ANDHRA PRADESH STATE COUNCIL OF HIGHER EDUCATION

Model Syllabus for 4-Year UG Honours in B.Sc. (Physics) as Major in consonance with Curriculum framework w.e.f. AY 2025-26

COURSE STRUCTURE (for Semester I to VI)

Year	Semester	Course	Title of the Course	No. of Hrs /Week	No. of Credits
I	I	1	Introduction to Mathematical Physics	3	3
			Introduction to Mathematical Physics-Practical	2	1
		2	Mechanics and Properties of Matter	3	3
			Mechanics and Properties of Matter-Practical	2	1
	II	3	Waves and Optics	3	3
			Waves and Optics-Practical	2	1
		4	Heat and Thermodynamics	3	3
			Heat and Thermodynamics-Practical	2	1
II	III	5	Atomic, Molecular & Nuclear physics	3	3
			Atomic, Molecular & Nuclear physics-Practical	2	1
		6	Basic Electronics	3	3
			Basic Electronics-Practical	2	1
		7	Applied Optics	3	3
			Applied Optics-Practical	2	1
	IV	8	Electricity, Magnetism and Electromagnetic Theory	3	3
			Electricity, Magnetism and Electromagnetic Theory-Practical	2	1
		9	Analog Electronics	3	3
			Analog Electronics-Practical	2	1
		10	Advances in Physics	3	3
			Advances in Physics-Practical	2	1
III	V	11	Introduction to Solid State Physics	3	3
			Introduction to Solid State Physics-Practical	2	1

SEMESTER-III

COURSE 5: ATOMIC, MOLECULAR AND NUCLEAR PHYSICS

Theory | **Credits: 3** | **3 hrs/week**

COURSE OBJECTIVE:

The course aims to introduce students to the principles of atomic structure, molecular spectroscopy, and fundamental nuclear physics. It covers key experimental methods and theoretical models, helping students understand how microscopic interactions lead to observable physical phenomena in atoms, molecules, and nuclei.

LEARNING OUTCOMES:

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

1. Understand the principles of atomic structure and spectroscopy.
2. Understand the principles of molecular spectroscopy.
3. Develop critical understanding of concept of Matter waves and Uncertainty principle.
4. Describe nuclear properties, binding energy, and nuclear models such as the liquid drop and shell model.
5. Explain the working of nuclear detectors and accelerators and classify elementary particles and their interactions.

UNIT-I: INTRODUCTION TO ATOMIC STRUCTURE AND SPECTROSCOPY (9 hrs.)

Introduction to Bohr's model of the hydrogen atom, Vector atom model and Quantum numbers associated with it, Stern and Gerlach experiment, Coupling Schemes (LS & JJ), Spectral terms and spectral notations, Selection rules, Zeeman effect, Experimental arrangement to study Zeeman effect and expression for Zeeman shift.

UNIT-II: MOLECULAR SPECTROSCOPY (9 hrs.)

Molecular rotational and vibrational spectra, electronic energy levels and electronic transitions, Raman effect, Characteristics of Raman effect, Experimental arrangement to study Raman effect, Quantum theory of Raman effect, Applications of Raman effect. Spectroscopic techniques: IR and UV-Visible.

UNIT-III: MATTER WAVES & UNCERTAINTY PRINCIPLE (9 hrs.)

Matter waves, de Broglie's hypothesis, Properties of matter waves, Davisson and Germer's experiment, Heisenberg's uncertainty principle for position and momentum & energy and time, Illustration of uncertainty principle using diffraction of beam of electrons (Diffraction by a single slit) and photons (Gamma ray microscope).

UNIT-IV: INTRODUCTION TO NUCLEAR PHYSICS (9 hrs)

Nucleus: Properties of nucleus, Mass defect, Binding energy – binding energy curve; Nuclear forces: Characteristics of nuclear forces, Yukawa's meson theory; Nuclear Models- Liquid drop model- Semi empirical mass formula, Shell model, magic numbers.

UNIT-V: NUCLEAR DETECTORS AND NUCLEAR ACCELERATOR (9 hrs)

Nuclear detectors: Geiger- Muller counter, Cloud chamber (expansion type), Scintillation counter. Nuclear Accelerators: Cyclotron-construction, working and applications; Synchrocyclotron-construction, working and applications. Classification of elementary particles, Types of interactions- strong, electromagnetic and weak interactions;

REFERENCE BOOKS:

1. BSc Physics, Vol.4, Telugu Akademy, Hyderabad
2. Atomic Physics by J.B. Rajam; S. Chand & Co.,
3. Modern Physics by R. Murugeshan and Kiruthiga Siva Prasath. S. Chand & Co.
4. Concepts of Modern Physics by Arthur Beiser. Tata McGraw-Hill Edition.
5. Nuclear Physics, Irving Kaplan, Narosa Pub. (1998).
6. Nuclear Physics, Theory and experiment – P.R. Roy and B.P. Nigam, New Age Int.1997.
7. Atomic and Nuclear Physics (Vol.2), S.N. Ghoshal, S. Chand & Co. (1994).
8. Nuclear Physics, D.C. Tayal, Himalaya Pub. (1997).

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SEMESTER-III

COURSE 5: ATOMIC, MOLECULAR AND NUCLEAR PHYSICS

Practical **Credits: 1** **2 hrs/week**

COURSE OBJECTIVE:

To develop practical skills and experimental understanding in atomic and nuclear physics, including spectral line measurements, particle detection, and verification of quantum and nuclear models.

LEARNING OUTCOMES:

1. Demonstrate a deep understanding of the principles and theories of modern physics through hands-on experimentation and data analysis.
2. Analyze and interpret experimental data using statistical methods and error analysis, drawing meaningful conclusions and relating them to theoretical concepts.
3. Design and conduct independent experiments or investigations related to modern physics, demonstrating the ability to plan, execute, and analyze experimental procedures and results.
4. Gain a solid understanding of fundamental concepts in nuclear physics.
5. Understand the principles and operation of laboratory equipment and instruments specific to nuclear physics experiments.
6. Develop proficiency in conducting experiments related to nuclear physics.

Minimum of 6 experiments to be done and recorded

1. e/m of an electron by Thomson method
2. Determination of Planck's constant using a photocell
3. Verification of inverse square law of light using photovoltaic cell
4. Determination of work function of the filament material using directly heated vacuum diode
5. GM counter – Determination of dead time
6. Study of characteristic curve of GM counter and estimation of its operating voltage
7. Estimation of efficiency for a gamma source using GM counter
8. Estimation of efficiency for a beta source using GM counter
9. Study of sodium doublet using a diffraction grating
10. IR or UV-Vis spectroscopy of samples using a portable spectrometer
11. Single slit diffraction of laser beam to illustrate uncertainty principle
12. Study of absorption of beta particles in aluminum sheets
13. Study of Compton scattering (demo or simulation)
14. Study of counting statistics using GM counter
15. Study of plateau region and dead time using a counting system

STUDENT ACTIVITIES

UNIT-I: Introduction to Atomic Structure and Spectroscopy

Spectroscopy Experiment

Divide the students into small groups and provide each group with a spectrometer or spectroscope, a light source, and different samples or elements for analysis.

Instruct the students to carefully observe the spectra produced by the samples using the spectrometer. Encourage them to note the presence of specific spectral lines or patterns.

Data Collection

Have the students record their observations in their lab notebooks or worksheets. They should note the wavelengths or colors of the observed spectral lines and any patterns they observe.

Analysis and Discussion: Guide a class discussion on the observed spectra and their significance. Discuss how the observed spectral lines correspond to specific energy transitions in the atoms. Ask students to compare the spectra of different samples or elements and identify any similarities or differences.

Discuss the concept of energy levels and how electrons transition between them, emitting or absorbing photons of specific wavelengths.

UNIT-II: Molecular Spectroscopy

Begin the activity with a brief introduction to molecular structure, discussing concepts such as chemical bonds, molecular geometry, and the importance of molecular structure in determining the properties and behavior of substances. Explain the principles of spectroscopy, focusing on vibrational and rotational spectra and how they relate to molecular vibrations and rotations.

UNIT-III: Matter waves & Uncertainty Principle

Begin the activity by introducing the concept of matter waves and the uncertainty principle. Discuss how the wave-particle duality of matter is a fundamental principle in quantum mechanics. Provide a brief overview of the historical development of the uncertainty principle and its implications for our understanding of the behavior of particles on a microscopic scale.

UNIT-IV: Introduction to Nuclear Physics

Provide students with a computer simulation or interactive app that allows them to explore radioactive decay processes. Ask students to observe and analyze the decay patterns of different isotopes, including the concept of half-life. Guide students to make connections between the simulation results and the fundamental principles of nuclear physics

UNIT-V: Nuclear Detectors and Nuclear Accelerators

Activity: Detector Comparison Chart – Students create a comparative table of detector types, operation principles, advantages, and use-cases.

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SEMESTER-III

COURSE 6: BASIC ELECTRONICS

Theory	Credits: 3	3 hrs/week

COURSE OBJECTIVES

This course aims to introduce undergraduate physics students to the fundamental principles of electronics. It covers passive components, semiconductor physics, diode and transistor operation, DC power supplies, and the basics of digital logic. The goal is to build a solid foundation in circuit analysis and electronic devices for students with minimal prior background.

LEARNING OUTCOMES:

By the end of the course, students will be able to:

1. Identify and explain the function and types of resistors, capacitors, and inductors.
2. Understand the basic concepts of semiconductors and diode characteristics.
3. Analyze simple transistor circuits and their applications.
4. Describe the functioning of rectifiers, filters, and voltage regulators.
5. Perform basic binary arithmetic and construct simple digital logic circuits.

UNIT I: PASSIVE COMPONENTS AND CIRCUIT FUNDAMENTALS (9 hrs)

Resistors: Types (carbon, wire-wound, metal film), color coding, tolerance, power ratings - Capacitors: Types (ceramic, electrolytic, film), applications, charge/discharge behavior - Inductors: Basic structure and applications - Series and parallel combinations: Equivalent resistance/capacitance/inductance - Basic laws: Ohm's Law, Kirchhoff's Voltage and Current Laws (KVL, KCL) with simple applications

UNIT II: SEMICONDUCTOR PHYSICS AND DIODES (9 hrs)

Intrinsic vs extrinsic semiconductors - Doping, energy band diagrams, charge carriers - PN junction diode: Construction, working, forward/reverse biasing, I-V characteristics - Special diodes: Zener diode, LED, photodiode, solar cell – construction, characteristics and uses

UNIT III: TRANSISTORS AND THEIR OPERATION (9 hrs)

BJT: Structure, current components, working of NPN/PNP - Configurations: CB, CE, CC – input/output characteristics - Applications: Transistor as switch and amplifier (qualitative understanding)

UNIT IV: POWER SUPPLIES AND REGULATION (9 hrs)

Need for DC power supply: Block diagram - Rectifiers: Half-wave, full-wave, bridge with waveforms - Filter circuits: RC, LC, and π filters – working principle - Voltage regulation: Zener diode regulation, IC regulators (brief intro)

UNIT V: INTRODUCTION TO DIGITAL ELECTRONICS (9 hrs)

Analog vs Digital signals - Number systems: Binary, decimal, hexadecimal – conversions, binary arithmetic - Logic gates: AND, OR, NOT – symbols, truth tables, simple logic circuits , Universal gates (NAND, NOR) – brief introduction

Textbooks / References:

1. V.K. Mehta & Rohit Mehta – *Principles of Electronics*, S. Chand
2. R.S. Sedha – *A Textbook of Applied Electronics*, S. Chand
3. D. Chattopadhyay & P.C. Rakshit – *Electronics: Fundamental Concepts*, New Central
4. Malvino & Leach – *Digital Principles and Applications*, McGraw-Hill
5. A.K. Maini – *Digital Electronics*, Wiley India

Student Activities

1. **Component Hunt**
    - Task: Identify and collect physical samples of resistors, capacitors, diodes, and transistors from old circuit boards.
    - Outcome: Visual and tactile understanding of component shapes, labels, and ratings.
2. **Poster Presentation**
    - Topic examples: "Types of Diodes and Their Applications" or "Power Supply Block Diagram."
    - Outcome: Encourages concise technical communication and peer learning.
3. **Group Demonstration**
    - Task: Simulate or build a basic rectifier or transistor switch circuit using breadboard or simulation software.
    - Outcome: Team collaboration and hands-on understanding.
4. **Number System Puzzle or Quiz**
    - Task: Convert between binary, decimal, and hexadecimal; perform binary addition/subtraction.
    - Outcome: Reinforces digital electronics basics through gamified learning.
5. **Mini Project (Optional)**
    - Task: Build a simple LED flasher or night lamp circuit using transistors and passive components.
    - Outcome: Design thinking and real-world application.
6. **Circuit Debugging Challenge**
    - Task: Find and correct errors in a faulty circuit diagram provided by the teacher.
    - Outcome: Improves analytical and practical troubleshooting skills.
7. **Logic Gate Simulation**
    - Task: Use a free simulator (like Falstad, Tinkercad, or Logic.ly) to create logic circuits.
    - Outcome: Concept reinforcement through virtual labs.

SEMESTER-III

COURSE 6: BASIC ELECTRONICS

Practical | **Credits: 1** | **2 hrs/week**

COURSE OBJECTIVE:

To develop practical skills in handling basic electronic components and circuits by constructing, testing, and analyzing simple electronic systems such as rectifiers, filters, diode/transistor configurations, and digital logic gates using fundamental measurement tools.

Learning Outcomes

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

1. Measure and verify the behavior of passive components in circuits.
2. Construct and test diode and transistor-based circuits.
3. Analyze rectifier output and filter performance using basic instruments.
4. Build and verify logic gate circuits using ICs or trainer kits.
5. Practice circuit debugging, use of multimeters, and interpretation of waveforms using a CRO.

Minimum of 6 experiments to be done and recorded

Experiments (Practical List)

1. **Verification of Ohm's Law** using resistive networks (series and parallel combinations).
2. Series and Parallel Combination of Capacitors and Inductors
3. **Capacitor charging and discharging curves** using RC circuits and a stopwatch/multimeter.
4. **V-I characteristics of a PN junction diode** (forward and reverse bias)
5. Temperature Dependence of Resistance (Using Thermistor).
6. **Zener diode characteristics** and voltage regulation behavior.
7. **Study of LED and photodiode characteristics** under different light conditions.
8. **BJT transistor as a switch**: ON/OFF control of an LED.
9. **Construction of half-wave and full-wave rectifiers** and measurement of output voltage.
10. **Design and analysis of simple π-filtered power supply circuits.**
11. **Verification of logic gates (AND, OR, NOT, NAND, NOR)** using digital ICs or simulation.

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SEMESTER-III

COURSE 7: APPLIED OPTICS

Theory **Credits: 3** **3 hrs/week**

COURSE OBJECTIVE:

This course aims to introduce students to the core principles of optics and the functioning of various optical instruments. The objective is to provide a clear understanding of ray optics, aberrations, lasers, optical fibers, holography, and their applications in modern optical systems such as microscopes and telescopes.

LEARNING OUTCOMES:

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

1. Understand the fundamentals of geometrical optics using ray matrices and apply them to complex lens systems.
2. Analyze and distinguish various types of optical aberrations and methods to minimize them.
3. Comprehend the basic principle of laser, the working of He-Ne laser and Ruby lasers and their applications in different fields.
4. Understand the basic principles of fibre optic communication and explore the field of Holography and Nonlinear optics and their applications.
5. Gain knowledge of various optical instruments including microscopes and telescopes, their types, and real-world applications

UNIT-I: GEOMETRICAL OPTICS

(9 hrs.)

Ray optics assumptions, Fermat principle, Translation matrix, Reflection matrix, Refraction matrix, ABCD matrices system matrix, Thick lens formula, Thin lens formula, Ramsden eyepiece, Huygens eyepiece, Two lens formula - (i) separated by a distance and (ii) in contact.

UNIT-II: ABERRATIONS

(9 hrs.)

Fresnel theory of Reflection and Refraction. Monochromatic aberrations, Spherical aberration, Methods of minimizing spherical aberration, Coma, Astigmatism and Curvature of field, Distortion; Chromatic aberration-the achromatic doublet; Achromatism for two lenses (i) in contact and (ii) separated by a distance.

UNIT-III: LASERS

(9 hrs.)

Lasers: Introduction, Spontaneous emission, Stimulated emission, Population Inversion, Laser principle, Einstein coefficients, Types of lasers: He-Ne laser, Ruby laser, Semiconductor laser, Applications of laser.

UNIT-IV: OPTICAL FIBERS AND HOLOGRAPHY **(9 hrs.)**

Principle of Optical fibers, Acceptance angle, Acceptance cone, Numerical aperture, Types of optical fibers - Graded and Stepped index, Types Signal attenuation mechanisms in optical fibers, Applications of Optical fibers - Sensors, Imaging, Communication.

Holography: Basic principle of holography-Gabor hologram and its limitations, Applications of holography.

UNIT-V: APPLICATIONS OF OPTICAL INSTRUMENTS **(9 hrs.)**

Introductory ideas and applications of various microscopes *viz*., (i) Optical microscopes (Compound microscope, Confocal microscope) (ii) Electron microscopes – SEM, Introductory ideas and applications of various telescopes *viz*., (i) Optical telescopes (ii) Radio telescopes (iii) Solar telescopes (iv) Infrared telescope (v) Ultraviolet telescope

REFERENCE BOOKS:

1. BSc Physics, Vol.2, Telugu Akademy, Hyderabad.
2. Optics - principles and applications Kailash K. Sharma
3. An introduction to Lasers M N Avadhanulu
4. Lasers Tyagarajan Ghatak 2nd Ed.
5. Introduction to Fiber Optics Tyagarajan Ghatak
6. Principles of Laser material processing Elijah Kannatey Asibu
7. Quantum optics An introduction Mark Fox

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SEMESTER-III

COURSE 7: APPLIED OPTICS

Practical	Credits: 1	2 hrs/week

COURSE OBJECTIVE:

To provide hands-on experience with optical components and instruments, and to reinforce theoretical concepts through practical applications involving lasers, optical fibers, microscopes, and ray optics techniques.

LEARNING OUTCOMES:

1. Understand and apply geometrical optics principles through practical experiments involving lens combinations, matrix methods, and measurement of focal lengths using systems like the two-lens setup.
2. Demonstrate hands-on understanding of monochromatic and chromatic aberrations by working with diffraction gratings and measuring resolving powers of optical components like gratings and telescopes.
3. Explore the operational principles and characteristics of lasers, including wavelength measurement using diffraction gratings and analysis of laser beam behavior through reflection and refraction experiments.
4. Operate and analyze optical fiber systems by determining the numerical aperture, acceptance angle, and exploring their applications in communication and light guiding.
5. Investigate holographic concepts by understanding the role of laser light in interference-based techniques and identifying the limitations of basic holographic setups.
6. Examine and interpret the working of various optical instruments such as microscopes and telescopes by studying resolution, power, and optical limitations through practical experiments and simulations.

Minimum of 6 experiments to be done and recorded

1. Wavelength of laser using Diffraction grating
2. Refractive index of liquid using Hollow prism
3. Resolving power of telescope
4. Resolving power of grating
5. Spectrometer: i-d curve
6. Laser Reflection grating using metal scale
7. Optical fiber - Numerical Aperture
8. Rabi Oscillations Octave program
9. Two lens system power pairs plot (Python/Octave)
10. Focal length and verification of matrix method for thick and thin lenses
11. Achromatic combination of two lenses – in contact and at a distance
12. Measurement of beam divergence and spot size of a laser
13. Verification of Malus' Law using a laser and polarizers
14. Study of diffraction pattern from circular aperture (Airy disk) – resolving limit
15. Young's double-slit experiment using laser – interference fringes and fringe width
16. Study of bending losses in optical fiber

STUDENT ACTIVITIES

Unit-I: Geometrical Optics

Activity: Lens Matrix Simulation and Eyepiece Comparison

Students can use Python or Octave to simulate the behavior of optical systems using ABCD matrices. They can plot system matrices for single and double-lens setups and analyze the effective focal length. Additionally, students may perform a comparative analysis between Ramsden and Huygens eyepieces using ray diagrams and matrix methods, presenting their findings through short presentations or lab reports

Unit-II: Aberrations

Ask students to observe and sketch the different images produced by the lens at different distances. Build a simple optical system with two lenses in contact and ask students to calculate the focal length and magnification of the system. Then, introduce a thin glass plate between the lenses to simulate the effects of chromatic aberration and ask students to observe and discuss the changes in the image produced.

Unit-III: Lasers

Activity: Laser Communication Demo – Group project to transmit voice using a laser beam and photodiode.

Unit-IV: Optical fibers and Holography

Demonstrate the principle of holography using a laser beam, a beam splitter, and a photographic plate. Ask students to record a hologram of a simple object and then reconstruct the image using a laser beam.

UNIT-V: Applications of Optical Instruments

Activity: Comparative Analysis of Optical and Electron Microscopes and Telescope Technologies Students will form groups to study various microscopes (compound, confocal, SEM) and telescopes (radio, solar, UV, IR). Each group will create a model or infographic that illustrates the working principles, resolution limits, and applications of these instruments. Presentations will focus on how optics is tailored to different wavelength regimes.

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SEMESTER-IV

COURSE 8: ELECTRICITY, MAGNETISM AND ELECTROMAGNETIC THEORY

Theory | **Credits: 3** | **3 hrs/week**

COURSE OBJECTIVE:

The course on Electricity, Magnetism and Electromagnetic theory aims to provide students with a fundamental understanding of the principles of electricity, magnetism, and electromagnetic theory.

LEARNING OUTCOMES:

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

1. Understand the Gauss law and its application to obtain electric field in different cases and formulate the relationship between electric displacement vector, electric polarization, Susceptibility, Permittivity and Dielectric constant.
2. To learn the methods used to solve problems using loop analysis, Nodal analysis, Thvenin's theorem, Norton's theorem, and the Superposition theorem
3. Distinguish between the magnetic effect of electric current and electromagnetic induction and apply the related laws in appropriate circumstances.
4. Understand Biot and Savart's law and Ampere's circuital law to describe and explain the generation of magnetic fields by electrical currents.
5. Develop an understanding on the unification of electric, and magnetic fields and Maxwell's equations governing electromagnetic waves.
6. Phenomenon of resonance in LCR AC-circuits, sharpness of resonance, Q- factor, Power factor and the comparative study of series and parallel resonant circuits

UNIT-I: ELECTROSTATICS AND DIELECTRICS (9 hrs)

Gauss's law - Statement and its proof, Electric field intensity due to uniformly charged solid sphere, Electrical potential–Equipotential surfaces, Potential due to a uniformly charged sphere. Dielectrics-Polar and Non-polar dielectrics - Effect of electric field on dielectrics, Dielectric strength, Electric displacement D, electric polarization Relation between D, E and P, Dielectric constant and electric susceptibility.

UNIT-II: CURRENT ELECTRICITY (9 hrs)

Electrical conduction - drift velocity-current density, equation of continuity, ohms law and limitations, Kirchhoff's Law's, Branch current method, Nodal Analysis, Star to Delta & Delta to Star conversions. Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum power transfer theorem.

UNIT-III: MAGNETOSTATICS AND ELECTROMAGNETIC INDUCTION (9 hrs)

Magneto statics: Biot-Savart's law and its applications: (i) long straight wire and (ii) circular loop, Hall Effect, determination of Hall coefficient and applications, magnetic charge, concept of vector potential.

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, Self-induction and Mutual induction, Self- inductance of a long solenoid, Magnetic Energy density, mutual inductance of a pair of coils, coefficient of Coupling.

UNIT-IV ELECTROMAGNETIC WAVES-MAXWELL'S EQUATIONS (9 hrs)

Maxwell's equations: integral and differential forms (No derivation), Continuity equation, Concept of displacement current. Plane electromagnetic wave equation, Hertz experiment - Transverse nature of electromagnetic waves, Electromagnetic wave equation in conducting media, Skin depth, Poynting theorem-Pointing vector, Wave equations for E & B, Maxwell's equations in matter.

UNIT-V VARYING AND ALTERNATING CURRENTS (9 hrs)

Growth and decay of currents in LR, CR, LCR circuits-Critical damping, alternating current - A.C. fundamentals, and A.C through pure R, L and C, Relation between current and voltage in LR and CR circuits, Phasor and Vector diagrams, LCR series and parallel resonant circuit, Q - factor, Power in ac circuits, Power factor.

REFERENCE BOOKS:

1. BSc Physics, Vol.3, Telugu Akademy, Hyderabad.
2. Electricity and Magnetism, D.N. Vasudeva. S. Chand & Co.
3. Electricity, Magnetism with Electronics, K.K. Tewari, R. Chand & Co.,
4. "Electricity and Magnetism" by Brijlal and Subramanyam Ratan Prakashan Mandir, 1966
5. "Electricity and Magnetism: Fundamentals, Theory, and Applications" by Murugeshan, Kiruthiga Siva prasath, and M. Saravanapandian
6. "Electricity and Magnetism: Theory and Applications" by Ajoy Ghatak and Lokanathan
7. Electricity and Magnetism: Problems and Solutions" by Ashok Kumar and Rajesh Kumar
8. Electricity and Magnetism, R.Murugeshan, S. Chand & Co.

SEMESTER-IV

COURSE 8: ELECTRICITY, MAGNETISM AND ELECTROMAGNETIC THEORY

Practical | **Credits: 1** | **2 hrs/week**

COURSE OBJECTIVE:

The Course Objective for a practical course in electricity and magnetism may include to develop practical skills in handling electrical and electronic components, such as resistors, capacitors, inductors, transformers, and oscillators.

LEARNING OUTCOMES:

1. Demonstrate a thorough understanding of the fundamental concepts and principles of electricity and magnetism.
2. Apply the laws and principles of electricity and magnetism to analyze and solve electrical and magnetic problems.
3. Design, construct, and test electrical circuits using various components and measuring instruments.
4. Measure and analyze electrical quantities such as voltage, current, resistance, capacitance, and inductance using appropriate instruments.
5. Apply the principles of electromagnetism to understand and analyze the behavior of magnetic fields and their interactions with electric currents

Minimum of 6 experiments to be done and recorded

1. LCR circuit series resonance, Q factor.
2. LCR circuit parallel resonance, Q factor.
3. Determination of AC-frequency –Sonometer.
4. Verification of Kirchhoff's laws and Maximum Power Transfer theorem.
5. Field along the axis of a circular coil carrying current-Stewart & Gee's apparatus.
6. Charging and discharging of CR circuit-Determination of time constant
7. A.C Impedance and Power factor
8. Determination of specific resistance of wire by using Carey Foster's bridge.
9. Study of electric field and equipotential lines using conducting paper/Solution
10. Measurement of inductance using bridge method (Maxwell's or Anderson's bridge)
11. Demonstration of electromagnetic shielding (Faraday cage effect)
12. Study of skin effect using high-frequency AC and measuring resistance variation
13. Simulation of electromagnetic wave propagation using MATLAB/Python
14. Poynting vector direction demonstration using polarizers and wave sources (conceptual demo)
15. Q factor and resonance frequency using CRO in LCR circuits (with variable frequency AC generator)

STUDENT ACTIVITIES

UNIT-I Electrostatics and Dielectrics

Conduct a simulation to visualize equipotential surfaces for a given charge distribution.

Conduct a group discussion on the significance of electric field lines and how they can be used to predict the motion of charged particles in electric fields.

UNIT-II Current electricity

Conduct a Wheatstone bridge experiment in class and discuss the balancing condition and sensitivity. Conduct a group activity where students are divided into groups and assigned a different circuit analysis method (nodal analysis, mesh analysis, superposition theorem, etc.) and asked to present their findings to the class.

UNIT-III Magneto statics and Electromagnetic Induction

Conduct a demonstration to show the Hall Effect and measure the Hall coefficient of a given material. Conduct a group activity where students are divided into groups, and assigned a different application of Faraday's law (electromagnetic induction, transformers, etc.) and asked to present their findings to the class.

UNIT-IV Electromagnetic waves

Conduct a group activity where students are asked to research the history of the development of Maxwell's equations and present their findings to the class.

Conduct a simulation to visualize the propagation of electromagnetic waves in different media (vacuum, air, water, etc.) and discuss the differences in the behaviour of waves in different media.

UNIT-V Varying and alternating currents

Conduct a demonstration to show the resonance in an LCR circuit and measure the Q-factor.

Conduct a group activity where students are divided into groups and assigned a different power factor correction method (capacitor banks, synchronous condensers, etc.) and asked to present their findings to the class.

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SEMESTER-IV

COURSE 9: ANALOG ELECTRONICS

Theory **Credits: 3** **3 hrs/week**

COURSE OBJECTIVE:

To build on the understanding of transistor and op-amp-based analog circuits, enabling students to analyze and design amplifiers, oscillators, and basic analog signal processing systems for real-world applications.

LEARNING OUTCOMES:

By the end of the theory course, the student will be able to:

1. Analyze the design and performance of BJT amplifier circuits and multistage configurations.
2. Distinguish between different classes of power amplifiers and understand feedback principles.
3. Understand the internal operation and characteristics of operational amplifiers.
4. Design practical op-amp-based analog circuits for mathematical operations and signal conditioning.
5. Explain the principles of sinusoidal oscillator circuits and their applications.

UNIT I: BJT AMPLIFIERS (9 hrs)

Review of transistor operation in CE configuration - Load line analysis, biasing concepts (fixed bias, voltage divider bias) - CE amplifier: Circuit, gain, input/output impedance - Frequency response, bandwidth - Multistage amplifiers and emitter follower (voltage follower)

UNIT II: POWER AND FEEDBACK AMPLIFIERS (9 hrs)

Classification of amplifiers: Class A, B, AB, C - Class A and Class B power amplifiers – working and efficiency - Push-pull amplifier – circuit and waveforms - Negative feedback: Types (voltage/current series/shunt), effect on gain, bandwidth, stability

UNIT III: OPERATIONAL AMPLIFIERS – BASICS (9 hrs)

Characteristics of ideal and practical op-amp - Parameters: CMRR, slew rate, input offset voltage, bias current - Pin configuration and block diagram of IC 741 - Open loop and closed loop configuration

UNIT IV: APPLICATIONS OF OP-AMPS (9 hrs)

Inverting and non-inverting amplifiers – gain derivation and characteristics - Adder, subtractor circuits - Integrator and differentiator – design and applications - Comparators and zero-crossing detectors

UNIT V: OSCILLATOR CIRCUITS (9 hrs)

Conditions for oscillations: Barkhausen criterion - RC oscillators: Phase shift oscillator, Wein bridge oscillator – circuit, working - LC oscillators: Hartley, Colpitts – basic theory and circuits - Crystal oscillator: Construction and applications

Textbooks / References:

1. Robert L. Boylestad – *Electronic Devices and Circuit Theory*, Pearson
2. Ramakant A. Gayakwad – *Op-Amps and Linear Integrated Circuits*, PHI
3. D. Roy Choudhury – *Linear Integrated Circuits*, New Age International
4. A.P. Malvino – *Electronic Principles*, Tata McGraw-Hill
5. Millman & Halkias – *Integrated Electronics*, McGraw-Hill

Student Activities List

1. **Waveform analysis**: Record and interpret CRO traces from amplifier and oscillator outputs.
2. **Op-amp datasheet exploration**: Interpret specifications of IC 741 or similar.
3. **Mini project:** Build a tone generator or audio amplifier circuit.
4. **Simulation task**: Simulate CE amplifier or op-amp circuit using free tools like Falstad or Multisim Live.
5. **Classroom quiz**: Identify amplifier classes and feedback types based on circuit conditions.
6. **Group circuit-building challenge**: Design a multistage amplifier with given constraints.
7. **Poster presentation**: On "Power Amplifier Classes: Differences and Applications."
8. **Function generator use**: Demonstrate square, triangle, and sine wave outputs and measure frequency.
9. **Lab oral viva:** Justify component selection in op-amp applications.
10. **Oscillator comparison chart**: Create a chart comparing Hartley, Colpitts, and Wein bridge oscillators.

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SEMESTER-IV

COURSE 9: ANALOG ELECTRONICS

Practical **Credits: 1** **2 hrs/week**

COURSE OBJECTIVE:

To provide hands-on experience in constructing and analyzing analog circuits involving BJTs, operational amplifiers, and oscillator configurations using commonly available components and instruments.

LEARNING OUTCOMES:

By the end of the lab course, the student will be able to:

1. Design and analyze various transistor amplifier circuits.
2. Measure amplifier parameters such as voltage gain, bandwidth, and input/output impedance.
3. Implement analog signal processing circuits using op-amps.
4. Test sinusoidal oscillator circuits and identify working conditions.
5. Utilize function generators, power supplies, and CROs for analog circuit testing..

Minimum of 6 experiments to be done and recorded

1. **CE amplifier design and performance:** Measure voltage gain and bandwidth.
2. **Transistor biasing circuits**: Fixed bias and voltage divider bias—measurement of Q-point.
3. **Class-B push-pull amplifier**: Construction and efficiency estimation.
4. **Negative feedback amplifier**: Study gain variation with and without feedback.
5. **Study of IC 741 op-amp parameters**: Offset voltage, bias current, and CMRR.
6. **Op-amp inverting and non-inverting amplifiers**: Gain and phase comparison.
7. **Op-amp adder and subtractor circuits**: Build and verify output equations.
8. **Op-amp integrator and differentiator**: Observe and sketch output waveforms.
9. **Wein bridge oscillator using op-amp or transistor**: Frequency and waveform measurement.
10. **Phase-shift oscillator** using RC networks and op-amp.

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SEMESTER-IV

COURSE 10: ADVANCES IN PHYSICS

Theory	Credits: 3	3 hrs/week

Course Objectives

1. To introduce students to fundamental concepts of quantum mechanics, classical mechanics, and the evolution of computing with emphasis on quantum computing principles.
2. To expose students to emerging areas in physics, including nanotechnology and renewable energy, and their practical applications in modern technology and sustainable development.

Learning Outcomes

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

1. Apply basic quantum mechanics concepts including the Schrödinger equation, quantum postulates, and Pauli matrices to simple physical systems.
2. Formulate and solve mechanical problems using Lagrangian and Hamiltonian formulations of classical mechanics.
3. Trace the historical and technological evolution of computers, and explain the significance of quantum algorithms and the concept of quantum supremacy.
4. Identify and describe types of nanomaterials and discuss their unique properties and applications in science and technology.
5. Compare various renewable energy sources and explain principles of energy generation, storage, and integration into modern power grids.

UNIT-I CONCEPTS OF QUANTUM MECHANICS (9 hrs.)

Photoelectric effect, Compton Effect, Schrodinger's wave Equation time dependent, Time independent, Postulates of Quantum mechanics, Properties of wave function, Expectation values. One-dimensional problems - Particle in a box. Pauli spin matrices.

UNIT-II LAGRANGIAN MECHANICS (9 hrs.)

Conservation laws, Constraints, Generalized coordinates and velocities, Virtual displacement, virtual work, D'Alambert Principle, Lagranges equation of motion, Application-Simple pendulum, Atwood machine. Principle of least action, Hamiltonian equation of motion, Legendre transformation.

UNIT III EVOLUTION OF COMPUTERS (9 hrs.)

Computers: Mechanical to electronic evolution, Generations of computers: Vacuum tubes, transistors, ICs, microprocessors, Moore's Law and classical computing limitations, Need for a new paradigm: Introduction to quantum concepts, Key contributions from Feynman, Deutsch, and others, Overview of Shor's and Grover's algorithms, Concept and implications of quantum supremacy

UNIT IV: FUNDAMENTALS OF NANOTECHNOLOGY (9 hrs.)

Introduction to Nanoscience and Nanotechnology, Definition, historical development, and importance. Volume to Surface ratio, quantum effects, Types of Nanomaterials: Nanoparticles, nanowires, nanotubes, quantum dots. Applications of Nanotechnology: In electronics, medicine, energy, and environment

UNIT V: RENEWABLE ENERGY (9 hrs.)

Conventional and Non-conventional energy sources. Renewable energy and its resources
Solar energy - Generation, energy storage. Grid Integration and Smart Grids
Green energies - Wind energy, Biomass energy, Tidal energy and green energy, Fuel cells

Books and References

1. **Quantum Mechanics: Concepts and Applications** – Nouredine Zettili
2. **Principles of Quantum Mechanics** – R. Shankar
3. **A Textbook of Quantum Mechanics** – P.M. Mathews and K. Venkatesan *(Indian Author)*
4. **Classical Mechanics** – H. Goldstein, C. Poole, and J. Safko
5. **Introduction to Classical Mechanics** – R.G. Takwale and P.S. Puranik *(Indian Author)*
6. **Classical Mechanics** – J.C. Upadhyaya *(Indian Author)*
7. **Computer Organization and Architecture** – William Stallings
8. **Quantum Computation and Quantum Information** – Michael A. Nielsen and Isaac L. Chuang
9. **Fundamentals of Computers** – V. Rajaraman *(Indian Author)*
10. **Quantum Mechanics and Path Integrals** – Richard P. Feynman and A.R. Hibbs
11. **Introduction to Nanotechnology** – Charles P. Poole Jr. and Frank J. Owens
12. **Nanoscience and Nanotechnology** – M.A. Shah and Tokeer Ahmad *(Indian Author)*
13. **Renewable Energy Resources** – John Twidell and Tony Weir
14. **Non-Conventional Energy Sources** – G.D. Rai *(Indian Author)*
15. **Solar Energy: Principles of Thermal Collection and Storage** – S.P. Sukhatme and J.K. Nayak *(Indian Author)*

Student Activities

1. **Solve numerical problems** on particle in a box, harmonic oscillator, and quantum statistics to reinforce conceptual understanding.
2. **Create a comparison chart** of industrial materials highlighting their properties and specific applications across different industries.
3. **Prepare a poster or presentation** on types of nanomaterials and their real-life applications in healthcare, electronics, or energy.
4. **Demonstrate or simulate** the working of basic sensors and use a CRO or signal generator to observe and analyze waveforms.
5. **Build a working model** or give a seminar on a renewable energy system (e.g., mini solar panel setup or wind turbine model).

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SEMESTER-IV

COURSE 10: ADVANCES IN PHYSICS

Practical **Credits: 1** **1 hrs/week**

Course Objective:

To provide students with hands-on experience and demonstrations of fundamental and emerging concepts in modern physics through physical and simulated experiments, focusing on quantum phenomena, material properties, energy technologies, and basic nanoscience.

Learning Outcomes

After successful completion of the course, the student will be able to:

1. **Demonstrate understanding of quantum and thermal physics principles** through experiments such as photoelectric effect and Boltzmann constant determination.
2. **Analyze electrical and magnetic properties** of materials using real measurements (resistivity, magnetization, LDR, etc.).
3. **Explore basic properties of nanomaterials and their synthesis** through simple laboratory techniques like green synthesis of nanoparticles.
4. **Develop awareness of renewable energy technologies** and compare efficiencies of energy devices like solar panels, LEDs, and fuel cells.
5. **Apply instrumentation skills** in using sensors, CROs, and circuit components for measuring physical parameters.
6. **Interpret results from simulated experiments** and link theoretical physics models with practical outcomes (e.g., Maxwell-Boltzmann distribution, particle in a box).
7. **Enhance scientific inquiry and experimental reporting skills** through observations, data analysis, and interpretation.

A minimum of 6 experiments to be performed and recorded

1. Photoelectric Effect using UV LED and LDR
    - Demonstrates threshold frequency and energy quantization.
2. Determination of Boltzmann Constant from Diode Characteristics
    - Uses current–voltage relation of a diode.
3. Simple Pendulum – Time Period vs. Lagrangian Prediction
    - Validates theoretical dynamics.
4. Atwood Machine – Verification of Newton's Laws
    - Demonstrates conservation of energy and force analysis.
5. LCR Circuit and Impedance Measurement
    - Explores phase relations and resonance in AC circuits..
6. Synthesis of Iron Oxide Nanoparticles (Green Method)
    - Simple and safe wet-chemical synthesis using plant extracts.
7. Surface Area to Volume Ratio Demonstration Using Sugar Cubes/Sponge
    - Explains nanoscale effects visually.

8. Wind Energy Demonstration (Fan + Mini Turbine Setup)
    - Demonstrates wind-to-electricity conversion.
9. Hydrogen Generation via Electrolysis and Fuel Cell Demonstration
    - Produces H_2 and shows voltage from a fuel cell.
10. Efficiency Comparison Between LED and Incandescent Bulbs
    - Measures power consumption and light output.
11. Solar Panel Efficiency under Different Light and Load Conditions
    - Demonstrates photovoltaic energy conversion and optimization.
12. Battery/Fuel Cell Voltage Measurement with Varying Load
    - Observes how output voltage changes with load resistance.

💻 Simulation-Based or Digital Experiments

13. 1D Particle in a Box – Simulation using PhET/Python
    - Visualizes quantum confinement and energy levels.
14. Rutherford Scattering Simulation
    - Models scattering patterns and cross-section concepts.
15. Spin-½ System and Pauli Matrices – Qiskit or QuTiP
    - Simulates spin operators and quantum states.
16. Visualization of Kepler's Laws and Satellite Orbits
    - Models elliptical motion and geostationary conditions.
17. Lagrangian and Hamiltonian Simulation (e.g., Double Pendulum)
    - Explores classical mechanics through dynamic systems..
18. Basic Quantum Circuit Simulation using IBM Quantum Lab (Qiskit)
    - Visualizes gates, superposition, and basic algorithms.

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