Name: Marshall, Edward Otu
Dept: Mechatronics Engineering
Matric no: 19/ENG05/035
Course code: PHY 102

Holiday assignment

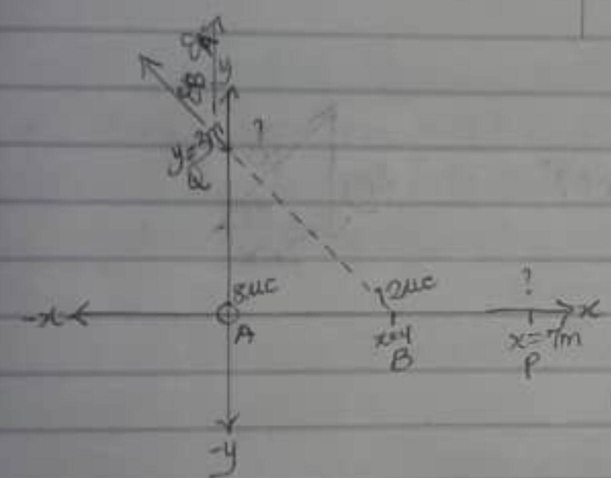
2a) Electric field

This is a region around a charge in which it exerts electrostatic force on other charges

Electric field intensity

This is the strength of an electric field at any point in space

b)



I) $E = \frac{kq}{d^2}$

$E_1 = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{(7)^2} = 1.469 NC^{-1}$

$E_2 = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{(4)^2} = 6.75 NC^{-1}$

$E_{total}(P) = 8.219 NC^{-1}$

I.) From ~~Ph.~~ Pythagoras theorem,

$BQ^2 = AB^2 + AQ^2$

$\therefore BQ = \sqrt{AB^2 + AQ^2}$

$BQ = \sqrt{4^2 + 3^2}$

$BQ = \sqrt{16 + 9}$

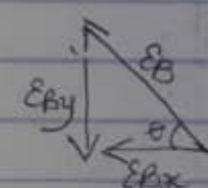
$= \sqrt{25} = 5cm$

$\mathcal{E} = kq/d^2$

$\mathcal{E}_A = \dfrac{9\times10^9 \times 8\times10^{-9}}{(3)^2} =$ ~~$2.88Nc^{-1}$~~ $8Nc^{-1}$

$\mathcal{E}_B = \dfrac{9\times10^9 \times 12\times10^{-9}}{(5)^2} = 4.32Nc^{-1}$

$\theta = 36.87^\circ$



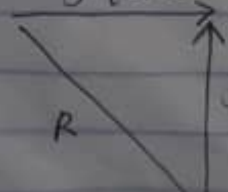
$\mathcal{E}_{Bx} = 4.32 \times \cos 36.87 = 3.46Nc^{-1}$

$\mathcal{E}_{By} = 4.32 \times \sin 36.87 = 2.59Nc^{-1}$

$\bar{x} = 3.46Nc^{-1}$

$\bar{y} = 8Nc^{-1} + (-2.59Nc^{-1})$

$= 5.41Nc^{-1}$



$R = \sqrt{(3.46)^2 + (5.41)^2}$

$= \sqrt{11.9716 + 29.2681} = 6.422Nc^{-1}$

5) a) I) Volume charge density (ρ)

$\rho = q/V$ where q = charge
V = volume of distribution

II) Surface charge density

$\sigma = q/A$ where q = charge
A = Area of the surface.

III) Linear charge density

$\lambda = q/l$ where q = charge
l = Length over which charge is distributed.

b) Electric potential difference is the amount of work done in carrying a unit charge from one point to another in an electric field. It is the difference in electric potential of 2 bodies (charged)

$$\text{electric potential } (V) = \frac{\text{Work done } (W)}{\text{Charge } (q)}$$

For 2 bodies with electric potential V_1 and V_2

$$\text{potential difference} = V_2 - V_1$$
$$= \frac{\Delta W}{\Delta q} = \frac{W_2 - W_1}{q_2 - q_1}$$

or

$$\Delta V_{AB} = V(x_B) - V(x_A)$$
$$= -\int_{r_0}^{x_B} \vec{\mathcal{E}} \cdot \vec{dl} - \left(-\int_{r_0}^{x_A} \vec{\mathcal{E}} \cdot \vec{dl} \right)$$

$$= -\int_{x_A}^{x_B} \vec{\mathcal{E}} \cdot \vec{dl}$$

5) a) The Biot - Savart law states that the flux density near a long, straight conductor is directly proportional to the current in the conductor and inversly proportional to the distance from the conductor.

b) By Biot - Savart:

$$d\vec{B} = \frac{\mu_0 I}{4\pi} \cdot \frac{d\vec{y} \times \hat{r}}{r^2} \Rightarrow \vec{B} = \sum_{}^{\infty} d\vec{B} = \int_{-\infty}^{+\infty} dB$$

$$= \frac{\mu_0 I}{4\pi} \times \int_{-\infty}^{+\infty} \frac{d\vec{y} \times \hat{r}}{r^2}$$

$$\therefore \vec{B} = \frac{\mu_0 I}{4\pi} \int_{-\infty}^{+\infty} \frac{dy \sin\theta}{r^2}$$

$$\boxed{x^2 + y^2 = r^2}$$

$$\tan\theta = \frac{-x}{y} \quad \therefore y = \frac{-x}{\tan\theta} \Rightarrow dy = \frac{x\,d\theta}{(\sin\theta)^2} = \frac{x\,d\theta}{\left(\frac{x}{r}\right)^2} = \frac{r^2 d\theta}{x}$$

$$\therefore \vec{B} = \frac{\mu_0 I}{4\pi} \int_0^{\pi} \frac{r^2 d\theta \sin\theta}{r^2 x} = \frac{\mu_0 I}{4\pi x} \int_0^{\pi} \sin\theta \, d\theta = -\frac{\mu_0 I \cos\theta}{4\pi x} \Big|_0^{\pi}$$

$$= \frac{\mu_0 I}{4\pi x}(+1+1) = \frac{2\mu_0 I}{4\pi x} = \frac{\mu_0 I}{2\pi x}$$ ~~Q.E.D~~

OR

$$\frac{\mu_0 I}{2\pi r}$$ Q.E.D

6) a) Faraday's law states that a changing magnetic field will induce a current into a conductor.

Electric ~~gu~~ guitars are made up of strings placed over "pickups". Pickups are magnets which are surrounded by coils of tiny wires. When the strings of the guitar are plucked, they generate variable magnetic fields that in turn induce a current into the coil of wires surrounding the magnets. These electrical signals are sent through the wires to an amplifier or a loud speaker to amplify the electrical signals, hereby producing sound.

b) i) 300 turns

$r = 2.0\Omega$

$l = 10cm = 0.1m$

~~$\Delta\theta$~~ $\Delta B = 0$

$B_1 = 0T$

$B_2 = 10T$

time $= 0.5$ secs

$$E.m.f = \frac{\Delta BA}{t}$$

$$= \frac{(10-0)(0.1 \times 0.1) \times 300}{0.5}$$

$$E.m.F = \frac{10 \times 3}{0.5} = \frac{30}{0.5} = 60V$$

II) Induced current $= (\text{induced e.m.f})/R$

$= 60V/2\Omega = 30A$

c) $L = 5cm$

$b = 8cm$

no of turns $= 75$

resistance $= 8\Omega$

$I = 0.1A$

$\Delta B = ?$

Area = 0·05 × 0·08 × 75

= 0·3 m^2

$I = \dfrac{\frac{d\phi B}{dt} \times A}{R}$

$\therefore \dfrac{d\phi B}{dt} = \dfrac{IR}{A}$

$\therefore \dfrac{d\phi B}{dt} = \dfrac{0·1 \times 8}{0·3}$

$= 2·67 \, Ts^{-1}$