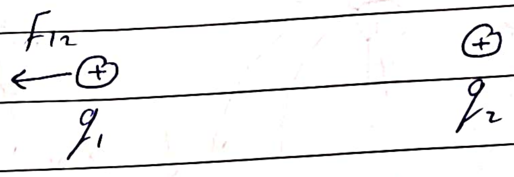
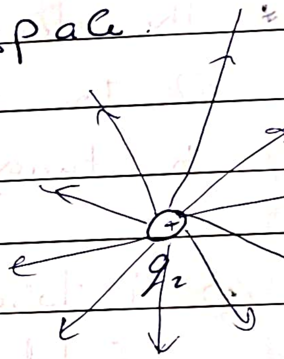
Ch 22: Electric Fields:

22-1 What is the electric field?



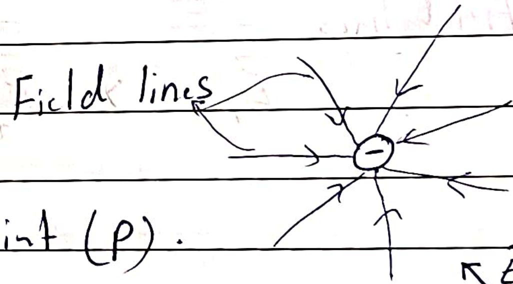
* how does particle ① know of the presence of particle ②!
& how can particle ② push on particle ①.
→ the explanation: particle ② sets up an electric field at all points in the surrounding space.



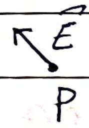
* the electric field is a vector field; it consists of a distribution of electric field vectors $\vec{E}$

* the electric field at any point (P):

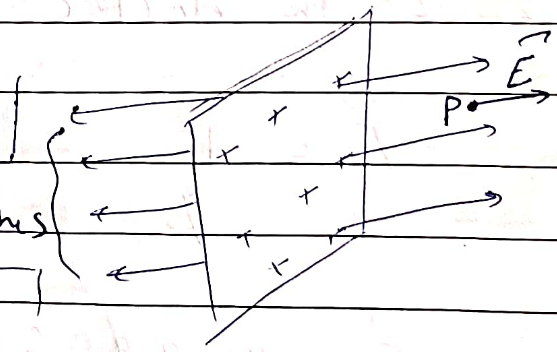
$$\vec{E} = \frac{\vec{F}}{q_0}$$



q_0: positive test charge at point (P).



$[\vec{E}] = N/C$



→ uniform electric field: has the same magnitude & direction at every point. $\boxed{\text{field lines}}$

* Electric field lines extent away from positive charge & toward negative charge.

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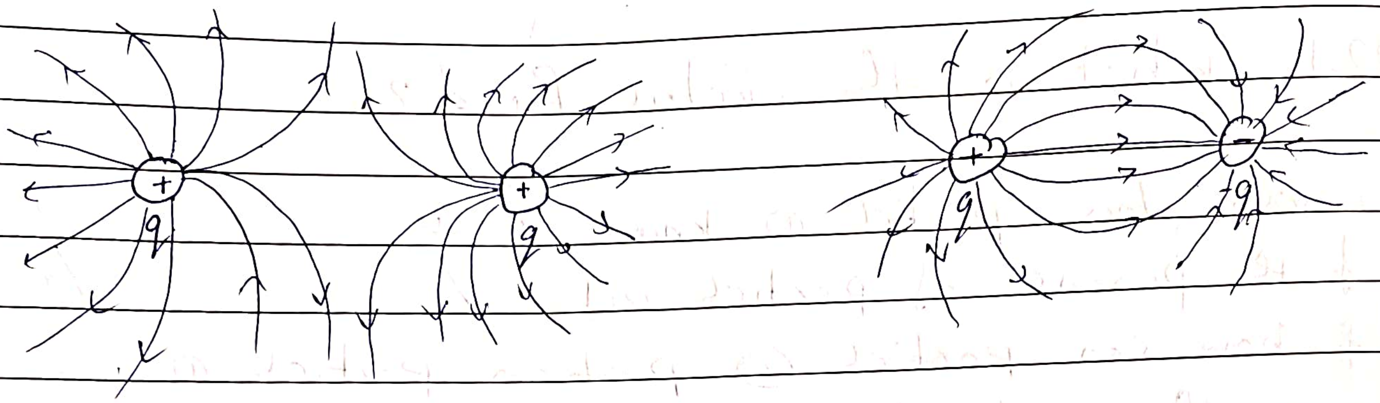
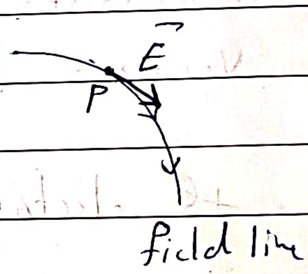
+ Electric field of two charges



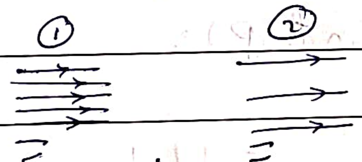
* The electric field lines:

① The electric field vector at any given point must be tangent to the field line at that point.



② A closer spacing means a larger field magnitude

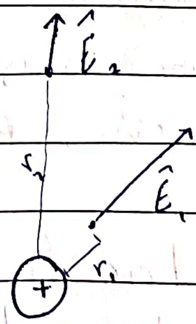
Field lines



$\vec{E}_1 > \vec{E}_2$

22-2 The electric field due a charged particle.

$$\vec{E} = \frac{\vec{F}}{q_0}$$



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

$$\Rightarrow \vec{E} = k \frac{q}{r^2} \hat{r}$$

$E_1 > E_2$

$$E = k \frac{|q|}{r^2} \quad \text{(magnitude)}$$

since $r_1 < r_2$

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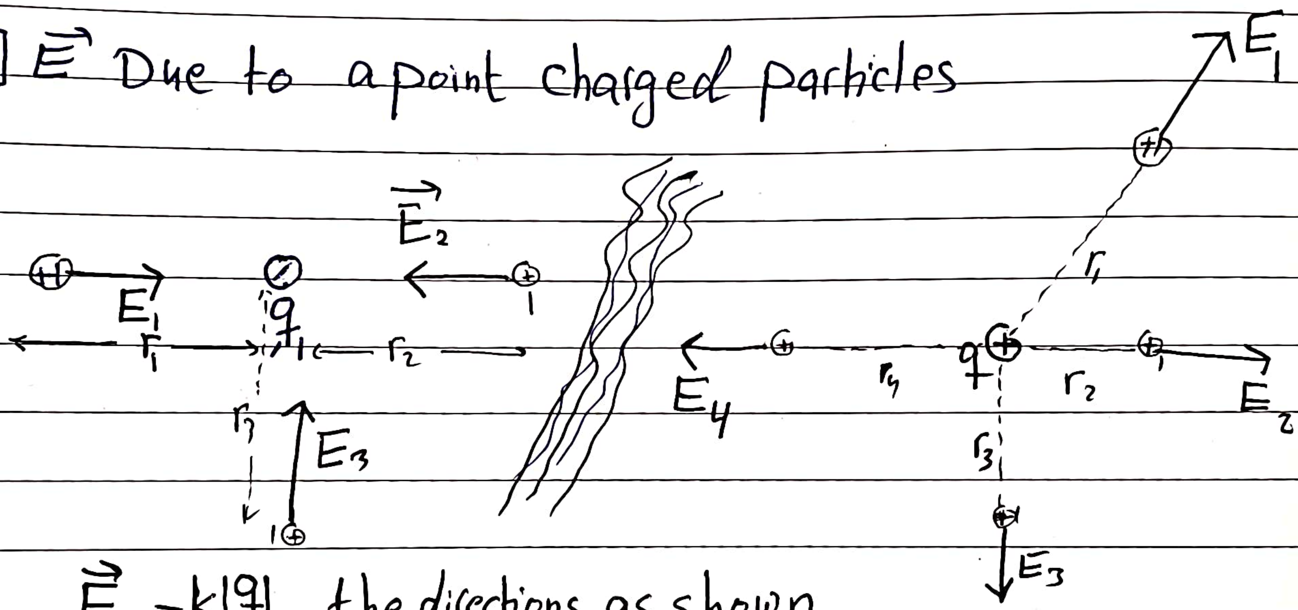
Electric Field lines extends away from positive charge and toward negative charge

In this Course we will find

$\vec{E}$
1) Due to a point charge
2) Due to a set of point charges
3) Due to a Continous Charge distribution

1] $\vec{E}$ Due to a point charged particles



$\vec{E} = k\frac{|q|}{r^2}$ the directions as shown

2] $\vec{E}$ Due to a Set of Point charges:

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \cdots\cdots$$

Solve sample Problem (22.01)

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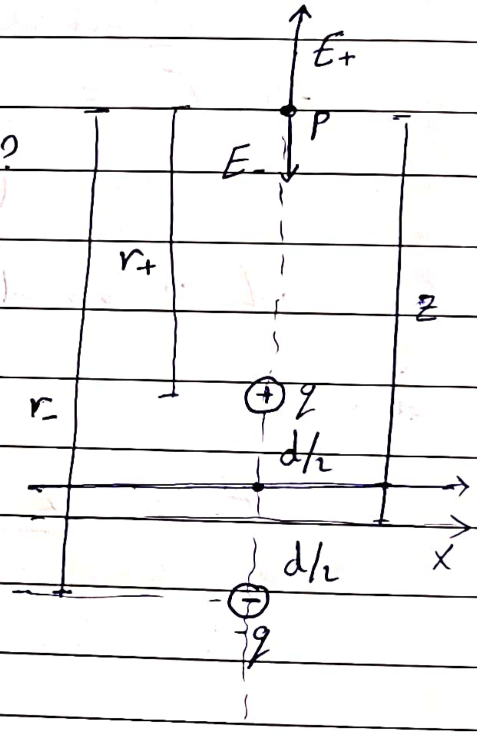
* If we want to find the electric field due several charged particles, we use superposition principle.

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \dots$$

22-3: The electric field due to a dipole:

electric dipole: two particles that have the same charge (q) but opposite signs.

Find $\vec{E}$ from the dipole at point p?



$$\vec{E} = \vec{E}_+ + \vec{E}_-$$

$$\vec{E} = E_+ \hat{k} - E_- \hat{k} \text{ (opposite dir)}$$

$$= \left(k\frac{q}{r_+^2} - k\frac{q}{r_-^2} \right) \hat{k}$$

$r_+ = z - d/2$, $r_- = z + d/2$, $a = d/2$

$= z - a$, $= z + a$

$$\Rightarrow E = kq \left[\frac{1}{(z - d/2)^2} - \frac{1}{(z + d/2)^2} \right]$$

$$= kq \left[\frac{(z+a)^2 - (z-a)^2}{(z-a)^2 (z+a)^2} \right]$$

$$= kq \left[\frac{(z^2 + 2az + a^2) - (z^2 - 2az + a^2)}{[(z-a)(z+a)]^2} \right]$$

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$$\vec{E} = \frac{kq\,(4az)}{(z^2 - a^2)^2}\,\hat{k} \quad , \; a = d/2$$

$$= \frac{kq\,(2dz)}{\left(z^2 - \left(\frac{d}{2}\right)^2\right)^2} = \frac{2k\,(qd)\,z}{\left(z^2 - \left(d/2\right)^2\right)^2}$$

$P = qd$ (electric dipol moment)

$[P] = C.m$

$\oplus$

$\uparrow \vec{P}$

$\ominus$

$$\Rightarrow \vec{E} = \frac{2kPz}{\left(z^2 - (d/2)^2\right)^2}\,\hat{k} \quad \text{(upward)}$$

if $z \gg d$, we can neglect $d/2$ term in the denominator.

$$E = \frac{2kPz}{z^4} = \frac{1}{2\pi\varepsilon_0}\,\frac{P}{z^3}\,\hat{k}$$

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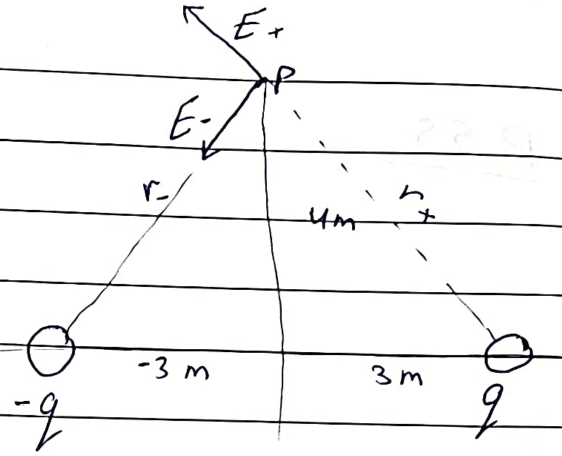


$q = 3.2 \times 10^{-19}$ C

Find E at p?

$r_+ = r_- = \sqrt{3^2 + 4^2}$

$= 5$ m

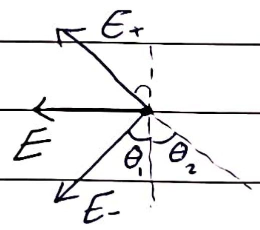
$E_+ = K \dfrac{|q|}{r_+^2} = K \dfrac{q}{5^2}$

$= 1.15 \times 10^{-10}$ c/m

$E_- = K \dfrac{|q|}{r_-^2} = \dfrac{K q}{5^2} = 1.15 \times 10^{-10}$ c/m

$(E_+)_y = (E_-)_y$ (opposite direction)

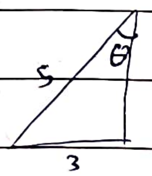
$\Rightarrow E_y$ Cancel



$E = (E_+)_x + (E_-)_x$

$\theta_1 = \theta_2$

$= 2 E_+ \sin\theta$, $\sin\theta = \dfrac{3}{5}$



$= 1.38 \times 10^{-10}$ c/m $(-\hat{i})$

dir: $\theta = 180^\circ$ with $(+x)$

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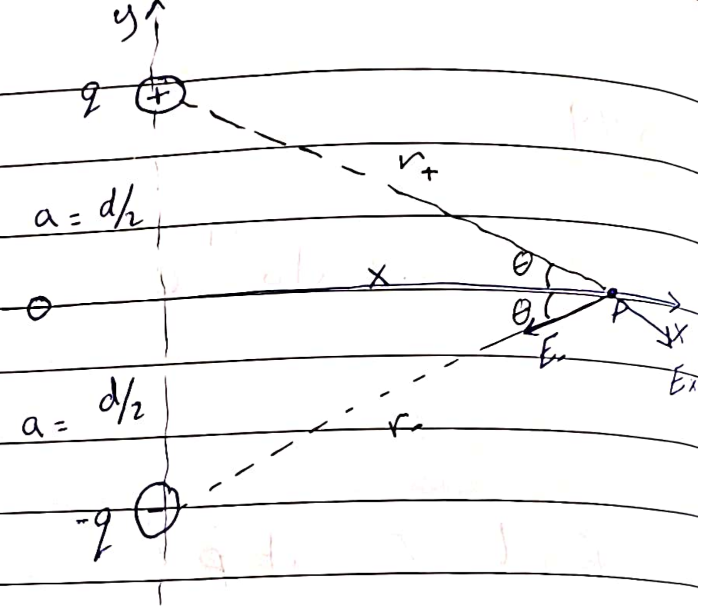

$$E_+ = \frac{k\,q}{r_+^2} = \frac{k\,q}{(x^2+a^2)}$$

$$E_- = \frac{k\,q}{r_-^2} = \frac{k\,q}{(x^2+a^2)}$$

$$\vec{E} = \vec{E}_+ + \vec{E}_- \longrightarrow E_x = E_+\cos\theta - E_-\cos\theta = 0$$

$$E_y = -E_+\sin\theta - E_-\sin\theta$$
$$= -2\,E_+\sin\theta$$

direction

$$E = 2\left(\frac{k\,q}{a^2+x^2}\right)\left(\frac{a}{\sqrt{a^2+x^2}}\right)(-\hat{j}) \qquad a = d/2$$

$$= \frac{k\,(2aq)}{(x^2+a^2)^{3/2}}$$

$$= \frac{k\,P}{(x^2+a^2)^{3/2}}\,(-\hat{j})$$

for $x \gg d \Rightarrow \vec{E} = \frac{P}{4\pi\varepsilon_0 x^3}(-\hat{j})$

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