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PHY 102
AERONAUTICAL ENGINEERING
18/ENG07/004
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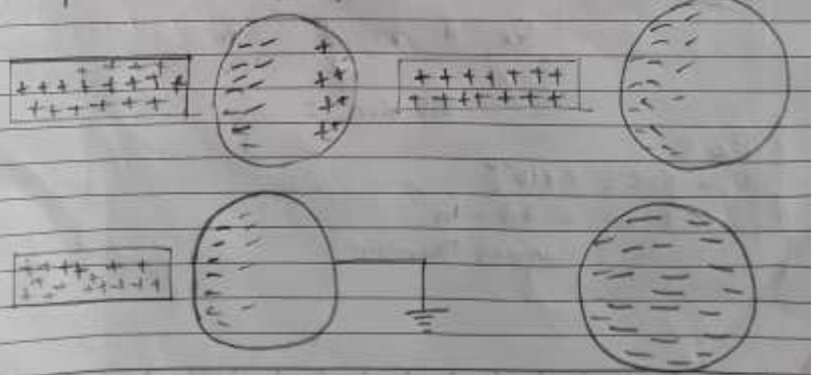
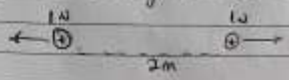
a Explain with the aid of a diagram how you can produce a negatively charged sphere by method of Induction

Consider a positively charged rod brought near a neutral charged sphere that is insulated so that there is no conducting path to the ground as shown below. The repulsive force between the electrons and those in the rod causes a redistribution of charges in the sphere so that some of the electrons move to the side of the sphere farthest away from the rod. The region of the sphere nearest the positively charged rod has an excess negative charge because of the migration of electrons away from the location. If a grounded conducting wire is then connected to the sphere and travel to the earth. If the wire [illegible] to the ground is then removed, the conducting sphere is left with an excess of induced negative charge. When the rod is removed from the vicinity of the sphere, the charge becomes uniformly distributed.



16 Each of the small sphere is charged positively, the combined charge being 5×10^{-5}c. If each sphere is repelled from the other by a force of 1.0N when the sphere are 2.0m apart. Calculate the charge in each sphere.



$$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2} \; ; \; F = \frac{q_1 q_2}{r^2} \times 8.9875\times10^{9}$$

$$F = 1N,\ r = 2m, \quad q_1 q_2 = 5\times10^{-5}$$

$$q_1 = 5\times10^{-5} - q_2$$

$$1 = \frac{(5\times10^{-5} - q_2)q_2 \times 8.9875\times10^{9}}{2^2}$$

$$0.44506\times10^{-9} - 5\times10^{-5}q_2 + q_2^2 = 0$$

$$q_2 = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$q_2 = \frac{5\times10^{-5} \pm \sqrt{25\times10^{-10} - 4(0.44506\times10^{-9})}}{2}$$

$$= \frac{5\times10^{-5} \pm \sqrt{(25 - 17.8)\times10^{-10}}}{2}$$

$$q_2 = \frac{5\times10^{-5} + 2.683\times10^{-5}}{2} = 3.85\times10^{-5}$$

or

$$q_2 = \frac{5\times10^{-5} - 2.683\times10^{-5}}{2} = 1.15\times10^{-5}$$

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

$$q_1 = 5\times10^{-5} - q_2$$

$$q_1 = 5\times10^{-5} - 3.85\times10^{-5}$$

$$q_1 = 1.15\times10^{-5}$$

or

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

$$q_1 = 5\times10^{-5} - q_2$$

$$q_1 = 5\times10^{-5} - 1.15\times10^{-5}$$

$$q_1 = 3.85\times10^{-5}$$

2a Distinguish between the terms: electric field and electric field intensity

Electric field is the region of space in which an electric charge will experience an electric force.

While electric field intensity is the force per unit charge of an electric charge. Mathematically represented as

$$E = \frac{F(N)}{q_0(C)}$$

And it is measured in ~~Coulomb~~ Newton per Coulomb (N/C)

2b A positive charge $Q_1 = 8nC$ is at the origin, and a second positive charge $Q_2 = 12nC$ is on the x-axis at $x = 4m$. Find-

(i) Net electric field at a point P on the x-axis at $x = 7m$

Sketch

$$E_1 = \frac{Kq}{r^2} = \frac{(9\times10^9 Nm^2/C^2)\times 8\times10^{-9}}{4^2} = 18.0 N/C$$

$$E_2 = \frac{Kq}{r^2} = \frac{(9\times10^9 Nm^2/C^2)\times 12\times10^{-9}}{7m} = 15.43 N/C$$

	Angle	x-Component
$E_1 = 18.0 N/C$	90	$E_{1x} = 18 \cos 90$ $= 0$
$E_2 = 15.43 N/C$	180	$E_{2x} = 15.43 \cos 180$ $= -15.43$

$$\sum E_x = -15.43 N/C$$

2b

(ii) Electric field at Q on the y axis at y = 3m

$$E_1 = \frac{kq}{r^2} = (9\times10^9)\times\left(\frac{8\times10^{-9}}{3}\right)$$

$$= 24\,N/C$$

Magnitude	Electric field	Angle	Y-component
	24 N/C	90	24 cos 90
			= 0
			$\Sigma x_y = 0$

3a State the formulations of the following densities of charge

(i) Volume charge Density, $\rho = \frac{dQ}{dV} \rightarrow dQ = \rho dV$

(ii) Surface charge Density, $\sigma = \frac{dQ}{dA} \rightarrow dQ = \sigma dA$

(iii) Linear charge density, $\lambda = \frac{dQ}{dl} \rightarrow dQ = \lambda dl$

3b Explain with appropriate equations, the electric Potential Difference

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. It is measured in volt (V) or Joules per Coulomb (J/C). Electric potential difference is a scalar quantity quantity.

$$dW = F \cdot dl$$

$$\bar{F} = q_0 E$$

$$\therefore dW = q_0 E\,dl$$

$$W(A \rightarrow B)_{ag} = -q_0 \int_A^B E\,dl$$

$$V_B - V_A = \frac{W(A-B)_{ag}}{q_0}$$

$$V_B - V_A = -\int_A^B E\,dl$$

4. What is Magnetic flux?
The magnetic flux is defined as the strength of magnetic field represented by lines of force. It is usually represented by the symbol ϕ.

4b An electron with a rest mass of 9.11×10^{-31} kg moves in a circular orbit of radius 1.4×10^{-7} m in a uniform magnetic field 3.5×10^{-1} weber/meter square perpendicular to the speed with which the electron moves. Find the cyclotron frequency of the moving electron.

$F_B = qVB \sin\theta$ move

$$V = \frac{qBr}{m_e}$$

$$\frac{qBr}{qr} = \frac{Vm_e}{qr}$$

$$B = \frac{Vm_e}{q_e r} = \frac{8 \times 9.11 \times 10^{-31}}{}$$

$$\omega = \frac{qB}{m_e} =$$

Since the charge of an electron $= -1.6 \times 10^{-19}$

$$w = \frac{-1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}} = 6.147 \times 10^{10}$$

4c ω is often referred to as the cyclotron frequency because the charge particle circulates at this angular frequency speed in the type of accelerator called cyclotron.
The formular for ω,

$$\omega = \frac{qB}{m_p}$$

5a The BIO-SAVART LAW
The Biot Savart law states that the magnetic intensity at any point due to a steady current in an infinitely long wire is directly proportional to the current and inversely proportional to the distance from point to wire.

5b Using the Biot-Savart Law, show that the magnitude of the magnetic field of a straight current-carrying conductor is given as

$$B = \frac{\mu_0 I}{2\pi r}$$

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I\, d\vec{l} \times \hat{r}}{r^2}$$

where μ_0 is a constant called permeability of free space
$\mu_0 = 4\pi \times 10^{-7}\ T.m/A$

$$\vec{B} = \frac{\mu_0}{4\pi r} \int \frac{I\, d\vec{l} \times \hat{r}}{r^2}$$

$$B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dl \sin\phi}{r^2}$$

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

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

Then $r^2 = x^2 + y^2$ (pythagoras theorem)

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

6a Explain the practical application of Faraday's law in the production of sound in an electric guitar

The coil in this case called the pickup coil is placed near the vibrating guitar string which is made of a metal that can be magnetized. A permanent magnet inside the coil magnetizes the portion of the string nearest the coil. When the string vibrates at some frequency, its magnetized segment produces a changing magnetic flux through the coil. The changing flux induces an emf in the coil that is fed to an amplifier. The output of the amplifier is sent to the loudspeakers which produces the sound waves we hear.

6b A coil consists of 300 turns of wire having total ~~[illegible]~~ resistance of 2.0Ω. Each turn is a square of side 4cm, and uniform magnetic field directed perpendicular to the plane of the coil is turned on. If the field changes linearly from 0 to 107 in 0.Tsec,

i) What is the magnitude of the induced emf in the coil while the field is changing.

Solution