2014

PHYSICS

(Major)

Paper : 3.2

(Current Electricity and Magnetostatics)

Full Marks : 60

Time : 2½ hours

The figures in the margin indicate full marks for the questions

1. Answer the following questions : 1×7=7

   (a) Write down the vector form of Ohm's law stating meaning of each term.

   (b) Express 'Henry' in terms of fundamental quantities (M, L, T, I).

   (c) Outline the principle used to build thermocouple thermometer.

   (d) Write down the expression of magnetic flux density at the centre of a long solenoid carrying current.

(e) If a sinusoidal voltage is applied across a resistor, show that voltage and current are in phase.

(f) What does time constant signify in case of growth and decay of current in a d.c. circuit?

(g) Explain the term 'eddy current'.

2. Answer the following questions : 2×4=8

(a) Distinguish between 'magnetic vector potential' and 'magnetic scalar potential'.

(b) Explain the meanings of 'impedance' and 'reactance' of an a.c. circuit.

(c) Explain the differences between a 'dead-beat galvanometer' and 'ballistic galvanometer'.

(d) Draw the circuit diagram of Kelvin's double bridge for the measurement of low resistance.

3. Answer any *three* of the following questions : 5×3=15

(a) A current $i(t) = 2e^{-t} - e^{-2t}$ μA charges up a 120 *n*F capacitor for a period of 2s. If the final voltage across the capacitor is 15 V, what is the initial voltage across it?

(b) A coil of resistance 10 Ω and inductance 0·1 *H* is connected in series with a capacitor with capacitance 150 μF across a 200 V (r.m.s.), 50 Hz supply. Calculate the power factor and power consumed in the circuit.

(c) A coil of resistance 20 Ω, fed by an alternating current, takes current 5 A (r.m.s.). The e.m.f. induced in an identical coil placed nearby is 30 V (r.m.s.) on open circuit. Find the self-inductance of each coil and mutual inductance between them.

(d) The charge on a lossless capacitor of value 1 μF falls to 50 percent of its initial value in 5 minutes when the two plates of the capacitor are joined by an unknown resistance. What is the value of the resistance?

(e) Two exactly alike conductor rings, one of copper and the other of constantan are connected together to form a closed ring of mean diameter 20 cm and cross-sectional area 1·2 cm^2. If one junction is held at 20 °C and the other at 120 °C, find the thermoelectric current in the rings.
[Given, for the copper-constantan thermo-couple, $a = 4 \cdot 8$ μV/°C, $b = 0 \cdot 09$ μV/°C^2, resistivity of copper= 1·6 μΩ-cm, resistivity of constantan= 49 μΩ-cm.]

4. What do you understand by 'self-' and 'mutual' inductances? Find an expression for the mutual inductance between the primary and secondary of a standard solenoid. Describe ballistic galvanometer and search coil method for the determination of mutual inductance. 2+4+4=10

Or

Explain Peltier and Thomson effects. Applying thermodynamics, derive the relations

$$\pi = T\frac{dE}{dT} \text{ and } \sigma_b - \sigma_a = T\frac{d^2E}{dT^2}$$

where the symbols have their usual meanings. 2+2+6=10

5. A d.c. e.m.f. is suddenly applied to a circuit consisting of a resistance R and a capacitor C in series. Investigate the growth of current in the circuit. Suppose after fully charging the capacitor, the d.c. e.m.f. is removed from the circuit. Now investigate the decay of current in the circuit. 5+5=10

Or

(a) Obtain an expression for the power factor of an a.c. circuit. Explain the term 'wattless current'. 3+2=5

(b) What is meant by resonance in an a.c. circuit? In an a.c. circuit containing L, C and R in series, find the condition under which the resonance is obtained. 2+3=5

6. A rectangular coil of length l and breadth b is carrying a current i. When the coil is placed in a uniform magnetic field $\vec{B}$, establish that the potential energy of the coil is $V = -\vec{m}\cdot\vec{B}$, where $\vec{m}$ is the dipole moment of the current-carrying coil. Why can the current-carrying coil be considered as a magnetic dipole? 8+2=10

Or

State and explain Ampere's circuital law. Using Ampere's circuital law, obtain an expression for the magnetic field due to a long straight current-carrying conductor. 2+8=10

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