1)

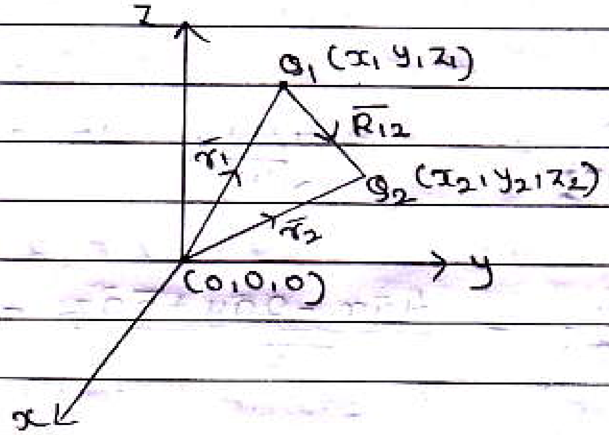
a) state vector ~~form~~ of a coloumb's law of force betn two point charges and indicate the unit's of the quantities in the eqn.

→ statement :- " The ~~col~~ Coulomb's law state's that the forse betwn the two point charges acts along the line joining the two point charges and it is directly proportional to the product of the two charges and Inversally proportional to the square of the distance between them.

Q_1 ←— R —→ Q_2.

i.e $F \propto \frac{Q_1 Q_2}{R^2}$

Vector form of coloumb's law :-



~~The forse~~ consider the 2-point charges Q_1 & Q_2 located at the points having position vectors r_1 & r_2

The forse exerted by Q_1 on Q_2 acts along the direction $\overline{R_{12}}$,

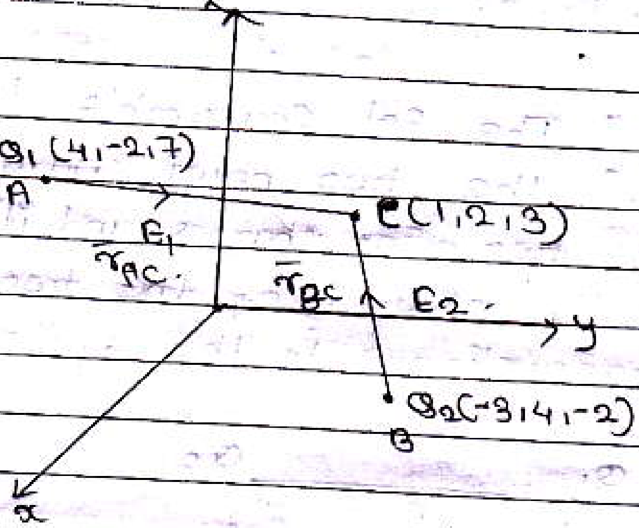
$$\therefore \overline{F_2} = \frac{Q_1 Q_2}{4\pi\epsilon_0 R_{12}^2} \cdot \overline{a}_{12}.$$

where, $\overline{a}_{12}$ is unit vector along $\overline{R_{12}}$

$$\Rightarrow \overline{a}_{12} = \frac{\overline{R_{12}}}{|\overline{R_{12}}|} \Rightarrow \frac{\overline{r_2} - \overline{r_1}}{|\overline{r_2} - \overline{r_1}|}$$

... point charge $Q_1 = 25nC$ be located at $A(4,-2, ...$ charge $Q_2 = 60nC$ be located at $B(-3,4,-2)$, find E at $C(1,2,3)$ & find the dir^n of $\vec{E}$

$\longrightarrow$



$\therefore \bar{E}_{total} = \bar{E}_A + E_B$

$$\bar{E}_{total} = \frac{Q_1}{4\pi\varepsilon_0 |r_{AC}|^2} \times \bar{a}_{AC} + \frac{Q_2}{4\pi\varepsilon_0 |r_{BC}|^2} \times \bar{a}_{BC}$$

$$\bar{a}_{AC} = \frac{\bar{R}_{AC}}{|\bar{R}_{AC}|} = \frac{-3\bar{a}_x + 4\bar{a}_y - 4\bar{a}_z}{\sqrt{41}} = \frac{-3\bar{a}_x + 4\bar{a}_y - 4\bar{a}_z}{(6.40)}$$

$$\bar{a}_{BC} = \frac{\bar{R}_{BC}}{|\bar{R}_{BC}|} = \frac{4\bar{a}_x - 2\bar{a}_y + 5\bar{a}_z}{\sqrt{45}} = \frac{4\bar{a}_x - 2\bar{a}_y + 5\bar{a}_z}{(6.70)}$$

$$\therefore \bar{E}_{total} = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{|r_{AC}|^2} \times \bar{a}_{AC} + \frac{Q_2}{|r_{BC}|^2} \cdot \bar{a}_{BC}\right]$$

$$= 8.98 \times 10^{9} \left[\frac{25\times10^{-9}}{(6.40)^3}(-3\bar{a}_x + 4\bar{a}_y - 4\bar{a}_z) + \frac{60\times10^{-9}}{(6.70)^3}(4\bar{a}_x - 2\bar{a}_y + 5\bar{a}_z)\right]$$

$$\bar{E}_{total} = 0.856(-3\bar{a}_x + 4\bar{a}_y - 4\bar{a}_z) + 1.79(4\bar{a}_x - 2\bar{a}_y + 5\bar{a}_z)$$

$$\therefore \bar{E}_{total} = 4.6\,\bar{a}_x - 0.16\,\bar{a}_y + 5.53\,\bar{a}_z \text{ V/m} \;//$$

direct^n :-

is $\bar{a}_E = \frac{\bar{E}}{|\bar{E}|} \Rightarrow \frac{4.6\bar{a}_x - 0.16\bar{a}_y + 5.53\bar{a}_z}{\sqrt{(4.6)^2 + (0.16)^2 + (5.53)^2}}$

$\bar{a}_E \Rightarrow 0.63\bar{a}_x - 0.022\bar{a}_y + 0.77\bar{a}_z$

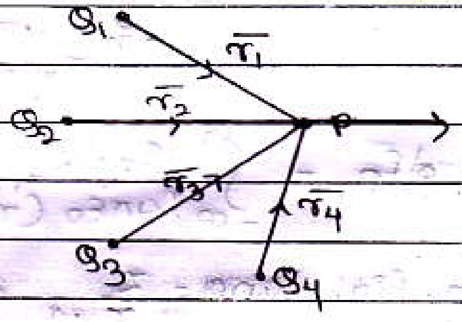
Q. c) Define electric field intensity due to number of point charge in vector form.

$\longrightarrow$

" The force experienced on a test charge due to a source charge by which it is repell or attract the test charg"

i.e $\bar{E} = \dfrac{Q}{4\pi\epsilon_0 R^2} \cdot \bar{a}_{QP}$

* Electric field due to number of charges -.



consider the $Q_1, Q_2 \ldots Q_n$ charges, The combined electric field intencity is to be obtained at a point P. The distance of point P from $Q_1, Q_2 \ldots Q_n$ are $R_1, R_2 \ldots R_n$ respect.

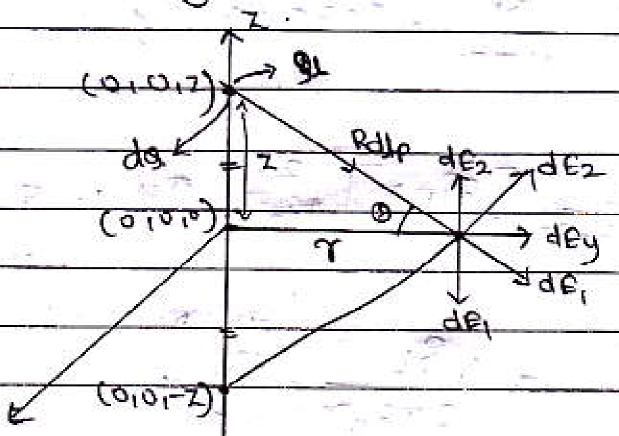
$\therefore$ The total electrical field intencity is given by,

$$\bar{E}_P = \bar{E}_1 + \bar{E}_2 + \bar{E}_3 + \bar{E}_4 \cdots\cdots E_n$$

$$\bar{E}_P = \frac{Q_1}{4\pi\epsilon_0 R_1^2} \cdot \bar{a}_{Q_1P} + \frac{Q_2}{4\pi\epsilon_0 R_2^2} \cdot \bar{a}_{Q_2P} + \frac{Q_3}{4\pi\epsilon_0 R_3^2} \bar{a}_{Q_3P} + \frac{Q_4}{4\pi\epsilon_0 R_4^2} \cdot \bar{a}_{Q_4P}$$

$$\Longrightarrow \left\{ \bar{E}_P = \sum_{i=1}^{N} \frac{Q_i}{4\pi\epsilon_0 R_i^2} \cdot \bar{a}_{Q_iP} \right\} \text{ in V/m}$$

2) a) Derive an expression for electric field intencity due to infinite line charges.



$4\pi\varepsilon_0 R^2 dl_p$

$$\bar{a}_{Rdp} = \frac{\bar{R}_{dp}}{|\bar{R}_{dp}|} = \frac{r\bar{a}_y - z\bar{a}_z}{\sqrt{r^2+z^2}}$$

$$\therefore \bar{dE}_p = \frac{dq}{4\pi\varepsilon_0(r^2+z^2)} \cdot \frac{r\bar{a}_y - z\bar{a}_x}{\sqrt{r^2+z^2}}$$

$\bar{E}$ due to entire line charges -

$$\bar{E}_p = \int d\bar{E}_p = \int_{-\infty}^{\infty} \frac{dq(r\bar{a}_z - z\bar{a}_z)}{4\pi\varepsilon_0(r^2+z^2)^{3/2}}$$

$$\therefore d\bar{E}_p = \int_{-\infty}^{\infty} \frac{\rho_z dz}{4\pi\varepsilon_0 (r^2+z^2)^{3/2}} \cdot r\bar{a}_y$$

from fig, $\tan\theta = \frac{z}{r}$

let $z = r\tan\theta \Rightarrow dz = r\sec^2\theta . d\theta$

when $z = -\infty, \Rightarrow \theta = -\frac{\pi}{2}$

$z = \infty \Rightarrow \theta = \pi/2$

$$\bar{E} = \int_{-\pi/2}^{\pi/2} \frac{\rho_L r \sec^2\theta d\theta}{4\pi\varepsilon_0(r^2 + r^2\tan^2\theta)^{3/2}} r . \bar{a}_y$$

$$= \int_{-\pi/2}^{\pi/2} \frac{\rho_L r^2 \sec^2\theta d\theta}{4\pi\varepsilon_0 r^3 (1+\tan^2\theta)^{3/2}} \bar{a}_y$$

$$= \int_{-\pi/2}^{\pi/2} \frac{\rho_L \sec^2\theta}{4\pi\varepsilon_0 \sec^3\theta} d\theta . \bar{a}_y$$

$$= \int_{-\pi/2}^{\pi/2} \frac{\rho_L}{4\pi r} . \cos\theta . d\theta \, \bar{a}_y$$

$$\bar{E} = \frac{\rho_L}{4\pi\varepsilon_0 r} [\sin\theta]_{-\pi/2}^{\pi/2} \bar{a}_y$$

$$\Rightarrow \left\{ \vec{E} = \frac{\rho_L}{2\pi\varepsilon_0 r} \bar{a}_y \right\}$$

b) Define electric flux density, find $\bar{D}$ in cartesian co-ordinate system at a point $P(6,8,-10)$ due to point charg 40mC at the origin & uniform line charge of ρ_L is 40 μC/m on the z axies

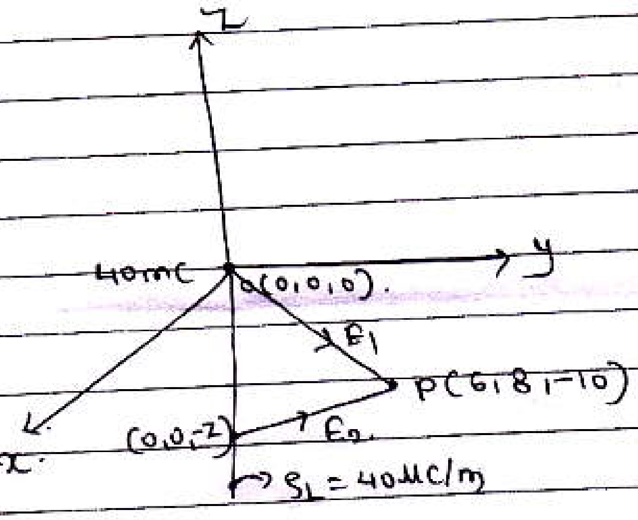
$\longrightarrow$

" The net flux passing normal through the unit surface area is called the electric flux dencity", is denoted by $\bar{D}$

$\therefore$

$$D = \frac{\psi}{S}$$

wher.
ψ = total flux.
S = total surfase are.



① due to point charge -

we have,
$$\bar{D}_1 = \frac{Q}{4\pi |r_{OP}|^2} \cdot \bar{a}_{rOP}$$

$$\bar{a}_{rOP} = \frac{6\bar{a}_x + 8\bar{a}_y - 10\bar{a}_z}{\sqrt{200}} \Rightarrow \frac{6\bar{a}_x + 8\bar{a}_y - 10\bar{a}_z}{14.14}$$

$$\therefore \bar{D}_1 = \frac{40 \times 10^{-3}}{4 \times \pi \times (14.14)^3} (6\bar{a}_x + 8\bar{a}_y - 10\bar{a}_z).$$

$$\Rightarrow \bar{D}_1 = (6.75\bar{a}_x + 9\bar{a}_y - 11.25\bar{a}_z)\ \mu C/m^2 //$$

② due to line charge -, $\rho_L = 40\ \mu C/m$.

$$\bar{D}_L = \frac{\rho_L}{2\pi r} \bar{a}_{zP}$$

$$\bar{D}_L = \frac{40 \times 10^{-6}}{2 \times \pi \times 100} \times (6a_x + 8a_y).$$

$$\Rightarrow \bar{D}_L = (0.38\bar{a}_x + 0.50\bar{a}_y)\ \mu C/m^2 //$$