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Course: PHY 105 Assignment

Solutions

1a. Producing a negative charged sphere by method of induction.
Electric charge can be obtained on an object without touching it, by a process called electrostatic induction.
Consider a negatively charged rubber rod brought near a neutral (uncharged) conducting sphere that is insulated so that there is no conducting path to ground. The repulsive force between the electrons in the rod and those in the sphere causes a redistribution of charges on the sphere so that some electrons move to the side of the sphere farthest away from the rod. The region of the sphere nearest the negatively charged rod has an excess of positive charge because of the migration of electrons away from this location. If a grounded conducting wire is then ~~conducted~~ connected to the sphere, some of the electrons leave the sphere and travel to the earth. If the wire to ground is then removed, the conducting sphere is left with an excess of induced positive charge.
Finally, when the rubber rod is removed from the vicinity of the sphere, the induced positive charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.

2a. Electric field is a region of space in which an electric charge will experience an electric force meanwhile electric field intensity is a point in an electric field where the test charge experiences a force

$K = 9\times10^{9}$; $q_1 + q_2 = 5\times10^{-5}C$, $F = 1N$, $d = 2$.

Calculate the charge on each sphere?

Recall that

$k = 9\times10^{9}$ $\quad F = \frac{k q_1 q_2}{r^2}$

$$1 = \frac{9\times10^{9} \times (q_1 q_2) 5\times10^{-5}}{2^2}$$

$4 = 9\times10^{9}\times5\times10^{-5}\, q_1 + 9\times10^{9} q_1^2$

$4 = 4.5\times10^{5} q^2 - 4.5\times10^{5} q_1 + 4 = 0$

$q_1 = 0.0000111C$ $\quad q_2 = 0.000038C$

$\simeq q_1 = 1.11\times10^{-5}C$ $\quad \simeq q_2 = 3.8\times10^{-5}C$

$Q_1 = Q_2 = 8\mu C$ $\quad d = 0.5m$

Determine Q if electric field at a point P is zero

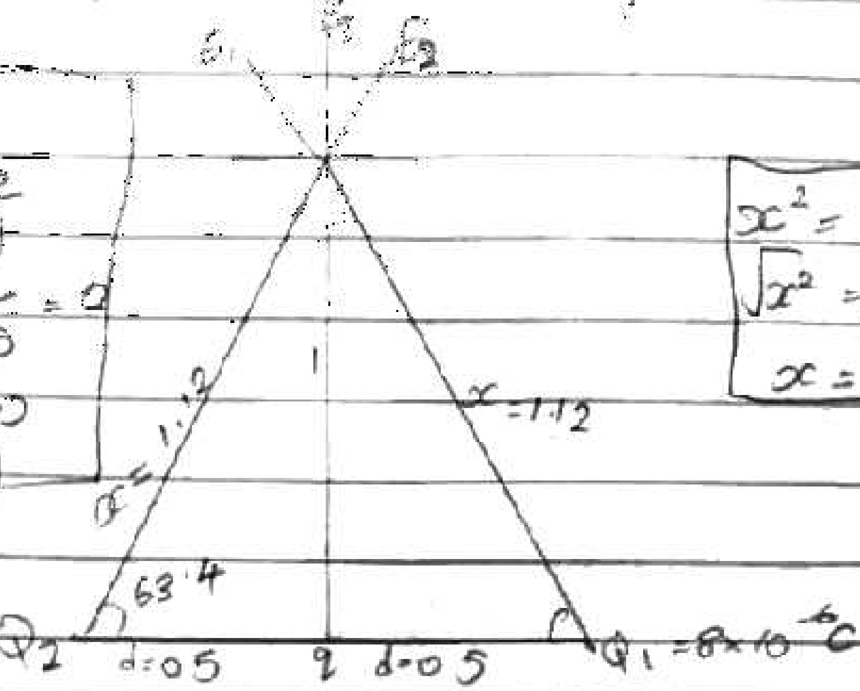
$Q =$

$\tan\theta = \frac{opp}{adj}$

$\tan\theta = \frac{1}{0.5} = 2$

$\theta = \tan^{-1}(2)$

$\theta = 63.4$



$x^2 = 1^2 + 0.5^2$

$\sqrt{x^2} = \sqrt{1.25}$

$x = 1.12$

Solutions

$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 5739.795$

$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{1.12^2} = 5739.795$

$E_q = \frac{kq}{r^2} = \frac{9\times10^9 \times q}{1} = 9\times10^9 q$

Vector	Angle	x-component	y-component
$E_1 = 5739.795$	$63.4°$	$E_1 = E_1\cos\theta = -2570.045$	$E_{1y} = E_1 \sin\theta = 5132.262839$
$E_2 = 5739.795$	$63.4°$	$E_{2x} = E_2\cos\theta = 2570.045$	$E_{2y} = E_2 \sin\theta = 5132.262839$
$E_q = 9\times10^9 q$	$90°$	$E_q\cos\theta = 0$ $\Sigma x = 0$	$E_y = 9\times10^9 q$ $= 10264.52568$

$\text{Magnitude} = \sqrt{(0)^2 + (10264.52568)^2}$

Since $E = 0$

$0 = 9\times10^9 q + 10264.52568$

making q subject of formulae

$q = \frac{-10264.52568}{9\times10^9}$

$q = 1.1405028533 \times 10^{-6}$

$\simeq q = 11.4\,\mu C$

F and can be defined as the force per unit charge.

b)

$$\vec{E_P} = \vec{E_1} + \vec{E_2}$$

$E_1 = 1.46\,N/C$

$E_2 = 12\,N/C$

Vector	Angle	x - component	y component
$E_1 = 1.4\,N/C$	0°	$E_{1x} = E_1 \cos\theta = 1.4\cos 0 = 1.4\,N/C$	$E_{1y} = E_1 \sin\theta = 1.4 \sin 0 = 0$
$E_2 = 12\,N/C$	0°	$E_{2x} = E_2 \cos\theta = 12\cos 0 = 12$	$E_{2y} = E_2 \sin\theta = 12 \sin 0 = 0$
		$\Sigma E_x = 13.5\,N/C$	$\Sigma E_y = 0$

$$E_P = \sqrt{(13.5)^2 + (0)^2}$$

$$= \sqrt{182.25}$$

$$= 13.5\,N/C$$

3) $\vec{E_Q} = \vec{E_1} + \vec{E_2}$

$a^2 = 3^2 + 4^2$

$a^2 = 9 + 16$

$\sqrt{a} = \sqrt{25}$

$a = 5$

$E_1 = 8\,N/C$

$E_2 = 4.32\,N/C$

Vector	Angle	x - component	y - component
$E_1 = 8\,N/C$	90°	$E_{1x} = 8\cos 90 = 0\,N/C$	$E_{1y} = 8 \sin 90 = 8\,N/C$
$E_2 = 4.32\,N/C$	37°	$E_{2x} = 4.32\cos 37 = 3.45\,N/C$	$E_{2y} = 4.32 \sin 37 = 2.6\,N/C$
		$\Sigma E_x = 3.45\,N/C$	$\Sigma E_y = 10.6\,N/C$

$$\Sigma E_Q = \sqrt{(3.45)^2 + (10.6)^2}$$

$$= \sqrt{11.9025 + 112.36} = \sqrt{124.2625}$$

$$= 11.2\,N/C$$

5a) (i) Volume charge density, $\rho = \frac{dQ}{dV} \longrightarrow dQ = \rho dV$

(ii) Surface charge density, $\sigma = \frac{dQ}{dA} \longrightarrow dQ = \sigma dA$

(iii) Linear charge density, $\lambda = \frac{dQ}{dL} \longrightarrow dQ = \lambda dL$

5b) The electric potential difference between two points in an electric field can be defined as the work done per unit charge against electrical forces when a charge is transported from one point to the other in an electric field. It is measured in volt (V) or Joules per coulomb (J/C).
Electric potential difference is a scalar quantity.

$E = \frac{F}{q}$

$F = Eq$

$F = q_o E$

An external force of $F = -q_o E$ must act on the charge.

$\therefore \quad dW = F \cdot dL \quad \ldots \quad (1)$

But $\quad F = -q_o E \quad \ldots \quad (2)$

Substituting equation (2) in (1) yields

$dW = -q_o E \, dL$

Then total work done in moving the test charge from A to B is:

$W(A \longrightarrow B)_{Ag} = -q_o \int_A^B E dL \quad \ldots \quad (4)$

From the definition of electric potential difference, it follows that:

$$V_B - V_A = \frac{W(A \longrightarrow B)_{Ag}}{q_o} \quad \ldots \quad (5)$$

Putting equation (4) in (5) yields

$$V_B - V_A = -\int_A^B E dL \quad \ldots \quad (6)$$

4a) The magnetic flux through a surface is the surface integral of the normal component of the magnetic field flux density B passing through that surface. The SI unit is the weber. It is defined as the strength of magnetic field represented by lines of force. It is represented by ϕ.

4b) mass = 9.11×10^{-31} kg, radius = 1.4×10^{-7} m, magnetic field = 3.5×10^{-1} T

$q = 1.6 \times 10^{-19}$ Cyclotron frequency = angular speed

$\omega = \frac{qB}{m}$ $\qquad \omega = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$

$$\omega = 6.1471 \times 10^{-12} \, \cancel{\text{rad/s}} \; T^{-1}$$

-1c. Cyclotron frequency is equal ~~to~~ the same thing as angular speed. It is called cyclotron frequency because it is a frequency of an accelerator called cyclotron.

Recall that angular speed is given as $\omega = \frac{v}{r} = \frac{qB}{m}$

Substituting we have $\omega = \frac{v}{r} = \frac{qB}{m} = 1.6 \times 10^{-19} \times 3.5 \times 10^{-1} \div 9.11 \times 10^{-31}$

$\frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}} = 6.2 \times 10^{-12} \, \cancel{\text{rad}} \; T^{-1}$

having a unit as $1/s$ which is equal to the unit of frequency dimensionally.

30 $Q_1 = 10\mu C = 10 \times 10^{-6} C$

$Q_2 = -2\mu C = -2 \times 10^{-6} C$

$x = 0$ and $x = 4m$ $V = 0$

$$V_P = K \left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2} \right]$$

$$V_P = 9 \times 10^9 \left(\frac{10 \times 10^{-6}}{4 + x} + \frac{(-2 \times 10^{-6})}{x} \right)$$

$$= 10 \times 10^{-6} x - 8 \times 10^{-6} - 2 \times 10^{-6} x$$

$$\cancel{\frac{8 \times 10^{-6}}{8 \times 10^{-6}}} = \frac{\cancel{8 \times 10^{-6}} x}{\cancel{8 \times 10^{-6}}}$$

$$1m = x$$

$$4 + 1 = 5$$