. Students apply general experience with non-relativistic quantum mechanics that is useful for further studies in theoretical physics, as well as nanotechnology
2. Students apply the variational method, time-independent perturbation theory and time-dependent perturbation theory to solve simple problems
3. . Students should understand and learn theoretical aspects at Quantum Level.
4. Students should know more about the insight of the microscopic world.
5. Students should understand the behaviour of particles under Classical and Quantum conditions.

Unit 1: Approximation Methods **(15)**

Revision: Time-independent Perturbation theory: Nondegenerate, degenerate.
Time dependent Perturbation theory: Transition amplitude, 1^{st} and 2^{nd} order, selection rules, Fermi's golden rule, Harmonic perturbation, dipole approximation, Einstein coefficient for spontaneous emission.

Unit 2: Variational method and WKB approximation: **(15)**

Basic principles and application to hydrogen atom, helium atom.

WKB approximation: General formalism, Bound states for potential wells – with no rigid walls, with one rigid wall, with two rigid walls. Bohr's quantization condition, Tunnelling through a potential barrier, Problems.

Unit 3: Theory of Scattering **(15 L)**

Introduction to scattering: Laboratory and CM reference frames; scattering amplitude, differential scattering cross section and total scattering cross section: scattering by spherically symmetric potentials, Method of partial waves, Phase shift, Ramsauer-Townsend effect, scattering by a perfectly rigid sphere and by square well potential, Yukawa potential. The Born approximation, applications, and validity of the Born approximation. Problems

Unit 4: Symmetry in Quantum Mechanics **(15 L)**

Symmetry Parity, Identical particles, Symmetric and antisymmetric wave functions, Slater determinant, Symmetric and antisymmetric spin wave functions of two identical particles, Collisions of identical particles, Pauli's exclusion principle and Slater determent. Introduction to DFT (Density Functional Theory), Problems

Reference Books:

1. Quantum Mechanics by Nouredine Zettili, A John Wiley and Sons, Ltd.
2. Modern Quantum Mechanics by J. J. Sakurai.
3. A Text-book of Quantum Mechanics by P. M. Mathews and K. Venkatesan.
4. Quantum mechanics by A. Ghatak and S. Lokanathan.
5. Quantum Mechanics by L. I. Schiff.
6. Quantum Physics by R. Eisberg and R. Resnick.
7. Introduction to Quantum Mechanics by by David J. Griffiths.
8. Introductory Quantum mechanics by Granier, Springer Publication.
9. Introductory Quantum Mechanics by Li boff, 4th Edition, Pearson Education Ltd.
10. Principles of Quantum Mechanics by Shankar R. IInd Edition (Plenum, 1994).

M. Sc-I (Physics) Semester-II

PSPH 124: Classical Electrodynamics

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

Learning Objectives:

1. Students should learn how to use Maxwell equations in analysing the electromagnetic field due to time varying charge and current distribution.

2. Students should learn the nature of electromagnetic wave and its propagation through different media and interfaces.

3. Students should learn charged particle dynamics and radiation from localized time varying electromagnetic sources.

Learning outcomes:

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

1. Understand the concept of multipole expansions and deeper meaning of Maxwell's equations
2. Understand the technique of deriving formulae for the electromagnetic waves in stationary and conducting medium
3. Calculate the electromagnetic radiations from moving charges,taking into account retardation effects and make a detailed account for Gauge transformations
4. Embracing the concepts of special relativity as emerged through the laws of electrodynamics

Unit 1. Multipole expansions, material media and Time varying fields: (16L)

Multipole expansions for a localised charge distribution in free space, Linear quadrupole potential and field, static electric and magnetic fields in material media, Boundary conditions. Time dependents field, Faraday's law for stationary and moving media, Maxwell's displacement current, Differential, and Integral forms of Maxwell's equations, Maxwell's equations for moving medium.

Ref.1, Ref.2, Ref.3, Ref.4,Ref.6.

Unit 2. Energy, Force and Momentum relations in electromagnetic fields: (10L)

Energy relations in quasi-stationary current systems, Magnetic interaction between

two current loops, Energy stored in electric and magnetic fields, Poynting's theorem, Conservation laws.
Ref;1, Ref;2, Ref;4, Ref;5, Ref;6, Ref;8

Unit 3. Electromagnetic and Inhomogeneous wave equations: (20L)

Electromagnetic wave equations, Electromagnetic plane waves in stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Oblique incidence), Electromagnetic waves in conducting medium, Skin effect and skin depth. Inhomogeneous wave equations, Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D'Alembertian operator, Hertz potential and its use in computation of radiation fields, Dipole radiation
Ref.1, Ref.2,Ref.4, Ref.5, Ref.8.

Unit 4. Relativistic Kinematics, Covariance and Relativistic Mechanics: (14L)

Experimental basis for special theory of relativity (Michelson – Morley experiment), Lorentz transformations, Relativistic velocity addition, Mass- Energy relation (E=mc2). Minkowski's space-time diagram, Four vectors, Lorentz transformation of Four vectors, Lorentz force on a charged particle.
Ref.1; Ref.2; Ref.3; Ref.6, Ref 7.

Reference Books :

1. Introduction to Electrodynamics, (3rd Edition) by David J.Griffith.
Publication :Prentice-Hall of India, New Delhi
2. Introduction to Electrodynamics, by A.Z.Capri and P.V.Panat Narosa Publishing House
3.Classical electricity & Magnetism, by panofsky and Phillips, Addison Wesley
4.Foundations of Electromagnetic theory, by Reitz & Milford, World student series Edition.
5.Classical Electrodynamics, by J.D.Jackson, 3rd Edition John Wiley.
6.Electromagnetic theory and Electrodynamics, by Satya Prakash, Kedar Nath and co.Meerut.
7. Special theory of Relativity, by Robert Resnick.
8. Electromagnetics by B.B.Laud, Willey Eastern.
9. Matrices and Tensors in Physics, A. W. Joshi, 3rd Edition, New Age

M.Sc. I (Physics) Semester-II

PSPH 125: Electronics Laboratory-II

Credits: 04 **No of Practicals:10**

Learning Objectives:

1. To observe characteristics of operational amplifiers
2. To study different applications of op-amp
3. To be exposed to the different types of analog and digital circuits
4. To study designing process of experiements using different softwares

Learning Outcomes:

1. At the end of the course the students can be able to analyze the characteristics of different electronic devices such as diodes, transistors and amplifiers.
2. Learn about operation amplifiers and its applications
3. Learn using analog and digital circuits
4. Students will be able to design experiments using hardware and software.

(Students must perform Any 8 Experiments)

1. Op-amp as a Precision rectifier.
2. Frequency to voltage converter using OP-AMP.
3. Sample and hold circuits.
4. Shift Register using 7495.
5. Class-B push pull amplifier using Dual power supply and OP-AMP.
6. Fold back power supply.
7. Design built and test oscillator-phase shift oscillator.
8. Study of voltage-controlled oscillator using IC-566.
9. Frequency multiplier using PLL-565.
10. Crystal oscillator- Millar type.
11. Study of multiplexer and Demultiplexer.
12. Analog to Digital Converter (8-bit).
13. Mutual Inductance with a Lock in Amplifier
14. Diode pump using UJT.
15. Calibration of the Lock in Amplifier

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. I (Physics) Semester-II

PSPH 126: Basic Physics Laboratory-II

Credits: 04 **No of Practicals:10**

Learning Objectives:

1. Collect data and revise an experimental procedure iteratively and reflectively.
2. Evaluate the process and outcomes of an experiment quantitatively and qualitatively.
3. Extend the scope of an investigation whether results come out as expected.
4. Communicate the process and outcomes of an experiment.

Learning Outcomes:

a. Decide which data to collect, including which variables to vary
b. Analyze data using computational methods
c. Demonstrate skills and competencies to conduct wide range of scientific experiments.

(Students must perform Any 8 Experiments)

1. Skin depth in Al using electromagnetic radiation.
2. Franck – Hertz Experiment.
3. Thermionic Emission.
4. Electron Spin Resonance (ESR).
5. Study of Hysteresis (B-H curve)
6. Ionic Conductivity of NaCl.
7. Zeeman Effect.
8. Determination of Rydberg constant.
9. Study of electromagnetic damping
10. Study of the characteristics of a laser beam (Beam Divergence).
11. Determination of wavelength of He-Ne LASER by Reflection grating
12. Energy gap of semiconductor.
13. e/m by Thomson’s method
14. Optical activity of Sugar solution using Polarimeter.
15. G.M. counter: Determination of dead time of GM tube by Double source method

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