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Course PHY102

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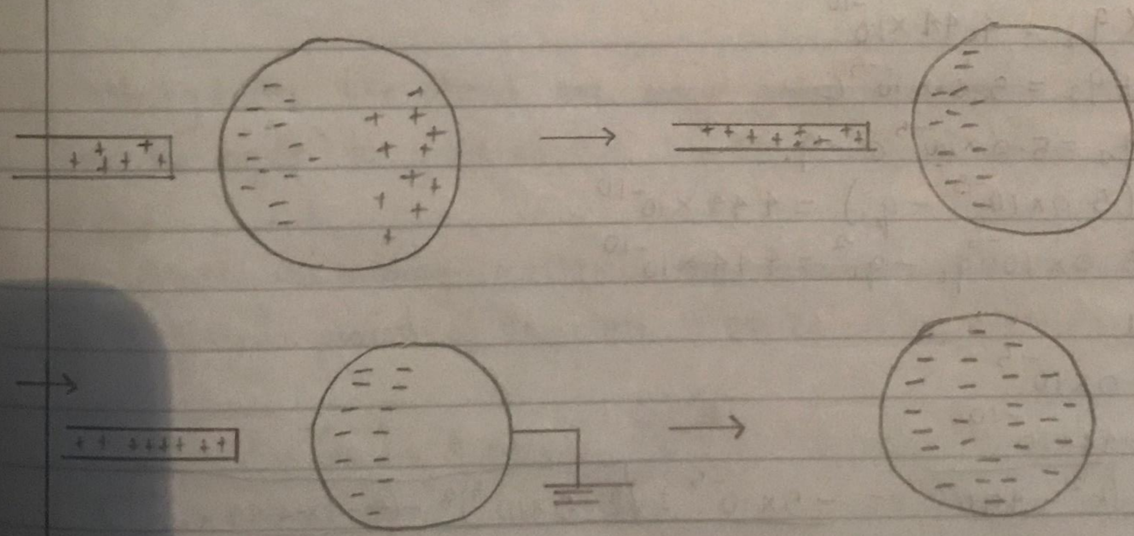
Assignment (COVID-19)

1a) Consider a positively charged rubber rod brought near a neutral conducting sphere.

- There becomes a redistribution of charges on the sphere due to a repulsive force between the protons in the rod and those in the sphere.
- The region of the sphere nearest the ~~negatively~~ positively charged rod has an excess negative charges because of the migration of protons
- The sphere is connected to a grounded earthing wire and the protons leave the sphere. Then the rod and earthing wire are removed, being uniformely induced and distributed negative around the sphere.



b) ~~$q_1 = 5.0 \times 10^{-5}\,C$~~ $q_1 + q_2 = 5.0 \times 10^{-5}\,C$

~~$q_2 = 5.0 \times 10^{-5}\,C$~~ $r = 2.0\,m$ $F = 1.0\,N$

$\therefore q_1 = 5.0 \times 10^{-5}\,C - q_2$

$F = \frac{K q_1 q_2}{r^2}$ $k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,Nm^2/C^2$

$\therefore 1 = \frac{q_2(5.0\times10^{-2} - q_2) \times 8.99\times10^{9}}{2^2}$

$4 = (5\times10^{-2} q_2 - q_2^2) \times 8.99\times10^{9}$

$4 = 4.495\times10^{8} q_2 - 8.99\times10^{9} q_2^2$

$0 = \cancel{-4} + 8.99\times10^{9} q_2^2 - 4.495\times10^{8} q_2 + 4$

$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = -\frac{(-4.495\times10^{8}) \pm \sqrt{(-4.495\times10^{8})^2 - 4\times-4\times-8}}{2(+8.99\times10^{9})}$

$q_2 = 4.99\times10^{-2}$ or 8.89×10^{-9}

$\therefore q_2 = 4.99\times10^{-2}$

$q_1 = 5.0\times10^{-2} - 4.99\times10^{-2} = 0.01\,C$

$\therefore q_1 q_2 = \frac{F.r^2}{k} = \frac{1\times2^2}{9\times10^{9}} = 4.44\times10^{-10}$

$q_1 \times q_2 = 4.44\times10^{-10}$

$q_1 + q_2 = 5.0\times10^{-5}\,C$

$q_2 = 5.0\times10^{-5}\,C - q_1$

$q_1(5.0\times10^{-5} - q_1) = 4.44\times10^{-10}$

$5.0\times10^{-5} q_1 - q_1^2 = 4.44\times10^{-10}$

$a = -1$

$b = 5.0\times10^{-5}$

$c = -4.44\times10^{-10}$

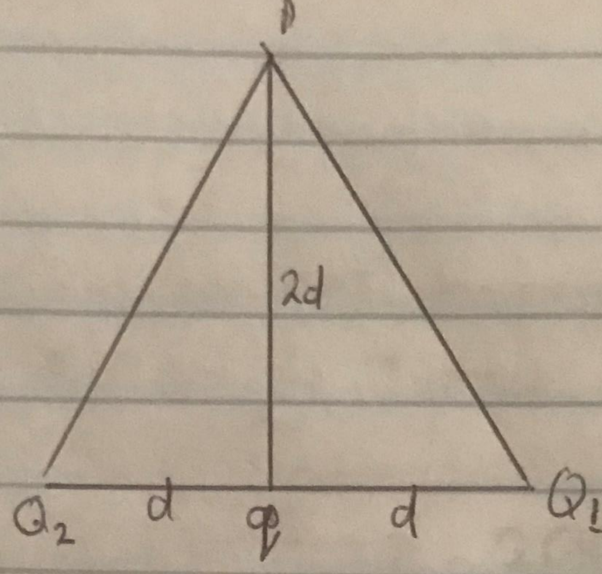
$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-5\times10^{-5} \pm \sqrt{(5.0\times10^{-5})^2 - (4\times-1\times-4.44\times10^{-10})}}{2(-1)}$

$\therefore q_1 = +1.15\times10^{-5}$ or $+3.85\times10^{-5}$

$q_2 = 5.0\times10^{-5} - q_1 = 5.0\times10^{-5} - 1.15\times10^{-5} = 3.85\times10^{-5}$

or $= 5.0\times10^{-5} - 3.85\times10^{-5} = 1.15\times10^{-5}$

1c



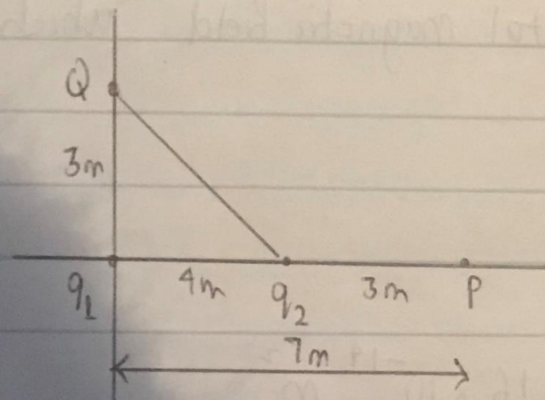
$d = 0.5\,m$ $\qquad$ $Q_1 = Q_2 = 8\,\mu C$

$$F = \frac{\cancel{4}Kq_1 q_2}{r^2} = \frac{9\times10^{9}\times(8\times10^{-6})^{2}}{0.5^{2}} = 2.304\ N$$

$$q = \frac{r^2 \times F}{Q} = \frac{0.5^2 \times 2.304}{8\times10^{-6}} = 7.2\times10^{4}\ C$$

2a Electric field is a region where electric charge will experience an electric force while electric field is the force per unit charge.

bi



$Q_1 = 8\times10^{-9}$ C

$q_2 = 12\times10^{-9}$ C

$$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^{9}\times8\times10^{-9}}{7^2} = 1.47\ N/C$$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^{9}\times12\times10^{-9}}{3^2} = 12 N/C$$

$$\therefore E_{net} = E_1 + E_2 = 1.47 + 12 = 13.47 N/C$$

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$$E_1 = \frac{9\times10^{9}\times8\times10^{-9}}{3^2} = 8\ N/C$$

$$E_2 = \frac{9\times10^{9}\times12\times10^{9}}{5^2} = 4.32\ N/C$$

$$\therefore E_{net} = E_1 + E_2 = 8 + 4.32 = 12.32\ N/C$$

4a Magnetic flux is a measurement of total magnetic field which passe[s] through a given area.

b $m = 9.11 \times 10^{-31}$ kg

$r = 1.4 \times 10^{-7}$ m

$\therefore \text{Area} = \pi r^2 = \pi \times (1.4 \times 10^{-7})^2 = 6.16 \times 10^{-14}\ m^2$

$B = 3.5 \times 10^{-1}\ W/m^2$

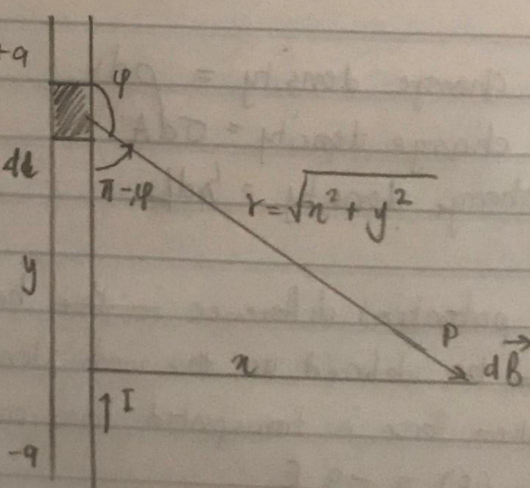
$q = 1.6 \times 10^{-19}$ C

$$\therefore f = \frac{qB}{2\pi m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{2\pi \times 9.11 \times 10^{-31}} = 9.78 \times 10^{9}\ Hz$$

c It took the electron a frequency of 9.78×10^{9} Hz to move perpendicular to the direction of the uniform magnetic field of $3.5 \times 10^{-1}\ W/m^2$.

5a Biot - Savart Law states that in a magnetic field $\vec{dB}$ at point P associated with a length $\vec{dL}$ of a wire carrying a steady current I

b $$B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dL \sin \varphi}{r^2}$$



$\sin(\pi - \varphi) = \sin \theta$

$$\therefore B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dL \sin(\pi - \varphi)}{r^2}$$

$\therefore r^2 = x^2 + y^2$

$$B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dL \sin(\pi - \varphi)}{(x^2 + y^2)} \quad - \text{eq } 1$$

$$\sin(\pi - \varphi) = \frac{x}{(x^2 + y^2)^{1/2}} \quad - \text{eq } 2$$

substitute eq2 to eq1

$$\therefore B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} dl \frac{x}{(x^2+y^2)^{3/2}}$$

recall $dl = dy$

$$B = \frac{\mu_0 I x}{4\pi} \int_{-a}^{a} \frac{1}{(x^2+y^2)^{3/2}} dy$$

after integration

$$B = \frac{\mu_0 I}{4\pi x} \left(\frac{2a}{(x^2+a^2)^{1/2}} \right)$$

$(x^2+a^2)^{1/2} \simeq a$, as $a \to \infty$

$$\therefore B = \frac{\mu_0 I}{2\pi x}$$