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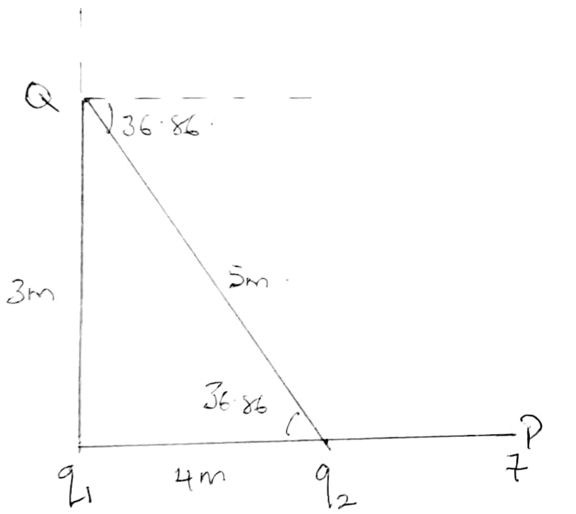
19/ENG04/002

PHY 102

Electrical Electronics.

1) Electric field is a region of space in which an electric charge will experience an electric force WHILE Electric field intensity $\vec{E}$, can be defined as the Force per Unit charge measured in Newton per coloumb (N/C)

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

b) 

i) $E_1 = \frac{kq_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{7^2} = \frac{72}{49} = 1.47 N/C$

$E_2 = \frac{kq_2}{r^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{3^2} = \frac{108}{9} = 12 N/C$

$\vec{E} = \vec{E_1} + \vec{E_2} = 12 + 1.47 = 13.47 N/C$

ii) $E_1 = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{9} = \frac{72}{9} = 8 N/C$

$E_2 = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{25} = 4.32 N/C$

$E_1 = 8$	90	$8\cos 90 = 0$	$8\sin 90$
$E_2 = 4.32$	36.86	$4.32\cos 36.86$	$-4.32\sin 36.86$
		3.46	-10.59

$$E = \sqrt{(3.46)^2 + (-10.59)^2}$$

$$E = \sqrt{124.1197}$$

$$E = 11.14\,N/C$$

3) a) i) Volume charge density, $\rho = \dfrac{dQ}{dV} \rightarrow dQ = \rho\, dV$

ii) Surface charge density, $\sigma = \dfrac{dQ}{dA} \rightarrow dQ = \sigma\, dA$

iii) Linear charge density, $\lambda = \dfrac{dQ}{dL} \rightarrow dQ = \lambda\, dL$

b) 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 transported from one point to the another. It is measured in volts or Joules per coloumb (J/C)

$$V_B - V_A = -\int_A^B E\,dL \quad \text{--- (1)}$$

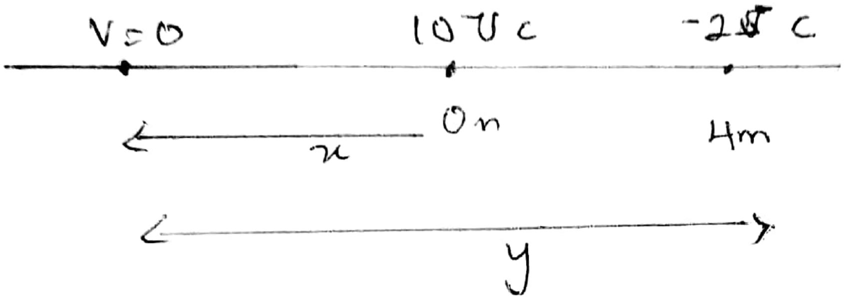
Electric potential due to a single Point charge.

$$V_B - V_A = \frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{r_B} - \frac{1}{r_A}\right]$$

Due to Several Point charges.

$$V = \sum^{n} V_i = \frac{1}{4\pi\varepsilon_0}\sum^{n}\frac{Q_i}{r_i}$$

the speed of light.



$y = x + 4$

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

$Q_1 = 100 \mu C \quad r_1 = x$

$Q_2 = -2 \mu C \quad r_2 = x + 4$

$0 = 9\times10^{9}\left[\frac{10\times10^{-6}}{x} + \frac{(-2\times10^{-6})}{x+4}\right]$

$0 = \frac{10\times10^{-6}}{x} - \frac{2\times10^{-6}}{x+4}$

$\frac{2\times10^{-6}}{x+4} = \frac{10\times10^{-6}}{x}$

$2\times10^{-6}x = 10\times10^{-6}x + 40\times10^{-6}$

$-10\times10^{-6}x + 2\times10^{-6}x = 40\times10^{-6}$

$-8\times10^{-6}x = 40\times10^{-6}$

$x = -5$

When $x = -5$, $y = -5 + 4$, $y = -1$

Distance $= -5$ and -1

5) The magnetic flux through a surface is what generates the field around a magnetic material. The S.I unit of magnetic flux is the Weber (Wb) (in derived units: Volts-Seconds)

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

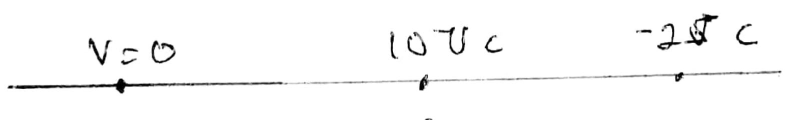
$r = 1.4 \times 10^{-7}$

$B = 3.5 \times 10^{-1}$ T

$q = 1.6 \times 10^{-19}$ C

$$W = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}} = 6.15 \times 10^{10} \text{ rad/s}.$$

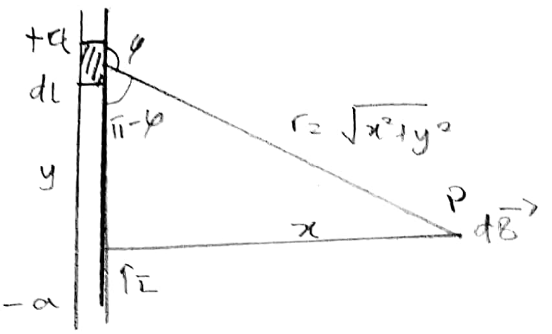
c) The electron has a charge 1.6×10^{-19} C moves with a cyclotron frequency / angular speed of 6.15×10^{10} rad/s in a circular orbit of radius 1.4×10^{-7} m perpendicular to the speed of light.



5) Biot - Savart Law

"the magnetic intensity at any point due to a steady current in an infinitely long straight wire is directly proportional to the current and inversely proportional to the distance from point to wire"

b)



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

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

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

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

From the diagram, $r^2 = x^2 + y^2$

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

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

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

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

Recall $dl = dy$.

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

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

Using Special Integrals

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

Therefore

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

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

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

when the length $2a$ of the conductor is very great in comparison to its distance x from point P, we consider it infinitely long. That is, when a is much larger than x

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

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