VANITA VISHRAM WOMEN'S UNIVERSITY

SCHOOL OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF PHYSICS

MASTER OF SCIENCE (M.Sc.) PHYSICS PROGRAMME

SEMESTERS 3

Syllabus applicable to the students seeking admission in

M.Sc. Physics

w.e.f. the Academic Year 2022-2023

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1. Preamble – VVWU

Vanita Vishram Women's University (VVWU) is the First-ever Women's University of Gujarat approved by the Government of Gujarat under the provisions of the Gujarat Private Universities Act, 2009. It is a University committed to achieve Women's Empowerment through Quality Education, Skill Development, and by providing employment opportunities to its girl students through its model curriculum, integration of technology in pedagogy and best-in-class infrastructure. The focus is on prioritizing practical component and experiential learning supported through academia-industry linkages, functional MoUs, skill development training, internships etc. It aims at providing opportunities to the girl students for holistic development and self-reliance.

VISION

Empowerment of women through quality education and skill development, so as to make them strong pillars of stability in the society.

MISSION

To provide Education & Professional Training to all women for their all-round development, so as to enable them to become economically independent and socially empowered citizens.

2. Introduction of the Programme

Physics is essentially one of the most fundamental scientific disciplines, and its main goal is to understand how the universe behaves. It seeks to understand natural phenomena in a quantitative manner, and to answer some of the oldest and deepest questions ever asked by human beings. Master of Science (M.Sc.) in Physics is one of the most preferred academic degree courses after graduating with Physics as a major subject.

Vanita Vishram Women's University (VVWU) is the First-ever Women's University of Gujarat proposed under Public-Private-Partnership with the Government of Gujarat under the Gujarat Private Universities Act, 2009. VVWU is committed to provide quality education and employment opportunities to its girl students through its revamped curriculum and pedagogy. Various courses at undergraduate and postgraduate level have been started under VVWU. We have state-of-the-art laboratories for conducting the various laboratory classes. We also have ICT-enabled classroom facilities to provide the students with the best learning experience.

3. Programme Specific Objectives (PSOs)

- ☞ The students are expected to understand the fundamentals, principles, physical concepts and recent developments in the subject area.
- ☞ The student can understand the role of Physics in society and has a background to consider ethical problems.
- ☞ To create an ample amount of prospects for the students in various fields like academics, industry, research organization, consultancy, defense and entrepreneurial pursuit at national and international level.
- ☞ To prepare students to take up challenges as a researcher in diverse areas of theoretical and experimental physics.
- ☞ Create the environment to perform the high end research through Dissertation work.
- ☞ To develop the scientific research approach among students, in defining problems, execution through analytical methods, and systematic presentation of results keeping in line with the research ethics through dissertations.

4. Programme Specific Outcomes (PSOs):

After the completion of the course student will:

PSO-1. Have proficiency in various mathematical concepts for the proper understanding of application in all physical systems especially in Nuclear physics, Statistical Mechanics, Spectroscopy, Electronics, Electromagnetism, Materials Science, Classical and Quantum Mechanics.

PSO-2. Have fundamental and advanced level knowledge in various subjects of physics such as advanced mathematical physics, classical mechanics, quantum mechanics, statistical mechanics, nuclear and particle physics, solid state physics, materials science and electronics.

PSO-3. Learn the laboratory skills, enabling measurements in a Physics Laboratory and analysis of the measurements to draw valid conclusions.

PSO-4. Have fundamental and advanced level knowledge in physics so as to handle the computational tools and scientific software.

PSO-5. Get opportunities to acquire or develop skills and expertise, a comprehensive understanding of techniques, and a thorough knowledge of the literature, applicable to their own research.

PSO-6. Have cross cultural competency exhibited by working as a member or in teams.

5. Structure of the Programme:

Sem-1	**Sem-2**	**Sem-3**	**Sem-4**
Core Course-I	Core Course-VII	Core Course-XII	Core Course -XVII
Core Course-II	Core Course-VIII	Core Course-XIII	Core Course -XVIII
Core Course-III	Core Course-IX	Core Course-XIV	Core Course-XIX
Core Course-IV	General Elective-I Or General Elective-II	Departmental Elective-I Or Departmental Elective-II	Departmental Elective-V Or Departmental Elective-VI
Core Course -V Practical	Core Course -X Practical	Departmental Elective-III Or Departmental Elective-IV	Core Course -XX Dissertation
Core Course -VI Practical	Core Course -XI Practical	Core Course-XV Practical	
		Core Course -XVI Practical	

6. Structure of the Course:

Sem-1	Sem-2	Sem-3	Sem-4
Mathematical Methods of Physics (4+1)	Quantum Mechanics-I (4+1)	Quantum Mechanics-II (4+1)	Nuclear & Particle Physics (4+1)
Classical Mechanics (4+1)	Statistical Mechanics (4+1)	Condensed Matter Physics (4+1)	Modern Optics (4+1)
Computational Physics (4+1)	Electrodynamics and Plasma Physics (4+1)	Atomic and Molecular Physics (4+1)	Molecular Spectroscopy OR Advanced Electronics
Electronics (4+1)	Introduction to Nano-science and Nanotechnology OR Medical Physics (3+1)	Material Science OR Raman Spectroscopy (3+1)	Dissertation (16)
General Physics Lab-I (4)	General Physics Lab-II (4)	Solar Photovoltaics OR Laser and Laser Applications (3+1)	
Electronics Lab-I (4)	Electronics Lab-II (4)	General Physics Lab-III (4)	
		Material Science Lab (4)	

7. Course Objectives – Course Outcomes – Course Contents

SEMESTER-3

Quantum Mechanics-II

(PH21120)

Credits: 4 (Theory) + 1 (Learning Outside the Class)
Contact hours per week: 4

Course Objectives:

The course aims to provide an introduction to advanced level topics in quantum mechanics. These include quantum theory of angular momentum, approximate methods for solving time dependent and time independent problems and an introduction to the quantum mechanical problem, 'scattering theory'.

The general objectives are to:

⇒ Formulate the methods to add and combine the angular momentum.

⇒ Discuss indistinguishably in multi-particle quantum systems and their wave-functions..

⇒ Introduce time-independent and time-dependent perturbation theory to solve problems.

⇒ Deal with the scattering theory quantum mechanically.

Prerequisites:

- ➢ Fundamentals of various kinds of angular momenta like Orbital, Spin and Total Angular Momenta.

Outline of the Course:

No.	Unit	Minimum No. of Contact Hours	Weightage in %
1.	**Addition of Angular Momenta, Identical Particles**	18	30
2.	**Approximation methods for stationary states**	13	22
3.	**Time-Dependent Perturbation Theory**	17	28
4.	**Scattering Theory**	12	20
	Total	**60**	**100**

Course outcome:

CO-1. Students will get a complete understanding of the addition and combination of an angular momenta. This is crucial to understand spectroscopic aspects of the systems.

CO-2. Students will be able to apply approximate methods like the perturbation theory, and variational methods to solve time-independent problems that are not exactly solvable.

CO-3. Perturbative approach to solve time-dependent problems will be understood. Various applications like Interaction of atoms with radiation will also be introduced

CO-4. Student will understand formulation of the quantum mechanical treatments to solve the scattering problem

M.Sc. Physics Semester-3	
Subject	**Hours**
CC1 Quantum Mechanics-II	**4 Hours /week**
Topic	**Hours**
Unit – I	
Addition of Angular Momenta: Addition of Two Angular Momenta - General Formalism, Clebsch–Gordan Coefficients, Eigenvalues of $\hat{J}^2$ and J_z, Calculation of the Clebsch–Gordan Coefficients, Coupling of Orbital and Spin Angular Momenta, Isospin **Identical Particles:** Many-Particle Systems: Schrödinger Equation, Interchange Symmetry, Systems of Distinguishable Noninteracting Particles, Systems of Identical Particles: Identical Particles in Classical and Quantum Mechanics, Exchange Degeneracy, Symmetrization Postulate, Constructing Symmetric and Antisymmetric Functions, Systems of Identical Noninteracting Particles, Pauli Exclusion Principle, Exclusion Principle and PeriodicTable	**18**
Unit – II	
Approximation Methods for Stationary States: Introduction, Time-Independent Perturbation Theory: Nondegenerate Perturbation Theory, Degenerate Perturbation Theory, Fine Structure and the Anomalous Zeeman Effect: Spin–Orbit Coupling, Relativistic Correction, The fine structure of Hydrogen	**13**
Unit – III	
Time-Dependent Perturbation Theory: Introduction, The Pictures of Quantum Mechanics: The Schrödinger Picture, The Heisenberg Picture, The Interaction Picture; Time-Dependent Perturbation Theory: Transition Probability, Transition Probability for a Constant Perturbation, Transition Probability for a Harmonic Perturbation, Adiabatic and Sudden Approximations: Adiabatic Approximation, Sudden Approximation; Interaction of Atoms with Radiation: Classical Treatment of the Incident Radiation, Quantization of the Electromagnetic Field, Transition Rates for Absorption and Emission of Radiation, Transition Rates within the Dipole Approximation, Electric Dipole Selection Rules, Spontaneous Emission	**17**
Unit – IV	

Scattering Theory: Scattering and Cross Section, Scattering Amplitude of Spinless Particles: Scattering Amplitude and Differential Cross Section, Scattering Amplitude; Born Approximation: The First Born Approximation, Validity of the First Born Approximation; Partial Wave Analysis: Partial Wave Analysis for Elastic Scattering, Partial Wave Analysis for Inelastic Scattering, Scattering of IdenticalParticles	**12**

Reference books:

1. Quantum Mechanics Concepts and Applications By Nourdine Zettili, 2nd edition, Wiley (2009)
2. Quantum Mechanics By L.I. Schiff, 4th Ed., McGraw Hill Education (2017).
3. Modern Quantum Mechanics By J.J. Sakurai, 2nd Ed., Cambridge University Press (2017).
4. A Text Book of Quantum Mechanics By P.M. Mathews and K. Venkatesan,
5. Introduction to Quantum Mechanics By D J Griffiths and D F Schroeter, Cambridge University Press (2019).
6. Quantum Mechanics By B. H. Bransden and C. J. Joachain, 2nd Ed., Pearson Education (2004).
7. Quantum Mechanics: 500 Problems with solutions By G Aruldhas, Prentice Hall India (2010).
8. Relativistic Quantum Mechanics By W. Greiner, 3rd Ed., Springer (2000).
9. Lectures on Quantum Mechanics By Paul Dirac, Snowball Publishing (2012).

SEMESTER-3

Condensed Matter Physics (PH21130)

Credits: 4 (Theory) + 1 (Learning Outside the Class)
Contact hours per week: 4

Course Objectives:

⇒ The course provides an introduction to the basic phenomena associated with condensed matter physics.

⇒ To introduce students with fundamental physical science of solid matters and to prepare students for advanced studies in similar fields.

Prerequisite:

- Basics of crystallography.

Outline of the Course:

No.	Unit	Minimum No. of Contact Hours	Weightage in %
1.	Determination of Crystal Structure & Reciprocal Lattice and Thermal Properties of Solids	15	25
2.	Free electron theory of metals, Band theory of solids	15	25
3.	Magnetism in Solids & Superconductivity-I	15	25
4.	Superconductivity-II	15	25
	Total	**60**	**100**

Course outcome:

Students will be able to:

CO-1. Understand the concept of reciprocal lattice, X-Ray diffraction methods for crystal structure analysis and thermal properties of solids.

CO-2. Explain the concept of free electron theory and its shortcoming and also energy bands theory of solids.

CO-3. Understand various types of magnetic phenomenon and physics behind them.

CO-4. Understand the concept of superconductivity, its properties, and important parameters related to possible applications.

M.Sc. Physics Semester-3	
Subject	**Hours**
Condensed Matter Physics	**4 Hours /week**
Topic	**Hours**
Unit – I	
Determination of Crystal Structure & Reciprocal Lattice: X-ray Diffraction: Bragg's law, X-ray Diffraction Methods, Reciprocal lattice and its properties, Bragg's law in reciprocal lattice, Concept of Brillion Zone, Atomic Structure factor. **Thermal Properties of Solids:** Classical Lattice Heat Capacity, Quantum Theory of Lattice Heat Capacity (Average thermal energy of harmonic oscillator, Einstein model, Phonon density of states, Debye continuum mode.	**12**
Unit – II	
Free Electron Theory of Metals: Drude model, Lorentz modification of drude model, Fermi-Dirac distribution function, Sommerfield Model, Electron Heat Capacity, Sommerfield Theory of Electric Conduction in metals, Thermoelectric Effects (Thermoelectric Power). **Band Theory of Solids:** Consequences of periodicity, Wave mechanical interpretation of energy bands, Kroning-Penney model, Nearly free electron model, Zone schemes for energy band, Energy bands in general periodic potential, Classification of metal, insulator and semiconductors, Concept of hole, Effective mass.	**18**
Unit – III	
Magnetism in Solids: Types of Classical and Quantum theory of Diamagnetism and Paramagnetism; Curie-Weiss law, Electron Spin Resonance, Magnetic Spin Resonance. **Superconductivity-I:** Phenomena without Observable Quantization (Zero resistance and persistent currents, Meissner Effect, London Equations, Type-I & Type-II Superconductors, Thermodynamics Properties) Energy Gap, Properties Dependent on Energy Gap (Heat Capacity, Thermal Conductivity, Isotope Effect)	**15**
Unit – IV	
Superconductivity-II: BCS Theory: A Qualitative Approach (Cooper Pair Formation, BCS Ground State), Important Predictions of the BCS Theory and Comparison with Experiment (Critical Temperature, Energy Gap, Critical Field, Heat Capacity, Acoustic Attenuation, Ginzburg-Landau Theory (Magnetic Flux Quantization, Coherent Length, Type-II Superconductor, Josephson Effect & Tunneling), High temperature superconductors, Introduction to superfluidity.	**15**

Note: In addition to above content, numerical solved/unsolved problems to be discussed from each unit.

Reference books:

1. Srivastava, J.P., Elements of Solid State Physics, Prentice Hall of India, (2008).
2. R. K. Puri & V. K. Babbar, Solid State Physics, S. Chand.
3. Omar, M.A., Elementary Solid State Physics, Pearson Education, (1999).
4. Ashcroft, N.W. and Mermin, N.D., Solid State Physics, Cengage Learning, (2008).
5. Dekker, A.J., Solid State Physics, Macmillan, (2003).
6. Kittel, C., Introduction to Solid State Physics, John Willey, (2007).

SEMESTER-3

Atomic and Molecular Physics

(PH21140)

Credits: 4 (Theory) + 1 (Learning Outside the Class)
Contact hours per week: 4

Course Objective:
Objectives of this course is to:

⇒ Understand the structure of atoms and molecules.

⇒ Imbibe the quantum mechanical skills to understand and analyse the atomic and molecular structure.

⇒ Discuss the importance of studying the atomic and molecular physics and its various applications in diverse fields.

Outline of the Course:

No.	Unit	Minimum No. of Contact Hours	Weightage in %
1.	Quantum Mechanics of One Electron Atom, Quantum Mechanics of Two Electron Atom	15	25
2.	Multi-Electron Atom	13	22
3.	Molecular Structure	18	30
4.	Masers, Lasers and their interaction with atoms and molecules, Applications of Atomic and Molecular Physics	14	23
	Total	60	100

Course Outcome:

CO-1. The students can apply the concepts of quantum mechanics in atomic and molecular physics. Competency developed in solving problems on atomic and molecular physics.

CO-2. Skill of empirical model development is created by studying the various approximations.

CO-3. Students will be able to understand the importance of this course and its variety of applications to serve the mankind.

M.Sc. Physics (Semester-3)	
Subject	**Hours**
Atomic and Molecular Physics	**4 Hours /week**
Topic	
Unit – I	
Quantum Mechanics of One Electron Atom: Quantum Mechanical Treatment of One Electron Atom, Electron Probability Density, Expectation Value, Orbital Angular Momentum, Parity of Eigenfunctions and determination of selection rules. **Quantum Mechanics of Two Electron Atom:** Exchange Force, Spectrum of Helium Atom, Splitting of the terms of **He** atom, Quantum Mechanical calculation of the ground state energy of **He** atom	**15**
Unit – II	
Multi-Electron Atom: Central Field Approximation, Spin-Pauli Exclusion Principle and Slater determinant, Electronic configuration-Shells and subshells, degeneracy, The Periodic System and atomic properties of the elements, The spectra of the alkalis	**13**
Unit – III	
Molecular Structure: General nature of molecular structure, The Born-Oppenheimer separation for diatomic molecules, Electronic structure of diatomic molecules: Symmetry properties, Spin; LCAO approximation for Molecular H_2 and molecular ion, The rotation and vibration of diatomic molecules, The structure of Polyatomic molecules: Rotational, Vibrational and Electronic structure, Examples of molecular structure: H2O, methane, ethylene and acetylene molecules	**18**
Unit – IV	
Masers, Lasers and their interaction with atoms and molecules: Masers and Lasers, method to achieve a population inversion, The NH_3 maser, LASERS: Solid state laser, Ruby laser, Dye laser, Semiconductor laser, Gas laser, He-Ne laser, CO_2 laser, Excimer lasers, Free Electron lasers, High intensity lasers. **Applications of Atomic and Molecular Physics:** Nuclear Magnetic Resonance (NMR), Chemical Shifts, Atom Optics: Focusing of atomic beams and atom lenses, Atom Mirrors, Atomic beam splitters	**14**

References Books:

1. Bransden B. H. and Joachian C. J., “Physics of Atoms and Molecules” 2nd Edition, Pearson Education Ltd. (2019).
2. Atomic and Molecular Spectra: LASER by Raj Kumar, 5th Ed., Kedar Nath Ram Nath Publication, Meerut (2019).
3. Molecular structure and Spectroscopy G. Aruldhas, 2nd Ed., PHI Learning Pvt. Ltd. (2008).
4. Molecular Quantum Mechanics By Peter Atkins and Ronald Friedman, 5th Edition, Oxford University Press (2011).
5. Haken H and Wolf H. C, “The Physics of Atoms and Quanta”, 6 Ed., Springer
6. Demtroder W., “Atoms, Molecules and Photons”, 2nd edition, Springer-Verlag
7. Eisberg R. and Resnick R., “Quantum Physics of Atoms, Molecules, Solids, Nuclei,and Particles”, 2nd Edition, Wiley Student Edition

SEMESTER-3

Materials Science
(PH24010)

Credits: 3 (Theory) + 1 (Learning Outside the Class)
Contact hours per week: 3

Course Objective:

⇒ The course deals with the crystal imperfections, diffusion in solids, and the phase diagram in the context of materials science.
⇒ The course also introduces the novel nanomaterials and its various nanoscale characterization techniques to the students.

Outline of the Course:

No.	Unit	Minimum No. of Contact Hours	Weightage in %
1.	Crystal Defects and Non-crystalline Structure – Imperfection, Diffusion in Solids and Phase Diagrams	18	40
2.	Thin-Film Nucleation and Growth & Properties of Thin-Films	14	31
3.	Advanced Nanomaterials and Advanced Characterization Techniques for Nanomaterials/Thin-Films	13	29
	Total	45	100

Course Outcomes:

Students will learn:

CO-1. Various types of crystal defects and diffusion processes in Solids and concept of phase diagram.
CO-2. Understand the process of nucleation and growth of thin-films & its properties.
CO-3. Concept of advanced nanomaterials and its usefulness.
CO-4. Understand the working principle and operation of various characterization methods used for Nanomaterials.

M.Sc. Physics (Semester-3)	
Subject	**Hours**
Material Science	**3 Hours /week**
Topic	
Unit – I	
Crystal Defects and Non-crystalline Structure – Imperfection: Solid Solution-Chemical Imperfection, Point Defects -Zero-Dimensional Imperfections, Linear Defects – One Dimensional Imperfections, Planar Defects – Two Dimensional Imperfections, Non-crystalline Solids – Three Dimensional Imperfections **Diffusion in solids:** Introduction, Diffusion Mechanisms, Fick's First Law, Fick's Second Law—Nonsteady-State Diffusion, Factors that Influence Diffusion **Phase Diagrams:** Phase Rule, Phase Diagram, Complete Solid Solution, Eutectic Diagram with no Solid Solution, Eutectic Diagram with Limited Solid Solution, Eutectoid Diagram, Peritectic Diagram, General Binary Diagrams, Lever Rule	**18**
Unit – II	
Thin Film Nucleation and Growth: Film formation and structure, Thermodynamics of nucleation, Nucleation theories: Capillarity model, homogeneous and heterogeneous nucleations, Atomistic model – Walton-Rhodin theory; Post-nucleation growth; Deposition parameters **Properties of Thin-Films:** Electrical, Mechanical, Optical and Magnetic Properties.	**14**
Unit – III	
Advanced Nanomaterials: Carbon Nanomaterials (Fullerene, Graphene, types and structures of carbon nanotubes) **Advanced Characterization Techniques for Nanomaterials/Thin Films:** Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Scanning Tunnelling Microscope (STM), Atomic Force Microscope (AFM), X-Ray Diffraction (XRD), UV-Vis-NIR Spectrometer, Photoluminescence Spectrometer, Electrical Resistivity Measurement by Four Probe.	**13**

Note: In addition to above content, numerical solved/unsolved problems to be discussed from each unit.

Reference books:

1. Introduction to Materials Science for Engineers by James F. Shackelford, 8th edition Pearson (2014).
2. Materials Science and Engineering: An Introduction by William D. Callister Jr. and David G. Rethwisch, 9th edition, Wiley (2013)

3. Materials Science and Engineering by V. Raghavan, Prentice Hall India Learning Private Limited; 6th edition (2015)
4. Thin Film Phenomena by K. L. Chopra, McGraw-Hill; (1969)
5. Thin Film Fundamentals; A. Goswami; New Age International Pvt. Ltd; 2007.
6. Materials Science of Thin Films; Milton Ohring; Academic Press; (2001)
7. Handbook of Thin Film Technology; Leon I. Maissel and Reinhard Glang; McGraw-Hill; (1970)
8. A. K. Bandhyopadhyay, Nanomaterials, New Age International Publishers (2007).
9. Nanotechnology: Principles and Practices, Sulabha K. Kulkarni, 3rd Edition, 2014 (Springer Nature)
10. Nanoscience and Nanotechnology: Fundamentals of Frontiers, Shubra Singh M.S. Ramachandra Rao, 1st Edition, 2013 (Wiley).
11. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
12. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited)

SEMESTER-3

Raman Spectroscopy

(PH24020)

Credits: 3 (Theory) + 1 (Learning Outside the Class)
Contact hours per week: 3

Course Objective:

⇒ The objective of this course is to understand the advanced applications of Raman spectroscopy including structure determination of micro and nano materials.
⇒ This course also aims to give insights into different Raman processes which have applications in industry, material science, medicine and forensic science etc.

Outline of the Course:

No.	Unit	Minimum No. of Contact Hours	Weightage in %
1.	**Different Types of Raman Effect-I**	20	44
2.	**Different Types of Raman Effect-II**	10	22
3.	**Raman Spectroscopy Setup**	15	34
	Total	**45**	**100**

Course Outcomes:

CO-1. After completion of this course, the students will have good fundamental understanding, instrumental aspects, analysis of materials with Raman spectroscopy

M.Sc. Physics (Semester-3)	
Subject	**Hours**
Raman Spectroscopy	**3 Hours /week**
Topic	
Unit – I	
Raman effect, classical theory of Raman effect, quantum mechanical treatment of Raman effect, Surface-Enhanced Raman Spectroscopy (SERS), Principle of SERS, Enhancement mechanism, Electromagnetic enhancement mechanism, Chemical enhancement, Surface selection rules, SERS substrates, metal lms, metallic nanoparticles, Applications-biomolecules, in medicine, forensic science.	**20**
Unit – II	
Hyper Raman effect, Classical treatment of Hyper Raman effect, Experimental techniques for hyper Raman effect, Stimulated Raman scattering, inverse Raman scattering, CARS (Coherent anti stokes Raman scattering)	**10**
Unit – III	
Raman spectrometer, Major Components, Excitation Sources, Sample Illumination, Wavelength Selectors, Detection, FT Raman, Detection, Photon Counting, photodiode array, CCD, Instrument Calibration, Sampling Techniques, Fluorescence Problems, Raman Difference Spectroscopy, Miniature Raman Spectrometers, FT Raman spectrometer, Single crystal Raman spectra, Raman Microscopy, Fibre optical Raman spectrometer	**15**

Note: In addition to above content, numerical solved/unsolved problems to be discussed from each unit.

Reference books:

1. Molecular Structure and Spectroscopy, G.Aruldhas, PHI Learning Private Limited New Delhi
2. Introductory Raman spectroscopy Second Edition, J R Ferraro, K.Nakamoto, C.W.Brown, Academic press, Elsevier

SEMESTER-3

Solar Photovoltaic

(PH24030)

Credits: 3 (Theory) + 1 (Learning Outside the Class)
Contact hours per week: 3

Course Objective:

⇒ To introduce students to the fundamental theories and technological aspects of power generation using solar photovoltaic technology.
⇒ The objective of the course is to develop an in-depth understanding of the physics of solar cells and various photovoltaic technologies (PV) and their applications to harness solar energy to electricity.

Outline of the Course:

No.	Unit	Minimum No. of Contact Hours	Weightage in %
1.	**Solar Cell Fundamentals & Design of Solar Cells**	15	34
2.	**Thin Film Solar Cell Technologies**	15	33
3.	**Solar Photovoltaic Modules & MPPT Tracking**	15	33
	Total	**60**	**100**

Course Outcomes:

After the successful completion of the course the students will be able to condently:

CO-1. Explain the working principle of solar cells and understand the various designs of solar cells.
CO-2. Understand various Thin-Film Solar Cell Technologies for Fabrication of Solar Cell for electricity generation.
CO-3. Understand the concept of solar model, series and parallel connection of solar cells, calculation of maximum power and its tracking process using MPPT.

M.Sc. Physics (Semester-3)	
Subject	**Hours**
Solar Photovoltaic	**3 Hours /week**
Topic	
Unit – I	
Solar Cell Fundamentals: p-n junction under illumination: solar cell (generation of photo voltage (PV), light generated current, IV equation for solar cell – solar cell characteristics. **Design of Solar Cells:** Upper limits of solar cell parameters, Losses in solar cell, Design of high short circuit current, Design for high open circuit voltage, Design for high fill factor, Analytical Techniques (solar simulator: I-V measurement – quantum efficiency measurement, Minority carrier lifetime and Diffusion length measurement)	**16**
Unit – II	
Thin-Film Solar Cell Technologies: Generic Advantages of Thin-Film Technologies, Materials for Thin-Film Technologies, Thin-Film Deposition Techniques (LPCVD, APCVD, PECVD & HWCVD), Common Features of Thin-Film Technologies (Use of TCO and Light Trapping), Possible Solar Cell Structures, Substrate and Superstrate Configuration, Thin-Film Module Manufacturing, CdTe Solar Cell Technology, Monocrystalline and Polycrystalline Solar Cells.	**16**
Unit – III	
Solar Photovoltaic Modules: Solar PV Modules from Solar Cells, Mismatch in Series and Parallel Connections, Design and Structure of PV Modules, PV Module Power Output. **MPPT Tracking:** Resistive load, DC/DC convertor, Buck Convertor, Boost Convertor, Maximum Power Point Tracking (MPPT), Algorithms for MPPT	**13**

Note: In addition to above content, numerical solved/unsolved problems to be discussed from each unit.

Reference books:

1. Solar Photovoltaic: Fundamentals, Technologies and Applications by Chetan Singh Solanki, 2nd Edition, PHI (2011).
2. Photovoltaics: Fundamental, Technology & Practice by Konrad Mertens, Willey, (2014)
3. Solar Cells: Operating principles, Technology and System Applications by Martin A Green, Prentice-Hall Inc. (1981).

4. Practical Photovoltaics: Electricity from Solar Cells Practical Photovoltaics: Electricity from Solar Cells Richard J. Komp 3rd Edn. aatec Publishers, Michigan.
5. Jenny Nelson, The Physics of Solar Cells, Imperial College Press (2003).
6. Larry D Partain ,Solar Cells and their Applications, John Wiley and Sons, Inc, New York, 1995.
7. Peter Wurfel, Physics of solar cells: from principles to advanced concepts, 2nd Edition, Wiley-VCH (2009).

SEMESTER-3

Laser and Laser Applications (PH24040)

Credits: 3 (Theory) + 1 (Learning Outside the Class)
Contact hours per week: 3

Course Objective:

⇒ This course also aims to give the detailed working principle of different laser systems, which has numerous applications in industry, material science, medicine, and telecommunications.

Outline of the Course:

No.	Unit	Minimum No. of Contact Hours	Weightage in %
1.	Einstein Coefficients and Light Amplification:	15	33.33
2.	Optical Resonators & Properties of Laser	15	33.33
3.	Some Laser Systems & Some Important Applications of Lasers	15	33.33
	Total	**45**	**100**

Course Outcomes:

Through this course students will learn following:

CO-1. Fundamental principles of stimulated emission and how to convert it into coherent light emission.

CO-2. The manipulation of light i. e. mode selection, continuous and pulsed generation, spectral narrowing etc.

CO-3. Applications of various lasers in various fields including scientific research to common use.

M.Sc. Physics (Semester-3)	
Subject	**Hours**
Laser and Laser Applications	**3 Hours /week**
Topic	
Unit – I	
Einstein Coefficients and Light Amplification: Introduction, Einstein Coefficients, Light Amplification, The Threshold Condition, Line Broadening Mechanisms, Saturation Behavior of Homogeneously and Inhomogeneously Broadened Transitions, Quantum Theory for the Evaluation of the Transition Rates and Einstein Coefficients, More Accurate Solution for the Two-Level System	**15**
Unit – II	
Optical Resonators: Introduction, Modes of a Rectangular Cavity and the Open Planar Resonator, Spherical Mirror Resonators, The Quality Factor, The Ultimate Linewidth of a Laser, ModeSelection, Pulsed Operation of Lasers **Properties of Lasers:** Introduction, Laser Beam Characteristics, Coherence Properties of Laser Light.	**15**
Unit – III	
Some Laser Systems: Ruby Lasers, Neodymium-Based Lasers, Nd: YAG Laser, Nd:Glass Laser, Titanium Sapphire Laser, He–Ne Laser, Argon Ion Laser, The CO2 Laser **Some Important Applications of Lasers:** Spatial Frequency Filtering and Holography, Laser-Induced Fusion, Light Wave Communications, Lasers in Science.	**15**

Note: In addition to above content, numerical solved/unsolved problems to be discussed from each unit.

Reference Books:

1. Lasers: Fundamental and Applications, Graduate Text in Physics, 2nd edition, K Thyagarajan, Ajoy ghatak (Springer, 2002)
2. Laser Fundamentals, by William T. Silfvast, Cambridge University Press, 2008.
3. Principles of Lasers, by Orazio Svelto; Springer, 2009
4. Laser Physics, by P. W. Milonni, J. W. Eberly; John Wiley and Sons, 2010

SEMESTER-3

GENERAL PHYSICS LAB-III
(PH21150)

Credits: 4 (Practical)
Contact hours per week: 8

Sr. No.	Name of the Experiment
1	Study of Beer Lambert's law.
2	Analysis of absorption spectra of liquids using spectrometer.
3	Dissociation Energy of I_2 molecule.
4	To determine the value of energy levels using the Frank-Hertz experiment.
5	Determination of Ionization Potential of mercury.
6	Verification of Hartmann formula for prism spectrogram.
7	Measurement of the optical spectrum of an alkali atom.
8	Determination of metallic component of an inorganic salt.
9	Measurement of the optical spectrum of alkaline earth atoms.
10	Measurement of Band positions and determination of vibrational constants of AlO molecule.
11	Measurement of Band positions and determination of vibrational constants of N_2 molecule.
12	Measurement of Band positions and determination of vibrational constants of CN molecule.

13	Measurement of Raman spectrum of CCl_4.
14	Determination of charge to mass ratio of electrons by Thomson method.
15	Atomic Spectra of two-Electron Systems
16	To measure the thickness of the glass slide using the Mach-Zender interferrometer.
17	Study of Fourier Optics of Fraunhofer diffraction.
18	Experiment on high intensity monochromator
19	Doppler free saturated absorption: Laser Spectroscopy
20	Permittivity of Air Experiment. i) To measure the force of attraction between charged capacitor plates by Null Method. ii) To calculate the permittivity of Air. iii) To measure the force between the current carrying conductor and determine the permeability of Air.
21	Gamma - Ray Spectroscopy Using NaI (Tl) detector
22	Study of the energy calibration of NaI Scintillation Detector and to determine the energy of unknown sources.
23	To Study the Compton scattering using NaI (TI) detector
24	Study of Feather analysis of GM counter.
25	To construct a decay curve and determine the half life of an unknown isotope using Geiger Muller Counter.
26	Study of Rutherford Scattering.
27	Study of Compton Effect and Application of Monte-Carlo Techniques to Nuclear Physics-estimation of Solid Angle, Expected counts rate etc.

28	Absorption of Ɣ - rays: To measure the attenuation of the intensity with absorber thickness and to derive the half thickness and the attenuation coefficient.
29	NMR Experiment: Determination of proton spin, Magnetic moment of a proton and nucleus, Determination of nuclear g-factor and to study Nuclear Spin tomography.
30	To Study the Solid State Nuclear Track Detector.
31	Determination of the range and energy of alpha particles using spark counters.
32	Neutron Activation Analysis Measurement of the Thermal Neutron Flux.
33	Fission Fragment Energy Loss Measurements from Cf252.

Note: At least 12 Experiments from the above list to be performed.

SEMESTER-3

Material Science Lab.
(PH21160)

Credits: 4 (Practical)
Contact hours per week: 8

Sr. No.	Name of the Experiment
1	Measurement of Heat Capacity of Solids
2	X-ray powder method – indexing, cell determination and identification of unknown elements
3	Electrical conductivity/resistivity of metals and alloys with temperature-four probe method
4	Determination of energy band gap of semiconducting material using four probe method
5	Hall effect - Determination of Hall Coefficient, Carrier Concentration and Mobility of Semiconducting Material.
6	Magnetic susceptibility by Quincke's method
7	Particle size determination-laser – Determin ation of wavelength of He-Ne laser-Diffraction method
8	Determination of Dielectric Constant of Solid Samples (Glass, Bakellie And Pzt) By Parallel Plate Capacitor.
9	Measurement of Dielectric Constant of Ferroelectric Samples at Different Temperature and hence Determine Curie Temperature of Samples
10	Determination of Dielectric Constant of Non-Aqueous Liquid Samples.
11	Determination of Magnetic Susceptibility of a Solid by Guoy's Method.
12	Study of the Dispersion Relation for The "Monatomic Lattice" and comparison with theory using Lattice Dynamic Kit
13	To Study Frequency Dependence of Dielectric Properties of the Material
14	Study of The Dispersion Relation For The Di-Atomic Lattice, Acoustical Mode And Energy Gap. Comparison With Theory.
15	To Study The Magnetic Field Dependence Of The Transverse Magnetoresistance Of A Given Semiconductor Sample.

16	X-ray diffraction simulation experiment
17	Study of Hall Effect in Metals
18	Study of Curie temperature of a given ferromagnetic material
19	Study of Thermoluminescence of F-centres Alkali Halide Crystals
20	Determination of optical constants of thin films from Reflectivity
21	Measurement of Dipole moment of non-aqueous liquids like nitrobenzene
22	To Study Thermoelectric Effect and to measure Seebeck and Peltier Coefficient and to measure Inversion Temperature.
23	To study the thermal Conductivity of Liquids, Nanofluids, Ferrofluids, Transformer Oils, Lubricants, Coolants etc.
24	Measurement of Magnetoresistance of Semiconductors

Note: At least 12 Experiments from the above list to be performed.

8. Teaching Methodology:

- Direct Instructions
  - Chalk and Talk
  - ICT based teaching
- Flipped Classroom
- Competency based learning
- Kinesthetic Learning
- Differentiated Instruction
- Personalised learning
- Inquiry-based Learning
- Expeditionary Learning
- Flipped Classroom
- Cooperative Learning
- Spaced Learning
- Use of maximum demonstration to explain theoretical concepts.

9. Glossary:

CC – Core Course
DEC – Department Elective Course
(P) – Practical
PW – Project Work
DW - Dissertation