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19/sci17/007
Biotechnology
PHY102 Assignment Answers

1a)

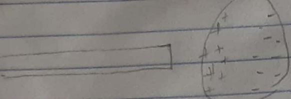


Fig 1.3a

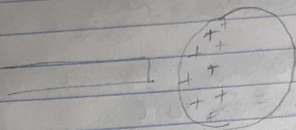


Fig 1.3c

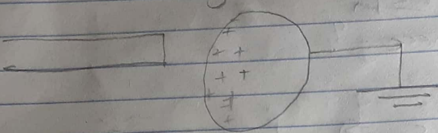


Fig 1.3b

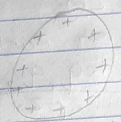


fig 1.3d

Charging by Induction:
Electric charges can be obtained on an object witho-
ut it, by a process called electrostatic Induction. Consider
a negatively charged rubber rod brought near a neu-
tral (uncharged) conducting sphere that is insulated so
that there is no conducting path to ground as
shown above. The repulsive force between the electrons
in the rod and those in the sphere causes redistri-
bution to charges on the sphere so that some electrons
move to the side of the sphere farthest away from
the rod (fig 1.3a). The region of the sphere near-
est the negatively charged rod has an excess of
positively charge because of the migration of
electrons away from this location. If a grounded
conducting wire is then connected to the sphere ~~and~~
as in (fig 1.3b), some of the electrons leave the
sphere and travel to the earth. If the wire to the
ground is then removed (fig 1.3c), 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 (fig 3d) the Induced positive charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.

1b $k = 9 \times 10^9$

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

$F = 1 Newton$

$d = 2m$ ∴ ~~F = 1m~~

Charge on each sphere = ?

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

$T = \frac{9 \times 10^9 (q_1 q_2 5 \times 10^{-5})}{2^2}$

$4 = 9 \times 10^9 \times 5 \times 10^{-5} q_1 q_{\not{2}} \times 10^9 q_2$

$4 = 4.5 \times 10^5 q_1 + 9 \times 10^9 q_2$

Quadratic equation

$9 \times 10^9 q_2 - 4.5 \times 10^5 q_1 + 4 = 0$

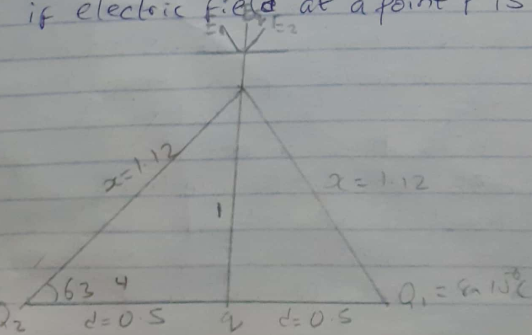
$q_1 = 0.0000111C \simeq 1.11 \times 10^{-5} C$

$q_2 = 0.000038C \simeq 3.8 \times 10^{-5} C$

1c $Q_1 = Q_2 = 84C$

$d = 0.5m$

Q_1 if electric field at a point P is zero



$x^2 = 1^2 + 0.5^2$ $\qquad$ $\tan\theta = \frac{opp}{adj} = \frac{1}{0.5}$

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

$x = \sqrt{1.25}$ $\qquad$ $\theta = 63.4$

$x = 1.12$

$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 57397.9598$

$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} =$ ~~9×10~~ 57397.9598

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

Vector	Angle (°)	x-component	y-component
$E_1 = 57397.9598$	63.4	$E_1\cos\theta = 2570.046$	$E_1\sin\theta = 5132.26$
$E_2 = 57397.9598$	63.4	$E_2\cos\theta = 2570.046$	$E_2\sin\theta = 5132.26$
$E_q = 9\times10^9 q$	90°	$E_q\cos\theta = 0$	$9\times10^9 q$
		$\Sigma_x = 0$	$\Sigma_y = 10264.53$

Magnitude $= \sqrt{(\Sigma_x)^2 + (\Sigma_y)^2}$

$E_q = \sqrt{(0)^2 + (1026.52568)^2}$

since $E_q = 0$

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

making q subject of formula

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

$q = 1.140502853\times10^{-16}$

$q = 11.4\,\mu C$

3) Volume charge density, $\rho = \frac{dQ}{dv}$ 'n $dQ = \rho dv$

ii) Surface charge density, $\sigma = \frac{dQ}{dA}$ 'n $dQ = \sigma dA$

iii) Linear charge density, $\lambda = \frac{dQ}{dL}$ 'n $dQ = \lambda dL$

3b The electric potential difference between two points in an electric field can be defined as the workdone per unit charge against electrical forces when a charge is trans-ported from one point to another. It is measured in volts(V) or Joules(J) per Columb(J/C). It is a scalar quantity.

Elemental works done dW is given as

$$dW = F dL \quad \text{--- (1)}$$

But $F = -q_0 E$ --- (2)

Substituting equation (2) in (1) $dW = -q_0 E d$ --- (3)

Total workdone in moving the test charge from A to B is

$$W(A'nB)_{Ag} = -q_0 \int_A^B E dL \quad \text{--- (4)}$$

~~Total work~~ from the definition of electric potential difference, it follows that:

$$V_B = V_A = \frac{W(A'nB)_{Ag}}{q_0} \quad \text{--- (5)}$$

putting equation (4) in (5) yields:

$$V_B - V_A = -\int_A^B E dL \quad \text{--- (6)}$$

SECTION B

4 Magnetic flux is the strength of the magnetic field which can be represented by line of forces. It is represented by the symbol ϕ. mathematically given as $\phi B - \phi A$

b $m = 9 \times 10^{-31} kg$ $r = 1.4 \times 10^{-7} m$ $B = 3.5 \times 10^{-1} weber/m^2$

Cyclotron Frequency = angular speed

$$\omega = \frac{v}{r} = \frac{qB}{m}$$

$$\omega = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9 \times 10^{-31}}$$

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$\omega = 6.22 \times 10^{10} T^{-1}$

4c mass of electron $= 9.11 \times 10^{-31}$ kg, radius $= 1.4 \times 10^{-7}$ m
magnetic field $= 3.5 \times 10^{-1}$ weber/meter^2
Cyclotron frequency can be called Angular speed, hence,
Angular speed $= \frac{v}{r} = \frac{qB}{m}$

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

$$= 6.22 \times 10^{10} T^{-1}$$

So cyclotron frequency $= 6.22 \times 10^{10} T^{-1}$, the unit is equal to unit of frequency dimensional

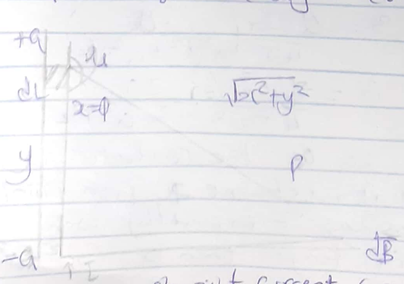
5 Biot-Savart's law states that the magnetic field is proportional to the product permeability of free space (μ) the current (I), the change in length, the radius and inversly proportional to the square of radius (r^2). It can be mathematically $dB = \frac{\mu_0 I dl \times r}{4\pi r^2}$

Where μ_0 is a constant called permeability of free space.

$$\mu = 4\pi \times 10^{-7} T \cdot m/A$$

Unit of B is weber/meter^2

5b Magnetic field of a straight current carrying conductor



A Section of a straight current carrying conductor

Applying the Biot-Savart law, we find magnitude of the field $d\bar{B}$

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

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

$$\therefore B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} \frac{dl\sin(\pi-\phi)}{r^2} \quad \text{——} (1)$$

From the diagram above $r^2 = x^2+y^2$ (pythagoras theorem)

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

But $\sin(\pi-\phi) = \frac{x}{\sqrt{x^2+y^2}} = \frac{x}{(x^2+y^2)^{1/2}}$ —— (2)

Substituting (2) into (1), $B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} dl \frac{x}{(x^2+y^2)(x^2+y^2)^{1/2}}$

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

recal $dl = dy$

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

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

Using special integrals. $\int \frac{dy}{(x^2+y^2)^{3/2}} = \frac{1}{x^2} \cdot \frac{y}{(x^2+y^2)^{1/2}}$

Equ(3) becomes $B = \frac{\mu_0 I x}{4\pi}\left[\frac{y}{x^2(x^2+y^2)^{1/2}}\right]_{-a}^{a}$

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

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

When the length 2a of the conductor is very great in comparison to its distance x from point P ~~to its distance~~, we consider it infinitely long. That is, when a is much longer than x, $(x^2+a^2)^{1/2} \simeq a$, as $a \longrightarrow x$

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

In a physical situation, we have axial symmetry about the y-axis. Thus, at all points in a circle of radius, r, around the conductor, the magnitude of B is

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