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TY BTech EXTC

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Date 22-07-20

EWE - Mock Test

Q1.] Three point charges $Q_1 = 1 mC$, $Q_2 = -2mC$ and $Q_3 = 3mC$ are, respectively, located at $(0,0,4)$, $(-2,5,1)$ and $(3,-4,6)$.

(a) Find the potential V_P at $P(-1,1,2)$.
(b) Calculate the potential difference V_{PQ} if $Q(1,2,3)$.

→ (a) Potential at a point is given by, $V_P = \sum_{i} \dfrac{Q_K}{4\pi|\bar{r}_p - \bar{r}_k|}$

Also, $V_P = V_{Q_1} + V_{Q_2} + V_{Q_3}$

i.e., $V_P = \dfrac{KQ_1}{R_1} + \dfrac{KQ_2}{R_2} + \dfrac{KQ_3}{R_3}$

$\therefore V_P = K\left(\dfrac{1\times10^{-3}}{\sqrt{1+1+4}} + \dfrac{(-2)\times10^{-3}}{\sqrt{1+16+1}} + \dfrac{3\times10^{-3}}{\sqrt{16+25+16}}\right)$

$= K\left(\dfrac{1}{\sqrt{6}} - \dfrac{2}{\sqrt{18}} + \dfrac{3}{\sqrt{57}}\right)\times10^{-3}$

$= 9\times10^{+9}\times0.3342\times10^{-3}$

$\therefore \underline{V_P = 3.01\times10^{6}\,V}$

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(b.) at point Q,

$$V_Q = V_{Q_1 Q} + V_{Q_2 Q} + V_{Q_3 Q}$$

$$= \frac{KQ_1}{R_1} + K\frac{Q_2}{R_2} + K\frac{Q_3}{R_3}$$

$$= K\left(\frac{1\times10^{-3}}{\sqrt{1+4+1}} - \frac{2\times10^{-3}}{\sqrt{9+9+4}} + \frac{3\times10^{-3}}{\sqrt{4+36+9}}\right)$$

$$= K\left(\frac{1}{\sqrt{6}} - \frac{2}{\sqrt{22}} + \frac{3}{\sqrt{49}}\right)\times10^{-3}$$

$$= 9\times10^{+9} \times 0.4104 \times 10^{-3}$$

$$\therefore V_Q = 3.694 \times 10^{6}$$

$$\therefore V_{PQ} = V_Q - V_P$$

$$= (3.694 - 3.01) \times 10^{6}$$

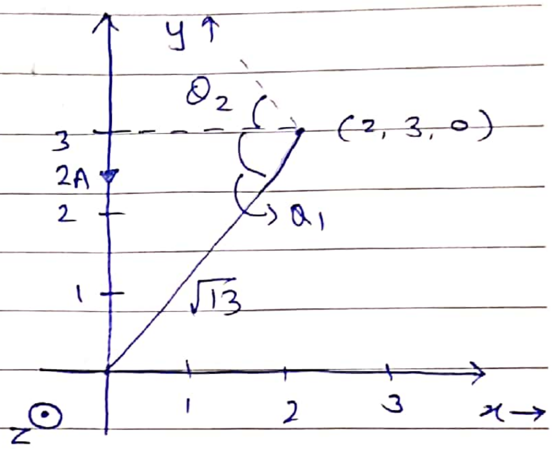
$$\therefore V_{PQ} = 6.84 \times 10^{5} V$$

$$= \underline{\underline{684 \text{ KV}}}$$

Q2.] The positive y-axis (semi-infinite line w.r.t origin) carries a filamentary current of 2A in the $-a_y$ direction. Assume it is part of a large circuit. Find H at

(a) A (2, 3, 0)
(b) B (3, 12, −4)

→ We know that magnetic field intensity due to a semi-infinite line is given by



$$B = \frac{\mu_0}{4\pi}\left(\frac{I}{r}\right)\left[\sin\theta_1 + \sin\theta_2\right]$$

also, $B = \mu_0 H$

i.e., $H = \frac{B}{\mu_0}$

(a) $H = \frac{1}{4\pi}\left(\frac{I}{r}\right)(\sin\theta_1 + \sin\theta_2)$

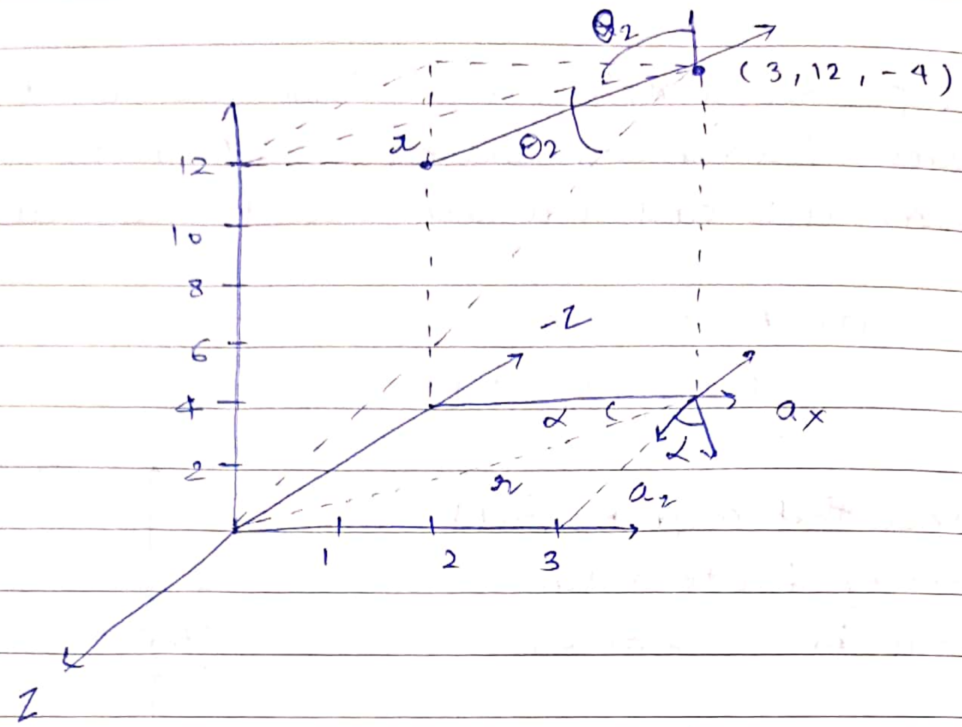
$\sin\theta_1 = \frac{3}{\sqrt{13}}$, $\sin\theta_2 = 1$ (since, $\theta_2 \simeq 90^\circ$ for infinite line)

$\therefore H = \frac{1}{4\pi}\left(\frac{2}{2}\right)\left(\frac{3}{\sqrt{13}} + 1\right)$ ($\because I = 2$; $r = 2$ (Perpendicular dist from point to the line))

$\Rightarrow H = 145.8 \text{ mA/m}$

By right hand thumb rule, $\boxed{\vec{H} = 145.8 \text{ mA/m } \hat{a}_z}$

(b.)

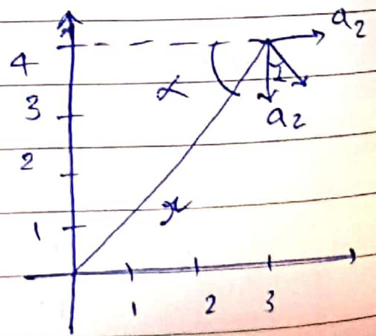


$$r = \sqrt{(3)^2 + (4)^2} = \sqrt{25} = 5 \text{ unit}$$

$$r' = \sqrt{(3)^2 + (12)^2 + (-4)^2} = 13 \text{ unit}$$

$$\sin\theta_1 = \frac{12}{13}$$

$$\sin\theta_2 = 1 \quad (\because \theta_2 \approx 90°)$$



$$H = \frac{1}{4\pi}\left(\frac{2}{5}\right)\left(\frac{12}{13}+1\right)$$

$$= \frac{1}{4\pi}\left(\frac{2}{5}\right)\left(\frac{25}{13}\right)$$

$$\Rightarrow H = 61.21 \text{ mA/m}$$

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Direction vector is given by $= \cos\alpha\, \hat{a_z} + \sin\alpha\, \hat{a_z}$

$= \frac{3}{5}\hat{a}_z + \frac{4}{5}\hat{a}_x$

$\therefore \vec{H} = (61.21)\left(\frac{3}{5}\hat{a}_z + \frac{4}{5}\hat{a}_x\right)$ mA/m

$$\boxed{\vec{H} = 48.97\,\hat{a}_x + 36.72\,\hat{a}_z \ \text{mA/m}}$$