

3. Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
4. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11/e, 2011, Kitab Mahal.

### **CC-III: Electricity and Magnetism (32221201)**

**Credit: 06 (Theory-04, Practical-02)**

**Theory: 60 Hours**

**Practical: 60 Hours**

#### **Course Objective**

This course reviews the concepts of electromagnetism learnt at school from a more advanced perspective and goes on to build new concepts. The course covers static and dynamic electric and magnetic fields, and the principles of electromagnetic induction. It also includes analysis of electrical circuits and introduction of network theorems. The students will be able to apply the concepts learnt to several real world problems.

#### **Course Learning Outcomes**

At the end of this course the student will be able to

- Demonstrate the application of Coulomb's law for the electric field, and also apply it to systems of point charges as well as line, surface, and volume distributions of charges.
- Demonstrate an understanding of the relation between electric field and potential, exploit the potential to solve a variety of problems, and relate it to the potential energy of a charge distribution.
- Apply Gauss's law of electrostatics to solve a variety of problems.
- Calculate the magnetic forces that act on moving charges and the magnetic fields due to currents (Biot- Savart and Ampere laws)
- Understand the concepts of induction and self-induction, to solve problems using Faraday's and Lenz's laws.
- Understand the basics of electrical circuits and analyze circuits using Network Theorems.
- In the laboratory course the student will get an opportunity to verify network theorems and study different circuits such as RC circuit, LCR circuit. Also, different methods to measure low and high resistance, capacitance, self-inductance, mutual inductance, strength of a magnetic field and its variation in space will be learnt.

#### **Unit 1**

**Electric Field and Electric Potential:** Electric field: Electric field lines. Electric flux. Gauss Law with applications to charge distributions with spherical, cylindrical and planar symmetry.

(6 Lectures)

**Conservative nature of Electrostatic Field:** Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole.

(6 Lectures)

**Electrostatic energy of system of charge:** Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

(10 Lectures)

**Dielectric Properties of Matter:** Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector  $\mathbf{D}$ . Relations between  $\mathbf{E}$ ,  $\mathbf{P}$  and  $\mathbf{D}$ . Gauss' Law in dielectrics.

(8 Lectures)

## Unit 2

**Magnetic Field:** Magnetic force between current elements and definition of Magnetic Field  $\mathbf{B}$ . Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of  $\mathbf{B}$ : curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.

(9 Lectures)

**Magnetic Properties of Matter:** Magnetization vector ( $\mathbf{M}$ ). Magnetic Intensity ( $\mathbf{H}$ ). Magnetic Susceptibility and permeability. Relation between  $\mathbf{B}$ ,  $\mathbf{H}$ ,  $\mathbf{M}$ . Ferromagnetism. B-H curve and hysteresis.

(4 Lectures)

**Electromagnetic Induction:** Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current.

(6 Lectures)

## Unit 3

**Electrical Circuits:** AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit.

(5 Lectures)

**Network theorems:** Ideal constant-voltage and constant-current Sources. Review of Kirchhoff's Current Law & Kirchhoff's Voltage Law. Mesh & Node Analysis. Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity Theorem, Maximum Power Transfer theorem. Applications to dc circuits.

**(6 Lectures)**

### **Practical : 60 Hours**

Dedicated demonstration cum laboratory sessions on the construction, functioning and uses of different electrical bridge circuits, and electrical devices like the ballistic galvanometer.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.

Sessions on least square fitting and computer programme to find slope and intercept of straight-line graphs of experimental data. Application to the specific experiments done in the lab.

At least 6 experiments from the following:

1. To study the characteristics of a series RC Circuit.
2. To determine an unknown Low Resistance using Potentiometer.
3. To determine an unknown Low Resistance using Carey Foster's Bridge.
4. To compare capacitances using De'Sauty's bridge.
5. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
6. To verify the Thevenin and Norton theorems.
7. To verify the Superposition, and Maximum power transfer theorems.
8. To determine self inductance of a coil by Anderson's bridge.
9. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
10. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
11. Measurement of charge sensitivity, current sensitivity and CDR of Ballistic Galvanometer
12. Determine a high resistance by leakage method using Ballistic Galvanometer.
13. To determine self-inductance of a coil by Rayleigh's method.
14. To determine the mutual inductance of two coils by Absolute method.

### **References for Theory:**

#### **Essential Readings:**

1. Fundamentals of Electricity and Magnetism, Arthur F. Kip, 2nd Edn.1981, McGraw-Hill.
2. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
3. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
4. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol.I, 1991, Oxford Univ. Press.
5. Network, Lines and Fields, John D. Ryder, 2<sup>nd</sup> Edn., 2015, Pearson.

#### **Additional Readings:**

1. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
2. Electricity, Magnetism & Electromagnetic Theory, S.Mahajanand Choudhury, 2012, Tata McGraw
3. Electricity and Magnetism, J.H.Fewkes& J.Yarwood. Vol.I, 1991, Oxford Univ. Press.
4. Problems and Solutions in Electromagnetics (2015), Ajoy Ghatak, K Thyagarajan & Ravi Varshney.
5. Schaum's Outline of Electric Circuits, J. Edminister & M. Nahvi, 3rd Edn., 1995, McGraw Hill.

### **References for Laboratory Work:**

1. Advanced Practical Physics for students, B.L. Flint and H.T.Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. Engineering Practical Physics, S.Panigrahi and B.Mallick,2015, Cengage Learning.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press

## **CC-IV: Waves and Optics (32221202)**

**Credit : 06 (Theory-04, Practical-02)**

**Theory : 60 Hours**

**Practical : 60 Hours**

### **Course Objective**

This course reviews the concepts of waves and optics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with explaining ideas of superposition of harmonic oscillations leading to physics of travelling and standing waves. The course also provides an in depth understanding of wave phenomena of light, namely, interference and diffraction with emphasis on practical applications of the same.

### **Course Learning Outcomes**

On successfully completing the requirements of this course, the students will have the skill and knowledge to: