

2.

a. An Electric Field is a region in space where an electric charge will experience an electric force, while Electric Field Intensity is the force per unit charge acting on a charged particle in an electric field.

b.  $q_1$                        $q_2$                        $E_{\text{net. ?}}$   
0                              4                              7<sup>2</sup>

$$q_1 = 8 \times 10^{-9} \text{ C}, q_2 = 12 \times 10^{-9} \text{ C}, r_1 = 7 \text{ m}, r_2 = 3 \text{ m}$$

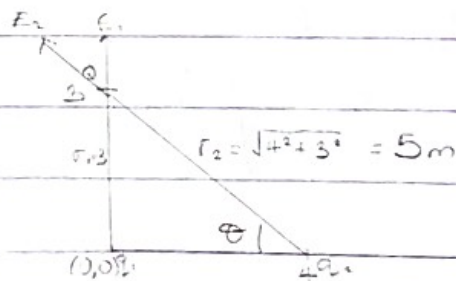
$$E_1 = \frac{kq_1}{r_1^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{7^2} = 1.47 \text{ N/C}$$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{(9 \times 10^9)(12 \times 10^{-9})}{3^2} = 12 \text{ N/C}$$

$$E_{\text{net}} = E_1 + E_2 = 13.47 \text{ N/C} \approx 13.5 \text{ N/C}$$

ii.  $E_1 = \frac{kq_1}{r_1^2} = \frac{(9 \times 10^9)(8 \times 10^{-9})}{3^2} = 8 \text{ N/C}$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{(9 \times 10^9)(12 \times 10^{-9})}{5^2} = 4.32 \text{ N/C}$$



$$\tan \theta = \frac{3}{4} \quad \theta = \tan^{-1}(0.75)$$

$$\theta = 37^\circ$$

$\hat{i}$	$\hat{j}$	$x$	$y$
$E_1$	$90^\circ$	$+ 8 \cos 90 = 0$	$+ 8 \sin 90 = 8$
$E_2$	$37^\circ$	$- 4.32 \cos 37 = -3.45$	$+ 4.32 \sin 37 = 2.59$
		$\Sigma E_x = -3.45$	$\Sigma E_y = 10.59$

$$E_{\text{net}} = \sqrt{(-3.45)^2 + (10.59)^2} = \sqrt{124} = 11.14 \text{ N/C}$$

3.

a. Volume charge density,  $\rho = \frac{dQ}{dV} \rightarrow dQ = \rho dV$ ii. Surface charge density,  $\sigma = \frac{dQ}{dA} \rightarrow dQ = \sigma dA$ iii. Linear charge density,  $\lambda = \frac{dQ}{dL} \rightarrow dQ = \lambda dL$ 

b. In moving a charge from a point A to another point B along an arbitrary path in an electric field, an external force,  $F = -q_0 E$  must act to counter the force,  $F = q_0 E$ , which the field exerts on the charge.

Work done on the charge  $dW$  is given as,

$$dW = F \cdot dL = q_0 E \cdot dL$$

$$dW = -q_0 E dL = -q_0 \left[ \frac{Q}{4\pi\epsilon_0 r^2} \right] dL$$

Total work done in moving test charge from A to B,

$$W(A \rightarrow B)_{q_0} = -q_0 \int_A^B E dL \quad \text{--- (1)}$$

From the definition of potential difference,

$$V_B - V_A = \frac{W(B \rightarrow A)_{q_0}}{q_0} \quad \text{--- (2)}$$

Putting (1) in (2),

$$V_B - V_A = - \int_A^B E dL$$

c.

Given

Let the point where  $v=0$  be  $x$ .

$$\therefore r_1 = |x|, r_2 = |4-x| \quad V = k \left[ \frac{Q_1}{r_1} - \frac{Q_2}{r_2} \right] = 0$$

$$\frac{Q_1}{r_1} = \frac{Q_2}{r_2} \quad , \quad \frac{10 \times 10^{-6}}{|x|} = \frac{-1.2 \times 10^{-6}}{|4-x|}$$

$$\frac{2 \times 10^{-6} |x|}{2 \times 10^{-6}} = \frac{10 \times 10^{-6} |4-x|}{2 \times 10^{-6}} \quad ; \quad |x| = 5 |4-x|$$

$$x = 5(4-x) \text{ or } x = 5(4-x)$$

$$x = 20 - 5x \text{ or } x = -20 + 5x$$

$$6x = 20 \text{ or } -4x = -20$$

$$\therefore x = \frac{10}{3} \text{ or } 5$$

4

a. Magnetic flux,  $\Phi$ , is defined as the strength of magnetic field, expressed by lines of force.

$$\Phi_0 = \int \vec{B} \cdot d\vec{A} = BA \cos \theta$$

b.  $m_e = 9.11 \times 10^{-31} \text{ kg}$

$B = 0.35 \text{ weber/m}^2$

$q = 1.60 \times 10^{-19} \text{ C}$

$\omega = ?$

$$\therefore \omega (\text{angular speed / cyclotron frequency}) = \frac{1.6 \times 10^{-19} \times 0.35}{9.11 \times 10^{-31}}$$

$$\omega = 6.15 \times 10^{10} \text{ rad/s}$$

c. The electron oscillates at an angular frequency of  $6.15 \times 10^{10} \text{ rad/s}$ .

b.

Like an electric guitar, the coil of the pickup coil is placed near the vibrating guitar string which is made up of a metal that can be magnetised. A permanent magnet inside the coil magnetises the pickup on the string near the coil. When the string vibrates at some frequency, its magnetised segment produces a changing magnetic flux through the coil. The changing flux induces an e.m.f. in the coil that is fed to an amplifier. The output of the amplifier is sent to the loudspeaker, which produces the sound waves we hear.

$$b. N = 300 \quad A = (0.1)^2 = 0.01 \text{ m}^2 \quad |e| = ?$$

$$R = 2.0 \Omega \quad \Delta \Phi_B = 10 \text{ T} \quad \Delta t = 0.5 \text{ s}$$

$$i. \text{ Induced emf } |e| = \frac{N \Delta \Phi}{\Delta t} = \frac{300 \times 0.01 \times 10}{0.5} = 60 \text{ V}$$

$$ii. \text{ Induced current } = \frac{|e|}{R} = \frac{60}{2} = 30 \text{ A}$$

$$c. A = 0.05 \times 0.06 = 4 \times 10^{-3} \text{ m}^2 \quad I = 0.1 \text{ A}$$

$$N = 75 \quad R = 8 \Omega \quad \Delta \Phi_B = ? \quad \Delta t = ?$$

$$I = \frac{|e|}{R} \quad |e| = 8 \times 0.1 \text{ A} = 0.8 \text{ V}$$

$$|e| = N \frac{\Delta \Phi_B}{\Delta t} \quad \therefore \frac{\Delta \Phi_B}{\Delta t} = \frac{0.8}{75 \times 10^{-3}} = 2.77 \text{ T/s}$$