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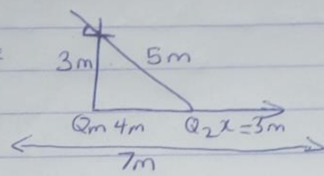
Physics 102
Department: Aeronautical Engineering

Section A

2a: An electric field is a region of space in which an electric charge will experience an electric force while electric field intensity can be defined as the force per unit charge. Electric field intensity can be express mathematically as $E = \frac{F(N)}{q(s)}$

b) $Q_1 = 8nc$ $Q_2 = 12nc$



① $E_{nd}\,p = EQ_1 + EQ_2$

$$EQ_1 = \frac{KQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 1.469 N/c$$

$$EQ = \frac{KQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^9}{3^2} = 12 N/c$$

$$E_{nd}\,p = 1.469 + 12 = 13.469 \simeq 13.5 N/c$$

ii, $E_{nd}\,Q = E_1 + E_2$

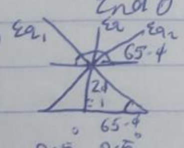
$$E_1 = \frac{KQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-4}}{3^2} = 8 N/c$$

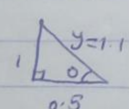
$$E_2 = \frac{KQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-7}}{5^2} = 4.32 N/c$$

Vector	Degree	X. component	Y. component
$E_1 = 8N/C$	$90°$	$8\cos 90 = 0$	$8\sin 90 = 8$
$E_2 = 4.32N/C$	36.9	$-4.32\cos 36.9 = 3.45$	$4.32\sin 36.9 = 2.59$
		$Efx = -3.45$	$Efy = 10.59$

$$E_{nd}\,O = \sqrt{(-3.45)^2 + (10.59)^2} = 11.14 NC^{-1}$$

a)





$hyp = \sqrt{1^2 + 0.5^2}$
$= \sqrt{1.25}$
$= 1.1$

$Tan\theta = \frac{1}{0.5}$
$Tan\theta = 2$
$\theta = Tan^{-1} 2$
$\theta = 63.43$

$$E_q = E_{q_1} + E_q + E_q = \frac{Kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{1.1} = 5970.4 NC^{-1}$$

$$E_q = \frac{Kq}{r^2} = \frac{9\times10^9 \times q}{1^2} = 9\times10^9 q NC^{-1}$$

Vector	Angle	X-component	Y-component
$q_1 = 59504$	63.4°	$-59504 \cos 63.4 = 26604 3 N/c$	$59504 \sin 63.4 = 53205 Nc^{-1}$
$q_2 = 59504$	63.4°	$59504 \cos 63.4 = 26604 3$	$59504 \sin 63.4 = 53200 Nc^{-1}$
$q = 9\times10^9 q$	90	$9\times10^9 q \cos 90 = 0$	$9\times10^9 q \sin 90 = 9\times10^9 q$
		$\Sigma fx = 0$	$\Sigma fy = 106410 + 9\times10^9 q$

$\Sigma P = \sqrt{0^2 + (106410 + 9\times10^9 q)^2}$

$\Sigma P = 106400 + 9\times10^9 q$

at $6p = 0$ it will be

$106410 + 9\times10^9 q = 0$ $\therefore \frac{9\times10^9 q}{9\times10^9} = \frac{-106410}{9\times10^9}$ $q = -1.182\times10^{-5}c$

$q = -12\mu c$

b) $f = 1N$, $d = r = 2m$, $Q = 5.0\times10^{-5}c$, $q_1 + q_2 = Q = 5.0\times10^{-5}c$

$F = \frac{Kq_1q_2}{r^2}$ $1 = \frac{9\times10^9 \times q_1q_2}{r^2}$ $\frac{4}{9\times10^9} = \frac{9\times10^9 q_1q_2}{9\times10^9}$

$q_1q_2 = 4.44\times10^{-10}$ --- (1) recall $q_1 + q_2 = 5.0\times10^{-5}$

$q_1 = 5.0\times10^{-5} - q_2$ --- (2) Put (2) in (1)

$q_2(5.0\times10^{-5} - q_2) = 4.44\times10^{-10}$

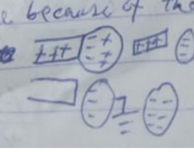
$5.0\times10^{-5}q_2 - q_2^2 = 4.44\times10^{-10}$

$-q_2^2 + 5.0\times10^{-5}q_2 - 4.44\times10^{-10}$

$q_2 = 3.85\times10^{-5}c$ or $q_2 = 1.155\times10^{-5}c$

$\therefore q_2 = 3.85\times10^{-5}$, $q_2 = 1.155\times10^{-5}c$

a Charging by reduction: Electric charges can be obtained on an object without touch light, by a process called electrostatic induction. Consider a positively charged rubber rod brought near a neutral conducting sphere that is insulated so that there is no conducting path to ground as shown below the repulsive force between the protons on the rod and those in the sphere causes a redistribution of charges on the sphere so that some protons move to the side of the sphere for that away from the rod. The region of the sphere nearest to the positively charged rod has an excess of negative charge because of the migration of protons away from the location Diagram



4a) ...ction B

Magnetic flux is defined as the strength of magnetic field represented by line of force it is usually represented by the symbol ϕ.

b) $m = 9.11\times10^{-31}kg$, $r = 1.4\times10^{-2}m$, $B = 3.5\times10^{-1}$ weber/m² $\theta = 90°$, $\omega = ?$

$q = -1.6\times10^{-19}c$ $\omega = \frac{qB}{mc}$

$$\omega = \frac{-1.6\times10^{-19}\times3.5\times10^{-1}}{9.11\times10^{-31}} \qquad \omega = -6.15\times10^{10}\ rad/s.$$

c) In the question we were given some parameters such as:

i. mass of the electron = $9.11\times10^{-31}kg$

ii. magnetic field of 3.5×10^{-1} weber m²

iii. A radius of $1.4\times10^{-2}m$.

And we are asked to find the cyclotron frequency which equal or the same thing as angular speed. It is called cyclotron frequency because it is a frequency of an accelerate called cyclotron.

Recall: Angular Speed is equal $\omega = v/r = qB/m$

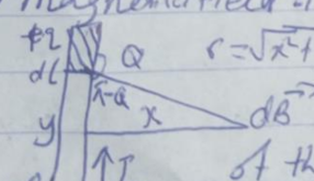
5a) Biot-Savart law states that the magnetic flux directly proportional to the product permeability of free space (μ) the current (I), the change in length, the radius and inversely proportional to sequence of radius (r²),

mathematically, it is expressed as: $dB = \frac{\mu \cdot I dl \times \hat{r}}{4\pi r^2}$

μ is a constant called permeability of force space

$\mu = 4\pi\times10^{-7}$ m/A unit fore is weber/meter square.

5'b) magnetic field of a straight current carrying conductor



$r = \sqrt{x^2+y^2}$

Applying biot-Savart law, we find the magnitude of the field $\vec{dB}$

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

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

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

... the diagram $r^2 = x^2 + y^2$

$$B = \frac{\mu . I}{4\pi} \int_{-a}^{a} \frac{dl \sin(\pi - \psi)}{x^2 + y^2} \quad \text{--- (1)}$$

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

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

Recall $dl = dy$

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

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

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

Equation (3) therefore becomes

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

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

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

When the length 2a the conductor is very great in comparison to the distance x form point p, we consider it refinity line. That is whe a is much logaritz x

$$(x^2 + a^2)^{\frac{1}{2}} \simeq a, \text{ as } a \to \infty$$

$$\therefore B = \frac{\mu . I}{2\pi x}$$

$\therefore$ In a physical situation, we have axial symmetry

$$B = \frac{\mu . I}{2\pi x}$$