Semester: VII	
Programme : Physics	
Course: Electricity and Magnetism & Electrical Circuits and Electronics	
Paper code: B4PB230721T	**Credits: 2+2**
Hours/week : 4	
Category: Core/MDC/SEC/VAC : Minor	
Theory / Practical / Composite : Theory	
No of Modules : 2	

Course Overview: Electricity and Magnetism

This module introduces the fundamental principles of classical electricity and magnetism for the students opting for this Physics minor course. In electrostatics, the course begins with a recapitulation of Coulomb's law, electric field and potential due to discrete and continuous charge distributions along with examples. Gauss's theorem is explained with standard applications. The course then examines capacitance, including energy storage and the role of insulating media. The method of images is introduced as a powerful mathematical tool for solving boundary-value problems in electrostatics. The next part focuses on the magnetic effects of electric current, including Biot–Savart's law, Ampere's circuital law, magnetic dipole moment of a current loop, force between currents, and torque on a current loop. The course then explores electromagnetic induction, introducing Faraday's and Lenz's laws, self and mutual inductance, and calculation of inductance for some common geometries. Finally, the course provides an introductory understanding of Maxwell's equations and displacement current, highlighting the unification of electricity and magnetism and the basis of electromagnetic wave theory.

Course Overview: Electrical Circuits and Electronics

This module provides foundational knowledge of electrical circuit analysis and basic electronic devices, forming the core for further studies in electrical, electronics, and communication engineering. It begins with steady current circuit analysis, covering network analysis techniques and the application of Kirchhoff's laws. Fundamental network theorems such as Thevenin's, Norton's, and Maximum Power Transfer (statements and simple applications) are introduced. The second part focuses on alternating current (AC) circuits, including phasor representation, analysis of LCR series circuits, resonance phenomena, and the concept of quality factor (Q). The module then introduces semiconductor devices and basic electronics. Topics include semiconductor fundamentals, PN junction diode characteristics, rectifiers (half-wave and bridge), Zener diode characteristics, and voltage regulation. The study of transistors covers modes of operation, current gains (α and β), CE characteristics, and applications of transistors as amplifiers and switches. Digital electronics includes binary number systems, subtraction using 2's complement, basic logic gates, diode logic, Boolean algebra fundamentals, and the realization of NAND and NOR gates as universal gates.

Course Outcome: Electricity and Magnetism				
1. Apply Coulomb's law to compute electric forces, fields, and potentials for discrete and continuous charge distributions, and use Gauss's theorem to solve symmetric electrostatic problems				
2. Analyze parallel-plate capacitors and understand the effect of dielectric materials on electric fields and capacitance				
3. Use the method of images to solve electrostatic problems involving infinite plane conducting sheets				
4. Determine magnetic fields for simple current configurations, understanding magnetic dipole moment and determine torque on a current loop in a uniform magnetic field				
5. Analyze induced emf and currents, and calculate self and mutual inductance for standard geometries such as coils, solenoids, and coaxial cylinders				
6. Understand the role of displacement current and interpret Maxwell's equations as the unified framework of electricity and magnetism				
Course Outcome: Electrical Circuits and Electronics				
1. Understand and apply network analysis techniques to solve simple circuits				
2. Analyze and apply concepts of alternating current (AC) circuits				
3. Understand and apply semiconductor devices like PN diodes, rectifiers, and Zener diodes				
4. Understand and apply transistor operation for amplification and switching				
5. Apply digital logic concepts to design simple circuits				
Prerequisites: High school knowledge of Electricity, Magnetism and Simple Circuit Analysis				
SYLLABUS				
UNIT/Module	**CONTENT**	**HOURS or NUMBER OF CLASSES**	**CO Mapping**	**COGNITIVE LEVEL**
A	**ELECTRICITY AND MAGNETISM:** **A)** Electrostatics: Coulomb's law, potential and field intensity for discrete and continuous charge distribution, Gauss' theorem and its applications (infinite plane, charged spherical shell, charged solid sphere). Capacitors - parallel plate, energy stored by a charged capacitor (parallel plate), effect of dielectric in a capacitor. Method of images and its application to a plane infinite sheet.	**10L**	CO1, CO2, CO3	K2, K3, K4

	B) Magnetic effect of current: Biot-Savart's law, application for simple cases – (straight conductor, circular coil), Current loop as a magnetic dipole moment, Ampere's circuital law, applications of circuital law to a long solenoid, force on a current carrying conductor in a magnetic field, Lorentz force, action of current on current, torque on a current loop in a uniform magnetic field.	**8L**	CO4	K2, K3, K4
	C) Electromagnetic Induction: Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance (calculations for circular coil, long solenoid, coaxial cylinders) Energy stored in a magnetic field. Introduction to Maxwell's equations. Displacement current.	**6L**	CO5, CO6	K2, K3, K4, K5
B	**ELECTRICAL CIRCUITS AND ELECTRONICS:** **A)** Steady current - Network analysis, Kirchhoff's laws, Thevenin, Norton and maximum power transfer theorems (statements only) and applications to simple circuits.	**4L**	CO1	K2,K3,K4
	B) Alternating Current: Phasor diagrams, L-C-R series circuit, resonance, Q factor	**4L**	CO2	K2,K3,K4
	C) Electronics: Introduction to semiconductors, Semiconductor diodes–PN diode characteristics, rectifier – half wave and bridge, Zener diode characteristics, voltage regulation.	**5L**	CO3	K2,K3,K4
	D) Transistor: introduction, modes of operation, α, β. CE characteristics, Transistor as an amplifier and a switch.	**5L**	CO4	K1,K2,K3,K4
	E) Digital electronics: Binary number system, subtraction using 2's complement, Basic gates, using diodes as OR and	**6L**	CO5	K1, K2,K3,K4,K6

	AND gate, fundamentals of Boolean algebra, NAND and NOR as universal gates.			

Text Books

MODULE – A

1. Electricity & Magnetism, D. C. Tayal, Himalaya Publishing House
2. Handbook of Degree Physics, C. R. Dasgupta, Book Syndicate Pvt. Ltd.

MODULE – B

1. Electricity & Magnetism, D. C. Tayal, Himalaya Publishing House
2. Handbook of Degree Physics, C. R. Dasgupta, Book Syndicate Pvt. Ltd.
3. Foundations of Electronics, D. Chattopadhyay, P.C. Rakshit, B. Saha and N.N. Purkait, New Age International Publishers

Suggested readings

1. Electronic Principles, A. Malvino and D. J. Bates, McGraw Hill Education
2. Integrated Electronics, J. Millman and C. C. Halkias, McGraw Hill Education
3. Introduction to Electrodynamics by David J. Griffiths, Pearson Publishers

Web Resources

1. Libretext Physics: Electricity and Magnetism (**https://phys.libretexts.org/Bookshelves/Electricity_and_Magnetism**)
2. Lessons in Electric Circuits by Tony R. Kuphaldt (**https://www.ibiblio.org/kuphaldt/electricCircuits/**)

Evaluation Theory CIA: 30 (2 x 10 + 5/assgn.+ 5/attn.). Semester Exam:70
Practical (if applicable) CA: Semester Exam:

Paper Structure for Theory Semester Exam Module : For each module of 35 Marks:
15 Marks from 3 marks questions (5 out of 7)
20 Marks from 10 marks questions (2 out of 3)

Course outcomes (COs) for Electricity and Magnetism and Cognitive Level Mapping

COs	CO Description	Cognitive levels
CO1	Apply Coulomb's law to compute electric forces, fields, and potentials for discrete and continuous charge distributions, and use Gauss's theorem to solve symmetric electrostatic problems	K2, K3, K4
CO2	Analyze parallel-plate capacitors and understand the effect of dielectric materials on electric fields and capacitance	K2, K3, K4
CO3	Use the method of images to solve electrostatic problems involving infinite plane conducting sheets	K2, K3, K4
CO4	Determine magnetic fields for simple current configurations, understanding magnetic dipole moment and determine torque on a current loop in a uniform magnetic field	K2, K3, K4
CO5	Analyze induced emf and currents, and calculate self and mutual inductance for standard geometries such as coils, solenoids, and coaxial cylinders	K2, K3, K4, K5

CO6	Understand the role of displacement current and interpret Maxwell's equations as the unified framework of electricity and magnetism	K2, K4, K5

Course outcomes (COs) for Electrical circuits and Electronics and Cognitive Level Mapping

COs	CO Description	Cognitive levels
CO1	Understand and apply network analysis techniques to solve simple circuits	K2,K3,K4
CO2	Analyze and apply concepts of alternating current (AC) circuits	K2,K3,K4
CO3	Understand and apply semiconductor devices like PN diodes, rectifiers, and Zener diodes.	K2,K3,K4
CO4	Understand and apply transistor operation for amplification and switching	K1,K2,K3,K4
CO5	Apply digital logic concepts to design simple circuits	K1,K2,K3,K4,K6