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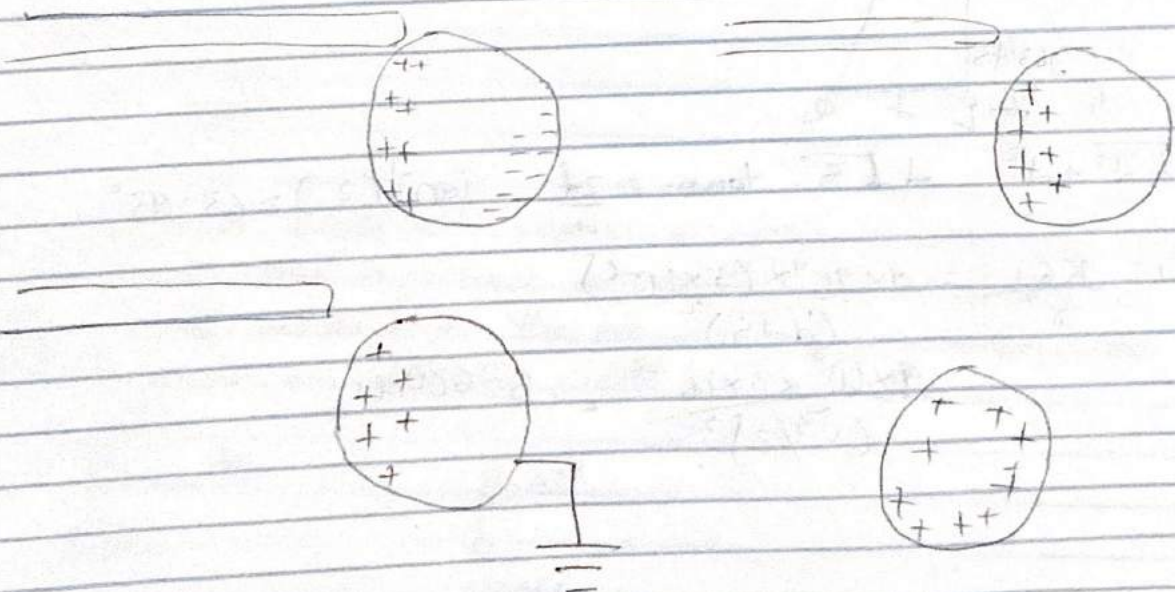
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Course code: PH 102

Consider a negatively charged rubber rod brought near a neutral conducting sphere that is insulated so that there is no conductivity path to the ground as shown below. The repulsive force between the electrons on the rod and those in the sphere causes a redistribution of charges in the sphere so that some of the electrons move to the side of the sphere furthest away from the rod.

The region of the sphere nearest the relatively charged rod has an excess positive charge because of the migration of electrons away from this location. If a grounded conducting wire is connected to the sphere, some electrons leave the sphere and travel to the earth. If the wire to be grounded is then removed, the conducting sphere is left with an excess induced positive charge. When the rubber rod is removed, the majority of the sphere's induced positive charge remains ungrounded.



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

$$F = k \frac{q_1 q_2}{r^2}, \quad 1.0 = \frac{9 \times 10^9 q_1 q_2}{2^2}$$

$$4 = 9 \times 10^9 \times (5 \times 10^{-5} - q_2) q_2$$

$$4 = 4.5 \times 10^5 q_2 - 9 \times 10^9 q_2^2$$

$$-9 \times 10^9 q_2^2 + 4.5 \times 10^5 q_2 - 4 = 0$$

using quadratic formula

$$q_2 = \frac{-4.5 \times 10^5 \pm \sqrt{(4.5 \times 10^5)^2 - 4(-9 \times 10^9)(-4)}}{2(-9 \times 10^9)}$$

$$q_2 = \frac{4.5 \times 10^5 \pm \sqrt{5.8 \times 10^{10}}}{-1.8 \times 10^9}$$

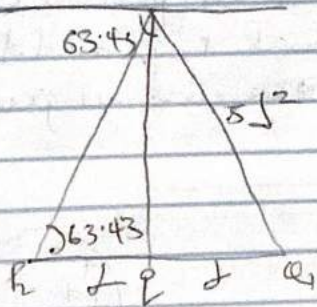
$$q_2 = \frac{4.5 \times 10^5 \pm 241267.7}{-1.8 \times 10^9}$$

$$q_2 = 1.156 \times 10^{-5} \text{ or } 3.84 \times 10^{-5} \text{ C}$$

$$q_1 = 1.156 \times 10^{-5} \text{ C}$$

$$q_2 = 3.84 \times 10^{-5} \text{ C}$$

(c)



$$\sqrt{2d^2 + d^2} = d\sqrt{3} \quad \tan \theta = \frac{2d}{d} \quad \tan^{-1}(2) = 63.43^\circ$$

$$E_1 = \frac{kQ_1}{r^2} = \frac{9 \times 10^9 \times (3 \times 10^{-6})}{(d\sqrt{3})^2}$$

$$\frac{9 \times 10^9 \times 3 \times 10^{-6}}{(\sqrt{3}/2)^2} = 57600 \text{ N/C}$$

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$$E_q = \frac{kq}{r^2} = \frac{9 \times 10^9 \times q}{(2d)^2} = \frac{9 \times 10^9}{4} = 9 \times 10^8 \text{ N/C}$$

Vector	$\theta$	x component	y component
$E_1 = 57600 \text{ N/C}$	$63.43^\circ$	$57600 \cos 63.43$ $= -25764$	$57600 \sin 63.43$ $= +51516$
$E_2 = 57600 \text{ N/C}$	$63.43$	$57600 \cos 63.43$ $= +25764$	$57600 \sin 63.43$ $= +51516$
$E_q = 9 \times 10^8 \text{ N/C}$	$90^\circ$	$9 \times 10^8 \cos 90$ $= 0$	$9 \times 10^8 \sin 90$ $= 9 \times 10^8$
		$E_{fx} = 0$	$E_{fy} = 103033.6$

$$E_{\text{net}} = \sqrt{E_{fx}^2 + E_{fy}^2}$$

at point P = 0

$$0 = \sqrt{0^2 + (103033.6 + 9 \times 10^8)^2}$$

$$0 = 103033.6 + 9 \times 10^8$$

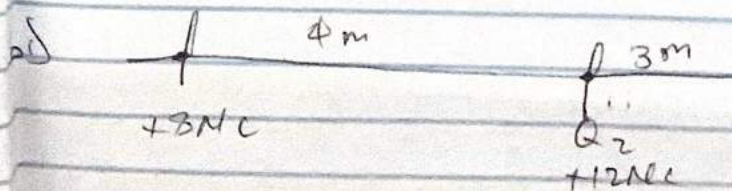
$$q = -\frac{103033.6}{9 \times 10^9}$$

$$q = -1.14481377 \times 10^{-5}$$

$$q = -11.4 \text{ nC}$$

(2)

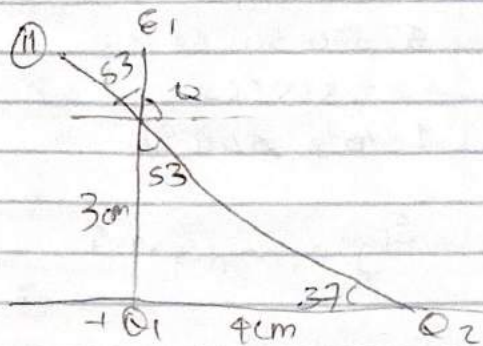
An electric field is a region of space in which an electric charge will experience an electric force while electric field intensity is the per unit charge experienced by a charge in an electric field



$$E_1 = \frac{kQ_1}{r^2} = \frac{(9 \times 10^9) \times (3 \times 10^{-9})}{7^2} = 1.47 \text{ N/C}$$

$$E_2 = \frac{kQ_2}{r^2} = \frac{(9 \times 10^9) \times (12 \times 10^{-9})}{3^2} = 12 \text{ N/C}$$

$$E_{\text{net}} = 1.47 + 12 = 13.47 \text{ N/C}$$



$$E_1 = \frac{kQ_1}{r^2} = \frac{9 \times 10^9 \times (3 \times 10^{-11})}{3^2}$$

$$E_2 = \frac{kQ_2}{r^2} = \frac{9 \times 10^9 \times (12 \times 10^{-11})}{5^2} = 4.32$$

Vector	$\theta$	x component	y component
$E_1 = 2 \text{ N/C}$	$90^\circ$	$2 \cos 90^\circ$ $= 0$	$2 \sin 90^\circ$ $= +2$
$E_2 = 4.32 \text{ N/C}$	$37^\circ$	$4.32 \cos 37^\circ$ $= 3.45$	$4.32 \sin 37^\circ$ $= +2.6$
		$E_{fx} = -3.45$	$E_{fy} = 10.6 \text{ N/C}$

The resultant

$$E = \sqrt{E_{fx}^2 + E_{fy}^2} = \sqrt{(-3.45)^2 + (10.6)^2} = \sqrt{11.903 + 112.36}$$

$$= \sqrt{124.263}$$

$$= 11.147 \text{ N/C}$$

4) The magnetic flux is defined as the strength of a magnetic field represented by lines of forces usually represented by the symbol  $\Phi$

4b)  $m_e = 9.11 \times 10^{-31} \text{ kg}$ ,  $r = 1.4 \times 10^{-7} \text{ m}$ ,  $\theta = 90^\circ$   
magnetic field =  $3.5 \times 10^{-1} \text{ webers/meter square}$   $S = 0 = 1$

$$\omega = \frac{eB}{m}$$

$$\omega = \frac{1.6 \times 10^{-19} \times (3.5 \times 10^{-1})}{9.11 \times 10^{-31}}$$

$$\omega = 6.115 \times 10^{10} \text{ rad/s}$$

4c) An electron of mass  $9.11 \times 10^{-31} \text{ kg}$  and charge  $1.6 \times 10^{-19} \text{ C}$  in motion in a magnetic field of  $3.5 \times 10^{-1} \text{ Tesla}$  perpendicular with the field will have an angular frequency of  $6.15 \times 10^{10} \text{ rad/s}$

5) The vector  $d\vec{B}$  is perpendicular to  $d\vec{l}$  (which points in the direction of the current) and to the unit vector directed from  $d\vec{l}$  towards  $P$

i) The magnitude of  $d\vec{B}$  is inversely proportional to  $r^2$  where  $r$  is the distance from  $d\vec{l}$  to  $P$

ii) The magnitude of  $d\vec{B}$  is proportional to the current  $i$  and to the magnitude of the length element  $d\vec{l}$

iii) The magnitude of  $d\vec{B}$  is proportional to  $\sin \theta$  where  $\theta$  is the angle between  $d\vec{l}$  and  $\vec{r}$