2025

(NEP—2020)

(1st Semester)

PHYSICS (MAJOR/MINOR)

(Electricity Fundamentals)

Full Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

(SECTION : A—OBJECTIVE)

(*Marks* : 10) 1×10=10

Tick (✓) the correct answer in the brackets provided :

1. When a constant potential difference is applied across a metallic conductor of non-uniform cross-section, the quantity which remains constant along the conductor is

(a) electric field ( )

(b) current density ( )

(c) current ( )

(d) drift velocity ( )

2. The resistivity of a conductor of length L is ρ. If the length of the conductor is doubled and its area of cross-section is halved, then the new resistivity will be

(a) ρ ( )

(b) 2ρ ( )

(c) $\frac{\rho}{2}$ ( )

(d) $\frac{\rho}{4}$ ( )

3. If $\tau = 2 \times 10^{-3}$ s and $L = 5$ mH for an L-R series circuit, the value of R that must be connected in the circuit is

(a) 0·4 Ω ( )

(b) 2·5 Ω ( )

(c) 10^{-5} Ω ( )

(d) 5 Ω ( )

4. A horizontal overhead power line carries a current of 90 A in the south-to-north direction. What is the direction of the magnetic field due to the current at a point 1·5 m below the line?

(a) Eastward ( )

(b) Westward ( )

(c) Upward ( )

(d) Downward ( )

5. Faraday's laws of electromagnetic induction gives a relation between

(a) induced flux and current ( )

(b) induced AC and flux ( )

(c) induced e.m.f. and flux ( )

(d) induced e.m.f. and magnetic induction ( )

6. The representation of sinusoidal AC using rotating vectors is called

(a) Fourier representation ( )

(b) resonance representation ( )

(c) RMS representation ( )

(d) phasor representation ( )

7. In a purely inductive a.c. circuit, the current leads the voltage by a phase angle

(a) 0 ( )

(b) $\frac{\pi}{2}$ ( )

(c) $-\frac{\pi}{2}$ ( )

(d) π ( )

8. A pure resistor of resistance R is connected to an alternating source of r.m.s. voltage $V_{r.m.s.}$. The average power dissipated is

(a) $\frac{V_{r.m.s.}^2}{R}$ ( )

(b) $\frac{V_{r.m.s.}^2}{2R}$ ( )

(c) $\frac{2V_{r.m.s.}^2}{R}$ ( )

(d) $\frac{V_{r.m.s.}}{R}$ ( )

9. To convert a galvanometer into a voltmeter, we connect

(a) high resistance in parallel ( )

(b) low resistance in parallel ( )

(c) high resistance in series ( )

(d) low resistance in series ( )

10. The efficiency of a transformer is maximum when

(a) copper losses = 0 ( )

(b) copper losses > iron losses ( )

(c) copper losses < iron losses ( )

(d) copper losses = iron losses ( )

(SECTION : B—SHORT ANSWERS)

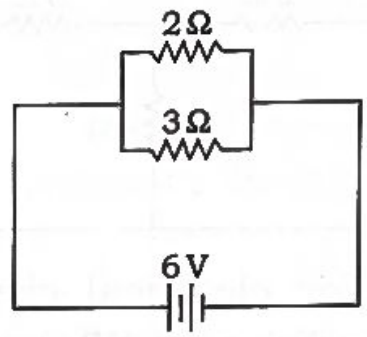
(*Marks* : 15)

Answer *five* questions, taking at least *one* from each Unit : 3×5=15

UNIT—I

1. What are Ohmic and non-Ohmic conductors? Give examples.

2. Using current divider rule, find the current flowing through the 3 Ω resistor in the circuit given below :



UNIT—II

3. Obtain Lorentz force equation for a charged particle moving in crossed electric and magnetic fields.

4. Explain the statement, "Lenz's law is a consequence of the law of conservation of energy".

UNIT—III

5. Distinguish between resistance, reactance and impedance for an AC circuit.

6. What is meant by wattless current? Illustrate with an example of circuit.

UNIT—IV

7. Mention the factors on which the sensitivity of a galvanometer depends.

8. Explain the working principle of a hot-wire ammeter.

(SECTION : C—DESCRIPTIVE)

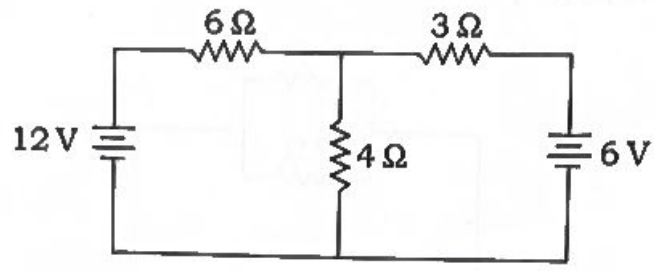
(*Marks* : 50)

Answer *five* questions, taking at least *one* from each Unit : 10×5=50

UNIT—I

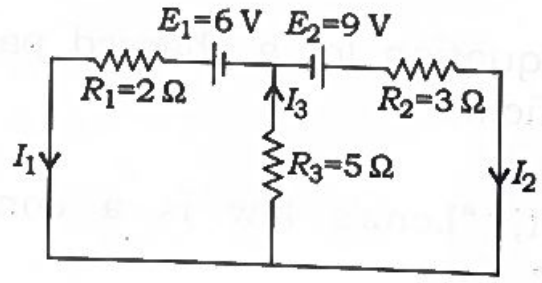
1. *(a)* State and prove Thevenin's theorem. 1+6=7

(b) Using Norton's theorem, find the current flowing through the 4 Ω resistor in the network given below : 3



2. *(a)* State Kirchhoff's laws for electrical circuits. Using Kirchhoff's laws, obtain the balanced condition of Wheatstone bridge. 2+4=6

(b) Using Kirchhoff's laws, find the currents flowing through $R_1 = 2\ \Omega$, $R_2 = 3\ \Omega$ and $R_3 = 5\ \Omega$ in the circuit shown below : 4



UNIT—II

3. *(a)* State Biot-Savart law and express this law in vector form. Derive the magnetic field at the centre of a current carrying circular coil using Biot-Savart law. 2+4=6

(b) Explain how a current loop acts like a magnetic dipole. What is the SI unit of magnetic dipole moment? 3+1=4

4. *(a)* What is mutual induction? Derive the expression for the coefficient of mutual inductance of two coils. 1+5=6

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(b) What is magnetic flux? A magnetic field of flux density 10 T acts normal to a coil of 50 turns having 100 cm^2 area. Find the e.m.f. induced, if the coil is removed from the magnetic field in 0·1 second. 1+3=4

UNIT—III

5. (a) Explain the energy exchange between the capacitor and inductor in an *L-C* circuit with the help of neat diagrams. Show that the charge on the capacitor varies harmonically with time in an *L-C* circuit. 3+4=7

(b) Show that when an alternating current flows through a pure resistance, the current is in phase with the applied e.m.f. 3

6. (a) Show that the resonant frequency in a parallel *L-C-R* circuit is

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

where the symbols have their usual meanings. 6

(b) Show that the mean value of an alternating current during a half cycle is 63·6% of its peak value. 4

UNIT—IV

7. (a) State and explain the principle, construction and working of a DC motor with a neat diagram. Write any two applications of a DC motor. 7+1=8

(b) Explain why a single-phase induction motor is not self-starting. 2

8. (a) Describe the construction and working of a transformer with a neat diagram. Derive an expression for the efficiency of a transformer. 3+3=6

(b) Explain the construction and working principle of a hot-wire instrument. Why can it be used for both AC and DC measurement? 2+2=4

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