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19/MH501/351

1a A positively charged rod is brought near a neutral sphere which is insulated so that there is no connection to the ground. The electrons in the sphere migrate toward the side closest to the positively charged rod, so the region farthest from the rod has an excess of positive charge, The sphere is polarized.
When a grounded conducting wire is connected to the sphere, ~~electron~~ ~~ente~~ positive charge farthest goes through or passes through the conducting ~~wire~~ wire to the ground, leaving ~~only~~ the excess negative charge in the sphere.
Finally, the rod is removed, the induced negative charge becomes uniformly distributed over the sphere.

neutral sphere | b: Sphere becomes polarized | c: Positive charge leaves

d: electrons distribute uniformly

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1b Let the spheres be q_1 and q_2

$f_{12} = 1.0N$; $q_1 + q_2 = 5.0 \times 10^{-5} C$

$r = 2.0m$; $r^2 = 4m^2$

from columb's law ; $F = \frac{kq_1q_2}{r^2}$

$F = \frac{kq_1q_2}{r^2}$; $Fr^2 = kq_1q_2$; $\frac{fr^2}{k} = q_1q_2$

$\frac{fr^2}{k} = q_1q_2$; $\frac{1 \times 4}{9 \times 10^9} = 4.44 \times 10^{-10} C^2$

$q_1q_2 = 4.44 \times 10^{-10} C^2$ ---- (i)

$q_1 + q_2 = 5.0 \times 10^{-5} C$ ---- (ii)

from equation (ii)

$q_1 = 5.0 \times 10^{-5} C - q_2$ ---- (iii)

Subtituting $q_1 = 5.0 \times 10^{-5} C - q_2$ into equation (i)

$\therefore q_2(5.0 \times 10^{-5} C - q_2) = 4.44 \times 10^{-10} C^2$

$5.0 \times 10^{-5} q_2 - q_2^2 = 4.44 \times 10^{-10} C^2$

$q_2^2 - 5.0 \times 10^{-5} q_2 + 4.44 \times 10^{-10} = 0$

Using quadratic equation formular

$q_2 = 3.86 \times 10^{-5} C$ or $1.14 \times 10^{-5} C$

from equation (ii)

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

$\therefore q_1 = 1.14 \times 10^{-5} C$ or $3.86 \times 10^{-5} C$

$q_2 = 3.86 \times 10^{-5} C$ or $1.14 \times 10^{-5} C$

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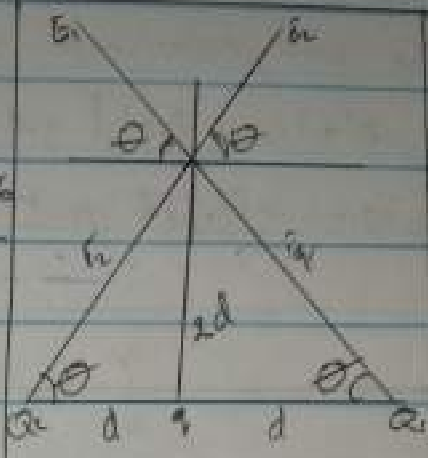
1c For the electric field at P to be zero;

$\vec{E}_{net} = 0 = \vec{E}_1 + \vec{E}_2 + \vec{E}_q$



Pythagoras theorem

$r_2^2 = (2d)^2 + d^2$

$d = 0.5m$

$= \sqrt{1.25}$

$r = 1.118m$

$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.118)^2}$

$E_1 = 5.76\times10^4$ N/C

$E_2 = 5.76\times10^4$ N/C

$E_q = \frac{(9\times10^9)\times q}{(1)^2} = 9\times10^9 q$ N/C

$\theta = \tan^{-1}\left(\frac{1}{0.5}\right)$

$\theta = 63.4°$

E	θ	x	y
E_q	90°	$+9\times10^9 q \cos 90 = 0$	$+9\times10^9 q \sin 90 = 9\times10^9 q$
E_1	63.4°	$-5.76\times10^4 \cos 63.4$	$-5.76\times10^4 \sin 63.4 =$
E_2	63.4	$+5.76\times10^4 \cos 63.4$	$+5.76\times10^4 \sin 63.4 =$
		$\Sigma E_x = 0$	$\Sigma E_y = 1.03\times10^5 + 9\times10^9 q$

$\vec{E}_{net} = 0 = \sqrt{0^2 + (1.03\times10^5 + 9\times10^9 q)^2}$

$0^2 = 1.03\times10^5 + 9\times10^9 q$

$0 = 1.03\times10^5 + 9\times10^9 q$

$-1.03\times10^5 = 9\times10^9 q$

$\frac{-1.03\times10^5}{9\times10^9} = \frac{9\times10^9 q}{9\times10^9}$

$q = \frac{-1.03\times10^5}{9\times10^9} = -11\times10^{-6} = -11\mu C$

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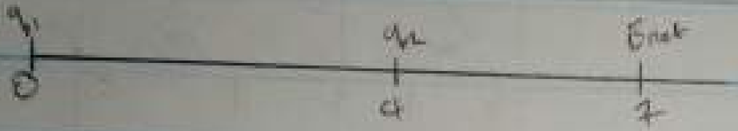
2 An Electric field is a region in space where an electric charge will experience electric force.
While electric field intensity is the force per unit charge acting on a charged particle in an electric field.

bi



$q_1 = 8 \times 10^{-9}C$; $q_2 = 12 \times 10^{-9}C$

$r_1 = 7m$; $r_2 = 3m$

$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-9}}{(7)^2} = 1.47N/C$

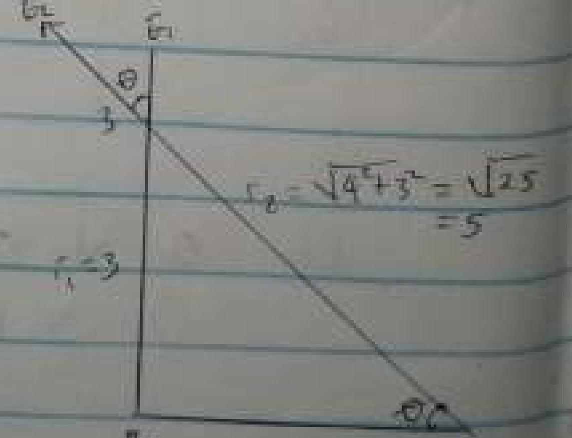
$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^9 \times 12\times10^{-9}}{(3)^2} = 12N/C$

$E_{net} = E_1 + E_2 = 1.47N/C + 12N/C = 13.47N/C \simeq 13.5N/C$

ii

$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8N/C$

$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32N/C$



$\tan\theta = \frac{3}{4}$

$\theta = \tan^{-1}(0.75)$

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E	θ	x	y
E_1	90°	$+8\cos 90 = 0$	$+8\sin 90 = 8$
E_2	37°	$-4.32\cos 37 = -3.45$	$+4.32\sin 37 = 2.54$
		$\sum E_x = -3.45$	$\sum E_y = +10.54$

$$E_{net} = \sqrt{(-3.45)^2 + (10.54)^2}$$

$$E_{net} = \sqrt{124} = 11.14 = 11.14\ N/C$$

4 Magnetic flux, Φ, is defined as the strenght of magnetic field represented by lines of force

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

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

$B = 0.35$ weber/m^2

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

$\omega = ?$

$\therefore \omega$ (angular speed/cyclotron frequency $= \frac{qB}{m_e}$

$$\omega = \frac{1.60 \times 10^{-19} \times 0.35}{9.11 \times 10^{-31}} = 6.15 \times 10^{10}$$

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

c The electron oscillates at an angular frequency of 6.15×10^{10} rad/s.

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6 In an electric guitar, the coil (which is the pickup coil) is placed near the vibrating guitar string which is made up of a metal that can be magnetized. A permanet magnet inside the coil magnetize the protion of the string nearest to the coil. When the string vibrates at some frequency, its magnetized segment produces a changing magnetic flux through the coil. The changing magnetic flux induces an emf in the coil that is fed to an amplifier. The output of the amplifier sent to the loud speaker, which produces the sound wave which we hear.

b $R = 2.0\Omega$; $N = 300$; $A = (0.1)^2 = 0.01m^2$
$\Delta\phi_B = 10T$; $\Delta t = 0.5s$; $|e| = ?$

~~Induced current $= \frac{|e|}{R}$~~

i Induced emf $|e| = \frac{N\Delta\phi A}{\Delta t} = \frac{300 \times 10 \times 0.01}{0.5} = 60v$

$|e| = 60v$

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

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C $A = 0.05 \times 0.08 = 4 \times 10^{-3} m^2$; $N = 75$

$I = 0.1A$; $R = 8\Omega$; $\Delta\Phi_B = ?$ $\Delta t = ?$

$$I = \frac{|\varepsilon|}{R}$$

$$|\varepsilon| = IR = 0.1 \times 8 = 0.8V$$

$$|\varepsilon| = \frac{N\Delta\Phi_B}{\Delta t}$$

$$\therefore \frac{\Delta\Phi_B}{\Delta t} = \frac{0.8}{75 \times 4 \times 10^{-3}} = 2.7 \, T/s$$

$$\frac{\Delta\Phi_B}{\Delta s} = 2.7 \, T/s$$