

**3 SEM TDC PHY M 2**

**2016**

( November )

PHYSICS

( Major )

Course : 302

**( Electricity and Magnetism )**

*Full Marks : 60*

*Pass Marks : 24 (Backlog)/18 (2014 onwards)*

*Time : 3 hours*

*The figures in the margin indicate full marks  
for the questions*

1. Choose the correct option from the following :

1×6=6

(a) The divergence of the curl of a vector function is

(i) a scalar

(ii) a vector

(iii) zero

(iv) None of the above

(b) Polarization of a dielectric material occurs due to

- (i) electrons
- (ii) bound charges
- (iii) free charges
- (iv) holes

(c) Twelve wires of same length are connected in the form of a cube. If the resistance of each wire is  $R$ , then the effective resistance between the diagonally opposite corners of the cube is

- (i)  $R$
- (ii)  $\frac{5}{6}R$
- (iii)  $\frac{3}{4}R$
- (iv)  $\frac{4}{3}R$

(d) The susceptibility of a diamagnetic material is

- (i) positive and proportional to temperature
- (ii) negative and inversely proportional to temperature
- (iii) negative and independent of temperature
- (iv) positive and inversely proportional to temperature

(e) The condition for resonance in series  $L$ - $C$ - $R$  circuit is

$$(i) \frac{R^2}{4L^2} < \frac{1}{LC}$$

$$(ii) \omega L < \frac{1}{\omega C}$$

$$(iii) \omega L = \frac{1}{\omega C}$$

$$(iv) \frac{R^2}{4L^2} = \frac{1}{LC}$$

(f) When a sinusoidal voltage is applied across a capacitor, the current through the capacitor

(i) is in phase with the voltage

(ii) leads the voltage by  $90^\circ$

(iii) lags the voltage by  $90^\circ$

(iv) is zero

2. (a) State Gauss law in electrostatics. Find the electric field strength of a spherically symmetric charge distribution at (i) an external point, (ii) an internal point, and (iii) the surface of charge distribution.

1+3=4

(b) Define divergence of a vector field and what is its physical meaning. Write the expression for the divergence of the electric field vector  $\vec{E}$  over the surface of a unit volume element surrounding a point in an electric field. State the Gauss' divergence theorem.  $1\frac{1}{2}+1\frac{1}{2}+1=3$

(c) An electric flux  $-5 \times 10^3 \text{ Nm}^2 \text{ C}^{-1}$  passes through a spherical Gaussian surface of radius 20 cm due to a charge placed at its centre. (i) Calculate the charge enclosed by the Gaussian surface. (ii) If the radius of the Gaussian surface is doubled, how much flux will pass through the surface? 3

3. (a) Deduce an expression for the capacity of two coaxial cylinders separated by a layer of dielectric constant  $k$ . 4

Or

An  $80 \mu\text{F}$  parallel-plate capacitor is connected to a 100 V battery. Calculate the energy stored in the capacitor.

The battery is disconnected and then the plates of the capacitor are pulled apart, doubling their separation. What is the final value of the stored energy? Also give reason for the change in the two cases.  $1+2+1=4$

- (b) What is molecular field in a dielectric? Derive Clausius-Mossotti relation for a dielectric medium. 1+5=6

4. (a) The coil of a suspended-coil galvanometer has 300 turns, each of area  $5 \text{ cm}^2$ , the radial magnetic field being 2500 oersted. A current of  $0.1 \mu\text{A}$  through the galvanometer produces a deflection of  $10^\circ$ . Determine the torque required to twist the suspension through 1 radian. 2

(b) A circuit containing an inductor and a resistor in series are across a cell. Find an expression for the growth of current in the circuit. 2

(c) By drawing a neat diagram, write in detail about the method of measuring very low resistance using Kelvin double bridge. Derive the necessary expression for the unknown resistance. 5

Or

Define Peltier and Thomson coefficient. Applying thermodynamics, derive the relations

$$(i) \pi = T \frac{dE}{dT} \text{ and } (ii) \sigma_a - \sigma_b = T \frac{d^2E}{dT^2},$$

the symbols having their usual meaning. 2+2+1=5

5. (a) Obtain an expression for the magnetic field at any point on the axis of a flat circular coil of radius  $a$  carrying a current  $I$ . Sketch the variation of this field with distance. How is uniform magnetic field produced due to flow of current in Helmholtz coil? 3+1+1=5

- (b) Define magnetic susceptibility and permeability. Show that

$$\mu_r = 1 + \chi_m \quad 3$$

Or

What are the characteristics of diamagnetic, paramagnetic and ferromagnetic substances? Give example of each of them. 3

- (c) "Magnetic behaviour of magnetic substances decreases with increasing temperature." Justify the statement. What is Curie point? 1 1/2 + 1/2 = 2

6. (a) An air core solenoid of 80 cm length has 500 turns and its circular cross-section has a diameter of 2 cm. Calculate the coefficient of self-inductance of the solenoid. ( $\mu_0 = 4\pi \times 10^{-7}$  Wb/Am) 2

- (b) Show that the equivalent inductance of two coils of self-inductances  $L_1$  and  $L_2$ , connected in parallel is

$$L = \frac{L_1 L_2 - M^2}{L_1 + L_2 + 2M}$$

where  $M$  is the mutual inductance between the coils.

3

7. (a) Describe a method to determine the self-inductance of a coil using an AC bridge.

5

Or

Define impedance ( $Z$ ) of an electrical circuit and write the expression for  $Z$  of an electrical circuit comprising  $L$ ,  $C$  and  $R$ .

A resistor  $R$ , an inductance  $L$  and a capacitor  $C$  are all connected in series with an a.c. supply. The reactance of  $R$  is  $16 \Omega$  and for the given frequency the inductive reactance of  $L$  is  $24 \Omega$  and the capacitive reactance of  $C$  is  $12 \Omega$ . If the current in the circuit is  $5A$ , find (i) the potential difference across  $R$ ,  $L$  and  $C$ , and (ii) the impedance of the circuit.

$$2+2+1=5$$

- (b) Distinguish between series resonance and parallel resonance. 2
- (c) What are the energy losses in a transformer? How are they reduced? 3

\*\*\*