**SEMESTER-IV**

## COURSE 8: ELECTRICITY, MAGNETISM AND ELECTROMAGNETIC THEORY

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

**SEMESTER-IV**

## COURSE 9: ANALOG ELECTRONICS

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

## 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.

## 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).

**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.