ELECTRIC FIELD

Date

Gravitational forces are ~~far~~ weaker than electric.

A field is defined as the property of space in which a material object experience a force.

The magnitude of electric field is,

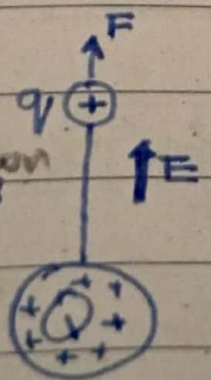
$$\boxed{E = \frac{F}{q}}$$

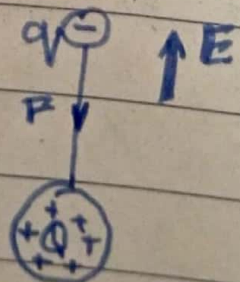
unit → N/C

The field E at a point exist wether there is a charge at that point or not.

~~The direction of~~

...ce direction
...me





Force direction opp to E

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From Coulombs law,

$$\vec{F_e} = \frac{k q q_0}{r^2} \hat{r}$$

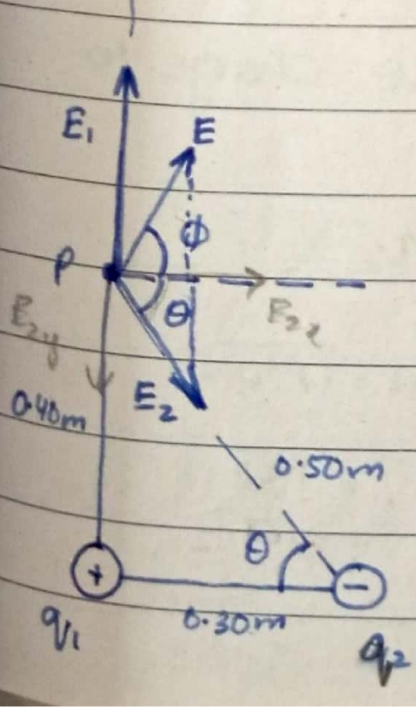
then

$$E = \frac{\vec{F_e}}{q_0} = \boxed{\frac{K q}{r^2} \hat{r}}$$

• **Superposition with Electric Fields**

At any point P, the total electric field due to a group of source charges equals the vector sum of the electric fields of all the charges.

$$\vec{E} = k_e \sum_i \frac{q_i}{r_i^2} \hat{r}_j$$



$$E_1 = K \frac{q_1}{r_1^2} = \frac{8.99\times10^9 \times 7.0\times10^{-6}}{(0.40)^2}$$

$$\boxed{E_1 = 3.9\times10^5 N/C}$$

$$E_2 = E_2 \cos\theta + (-E_2 \sin\theta)$$

$$E_2 = (1.1\times10^5 \hat{i} - 1.4\times10^5 \hat{j})\ N/C$$

$$E = E_1 + E_2 = (1.1\times10^5 \hat{i} + 2.5\times10^5 \hat{j})\ N/C$$

ELECTRIC DIPOLE:

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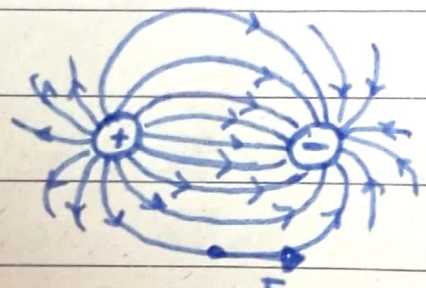
An electric dipole consist of two particles with charges of equal magnitude 'q' but opposite ~~direction~~ signs, seperated by small distance 'd'



Dipole moment = $p = q.d$ S.I unit → Cm

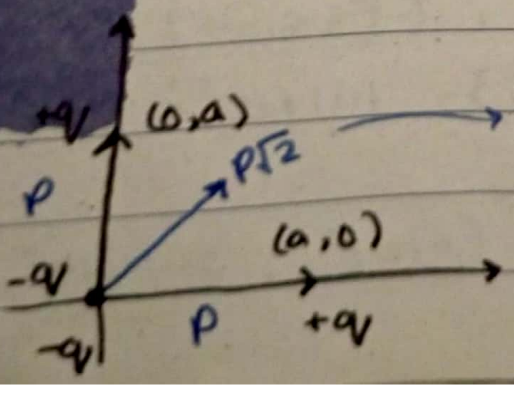
Columb meter

q ⊕ ⊖ q

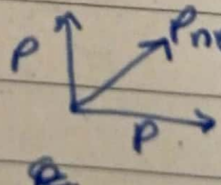
|— d —|

it's direction is taken from -ve charge to +ve charge.

) Find net dipole Movement from system.



→ $P = q \times a$



$P_{net} = \sqrt{P^2 + P^2}$

$= P\sqrt{2}$

$= qa\sqrt{2}$

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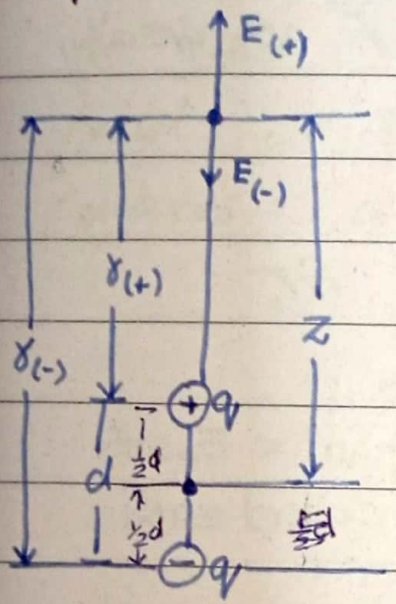
- Electric field due to a dipole on the axis of dipole. (at distance 'z' from center of dipole)



$$E = E_{(+)} - E_{(-)}$$

$$= \frac{Kq}{r_{(+)}^2} - \frac{Kq}{r_{(-)}^2}$$

$$= \frac{Kq}{(z-\frac{1}{2}d)^2} - \frac{Kq}{(z+\frac{1}{2}d)^2}$$

$$= Kq\left(\frac{z^2+\frac{1}{2}d(z)\times 2+\frac{1}{4}d^2 - \{z^2-\frac{1}{2}dz\times 2-\frac{1}{4}d^2\}}{(z-\frac{1}{2}d)^2(z+\frac{1}{2}d)^2}\right)$$

$$= \frac{Kq(2dz)}{(z^2-\frac{1}{4}d^2)^2}$$

$$= \frac{Kq\,2dz}{z^4}$$ $\because$ d is very small therefore neglecting it $d=0$

$$= \frac{1}{4\pi\epsilon_0}\frac{q\,2d}{z^3}$$

$$\boxed{E_{net} = \frac{1}{2\pi\epsilon_0}\cdot\frac{qd}{z^3}}$$ or $\frac{2Kp}{z^3}$

or $$\boxed{E_{net} = \frac{1}{2\pi\epsilon_0}\frac{p}{z^3}}$$ $\because p = qd$

electric dipole!

where z = distance from center of dipole to the point

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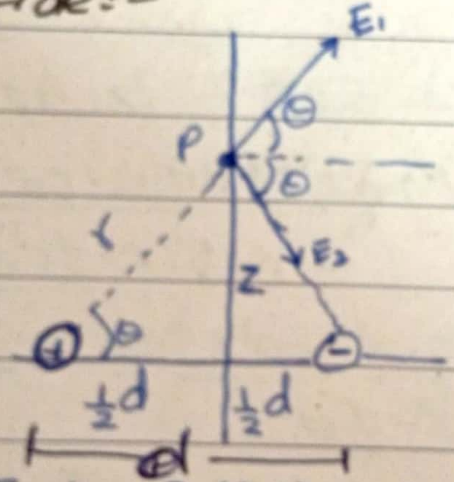
direction of $\vec{p}$ is taken to be from -ve to +ve end of the dipole. We use the direction of $\vec{p}$ to specify the orientation of a dipole.

ELECTRIC FIELD DUE TO DIPOLE AT ⊥ BISECTOR:-



$E_1 \sin\theta$ & $E_2 \sin\theta$ will cancel each other.

then

$E_{net} = E_1 \cos\theta + E_2 \cos\theta$

$\because E_1 = E_2$

$\therefore E_{net} = 2E\cos\theta$

$$E_{net} = \frac{2kq}{r^2}\cos\theta$$

$$\cos\theta = \frac{a}{r} = \frac{a}{(y^2+a^2)^{1/2}}$$

$$= \frac{2kq}{\left(\sqrt{z^2+\frac{d^2}{4}}\right)^2} \cdot \frac{d/2}{\left(z^2+\frac{d^2}{4}\right)^{1/2}}$$

$$= \frac{2kq\,d/2}{\left(z^2+\frac{d^2}{4}\right)^{3/2}}$$

$$E_{net_\perp} = \frac{2kq\,d/2}{z^3}$$ $\because d=0$ (i.e very small)

$$= \frac{kqd}{z^3}$$

$$\boxed{E_{net_\perp} = \frac{kP}{z^3}}$$

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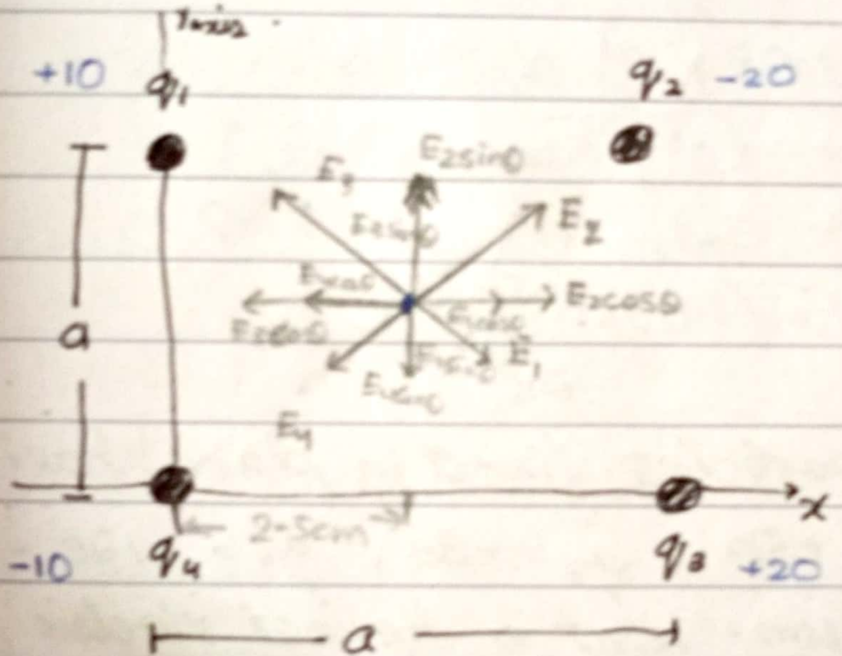
Q: $a = 5.00cm$, $q_1 = +10.0nC$, $q_2 = -20.0nC$, $q_3 = +20.0nC$ & $q_4 = -10.0nC$.
In unit vector notation, what net electric field do the particles produces at the square's center?



$r = 0.035m$

$$E_{net_x} = E_1\cos\theta + E_2\cos\theta - E_3\cos\theta - E_4\cos\theta$$

$$= \frac{Kq_1}{r^2}\cos 45 + \frac{Kq_2}{r^2}\cos 45 - \frac{Kq_3}{r^2}\cos 45 - \frac{Kq_4}{r^2}\cos 45$$

$$= \frac{K}{0.035^2}\left[10\times10^{-9} + 20\times10^{-9} - 20\times10^{-9} - 10\times10^{-9}\right]\cdot\frac{1}{\sqrt{2}}$$

$$E_{net_x} = 0$$

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$E_{net_y} = E_2\sin\theta + E_3\sin\theta - E_1\sin\theta - E_4\sin\theta$

$= \frac{K}{r^2}[q_2 + q_3 - q_1 - q_4] \cdot \frac{1}{\sqrt{2}}$

$= \frac{K}{0.0035^2}[20\times10^{-9} + 20\times10^{-9} + 10\times10^{-9} + 10\times10^{-9}] \cdot \frac{1}{\sqrt{2}}$

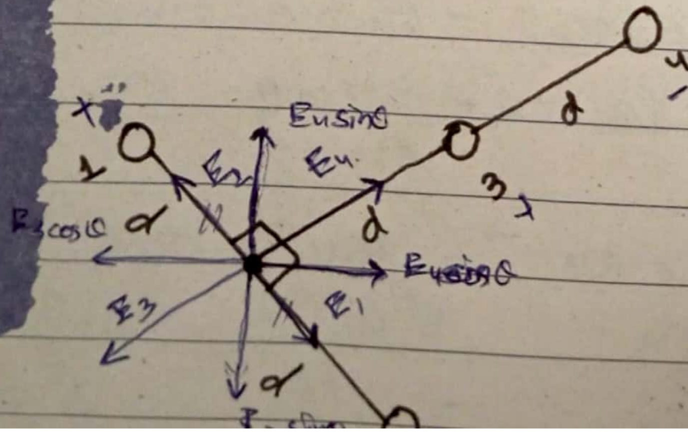
$E_{net_y} = 1.03\times10^5\ N/C$

$E = \sqrt{0^2 + E_{net_y}^2}$

$E_{net} = E_{net_y}$ $\quad x = 0$

$E_{net} = (1.03\times10^5)\hat{j}\ N/C$

Q: Four particles fixed in place having $q_1 = q_2 = +5e$, $q_3 = +3e$, $q_4 = -12e$. Distance $d = 5.0\ \mu m$. What is the net electric field at Point "P."



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$E_{net\,x} = E_4 \cos\theta - E_3 \cos\theta$

$E_{net\,x} = E_4 \sin\theta - E_3 \sin\theta$

$$E_{net\,x} = \frac{K q_4}{(2d)^2} - \frac{K q_3}{d^2}$$

$$= \frac{K}{d^2}\left(\frac{q_4}{4} - q_3\right)$$

$$= 0$$

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