2013

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 continuity equation that relates the charge density and current density at a point.

(b) Consider two ballistic galvanometers with ballistic constants 2×10^{-5} coulomb/radian and 2×10^{-4} coulomb/radian. Which of these galvanometers is more sensitive? Justify your answer.

(c) If an electron initially moving in the x-direction is subjected to a magnetic field in the z-direction, in which direction the electron will be deflected?

(d) Express 'tesla' in terms of fundamental quantities (M, L, T, I).

(e) Why no power is dissipated if a voltage of sinusoidal waveform is applied across a purely inductive or capacitive circuit?

(f) Write down the differential form of Ampere's circuital law for steady currents.

(g) Distinguish between Joule's heating and Peltier's effect.

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

(a) Establish the relation $V_{rms} = 0 \cdot 707\, V_0$, where V_{rms} and V_0 are the root mean square and peak values of voltage of sinusoidal waveform respectively.

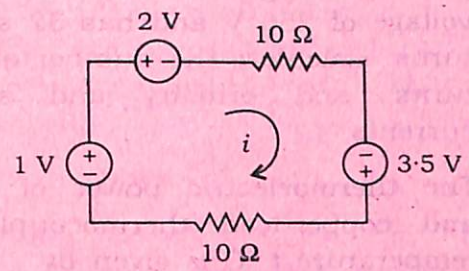
(b) Draw the circuit diagram of Anderson's bridge for the measurement of inductance.

(c) The magnetic vector potential in some region is

$$\vec{A} = x^2 y\hat{i} + y^2 x\hat{j} - 4xyz\hat{k} \text{ Wb/m}$$

Find the magnetic field $\vec{B}$ at the point $(1m, 3m, -5m)$.

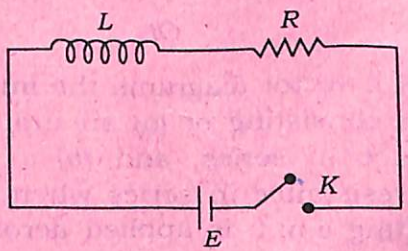
(d) From the circuit given below, find the current i :



3. Answer any *three* of the following questions : $5 \times 3 = 15$

(a) A charge particle $q = 3 \cdot 8 \times 10^{-19}$ C is revolving around a circular path of radius $r = 1$ Å with frequency $f = 10^{15}$ Hz. Calculate the magnetic induction and magnetic moment at the centre of the circular path. (Given, permeability $\mu = 4\pi \times 10^{-7}$ H/m)

(b) The circuit shown below is closed at $t = 0$, where a steady current was flowing prior to the time $t = 0$. Find an expression for transient current flowing through the circuit for $t > 0$:



(c) A single-phase 50 kVA transformer has primary voltage of 6600 V and secondary voltage of 256 V and has 32 secondary turns. Calculate the number of primary turns, and primary and secondary currents.

(d) The thermoelectric power of iron-lead and copper-lead thermocouples at a temperature t °C is given by

$$1734 - 4 \cdot 8t \ \mu V/°C \quad \text{and}$$

$$136 + 0 \cdot 95t \ \mu V/°C$$

respectively. Find the e.m.f. of a copper-iron thermocouple with junctions at 0 °C and 100 °C.

(e) Obtain an expression for the magnetic field near a straight wire of finite length carrying a steady current.

4. Set up the e.m.f. equation of series *R-L-C* circuit driven by a sinusoidal voltage. Solve the equation to find the instantaneous current. How does the impedance of the circuit behave at resonance? 2+6+2

Or

Find with vector diagrams the impedances of circuits consisting of *(a)* an inductance and resistance in series, and *(b)* a capacitance and a resistance in series when a source of alternating e.m.f. is applied across them. 5+5

5. A d.c. e.m.f. is suddenly applied to a circuit consisting of a resistor R and capacitor C in series. Write the e.m.f. equation for the circuit and hence the current at any instant. What is meant by time constant and what is its significance? 2+6+2

Or

Explain the generation of rotating magnetic fields in case of *(a)* two-phase power supply and *(b)* three-phase power supply. How is the principle of rotating magnetic fields employed to design induction motor? 4+4+2

6. State and explain Biot-Savart law in magnetostatics. Using the Biot-Savart law, obtain an expression for the magnetic field at a point on the axis of a circular conductor carrying a steady current. 10

Or

Define magnetic scalar potential. Obtain an expression for the magnetic scalar potential and hence magnetic field near a current-carrying loop. 2+6+2

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