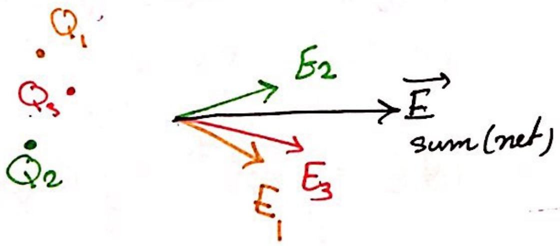
Chapter 22 : Electric field

E is a vector → pay attention to directions

first : E due to a point charge :

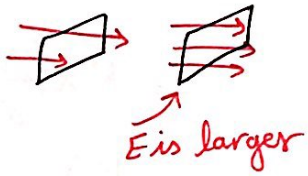
$$E = \frac{\vec{F}}{q_0} = \frac{Kq}{r^2}\hat{r} \qquad [E] = N/C$$

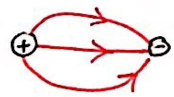
$$E_{net} = \vec{E_1} + \vec{E_2} + \vec{E_3} \text{ ----.}$$



Electric field lines :-

- Direction of lines = Direction of $\vec{E}$
- N° of lines propotional to $|\vec{E}|$
- They go from + charges to − charges



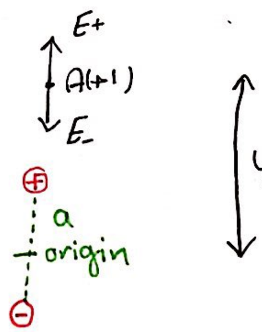


Electric dipole :-

2 charges equal in magnitude and opposite in charges with distance d in between

⊕← d →⊖

second: E due to an electric dipole



$$\text{At A:- } \vec{E} = \vec{E_+} + \vec{E_-}$$

$$\vec{E_+} = \frac{q}{4\pi\epsilon_0 r_+^2} = \frac{q}{4\pi\epsilon_0 (y-a)^2}\hat{j}$$

$$\vec{E_-} = \frac{q}{4\pi\epsilon_0 r_-^2} = \frac{q}{4\pi\epsilon_0 (y+a)^2} - \hat{j}$$

$$E = \frac{q}{4\pi\epsilon_0}\left[\frac{1}{(y-a)^2} - \frac{1}{(y+a)^2}\right] = \frac{q}{4\pi\epsilon_0}\left[\frac{(4ay)}{(y^2-a^2)^2}\right]\hat{j}$$

$$E = \frac{\boxed{2qa}\, 2y}{4\pi\epsilon_0 (y^2-a^2)^2} = \frac{2Py}{4\pi\epsilon_0 (y^2-a^2)^2} \qquad (2qa = P)$$

• Note : r is the distance between charge and point

• Note : P is the moment dipole

$P = dq$

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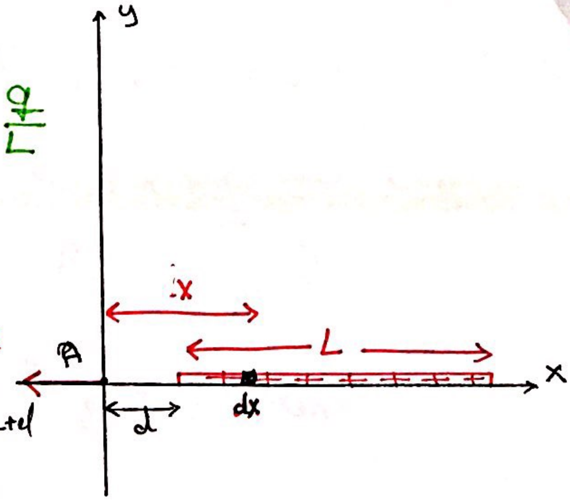
Third: $\vec{E}$ due to line of charge

A Rod :- length L

- linear charge density $\lambda = \frac{q}{L}$
- $dq = \lambda\, dx$



• since it's a line of charges we can't use $E = \frac{Kq}{r^2}$

$$E = \int dE = \int_d^{L+d} \frac{K\,dq}{x^2} = \int_d^{L+d} \frac{K\lambda\,dx}{x^2} = K\lambda\left(\frac{-1}{x}\right)\Bigg]_d^{L+d}$$

$$= K\lambda\left(\frac{1}{d} - \frac{1}{L+d}\right)$$

$$= \frac{K\lambda L}{d(L+d)}$$

$$= \frac{Kq}{d(L+d)}$$

• The Technique we use is the same for The Ring, The disk and the arc which is :-

1- you find a formula for The Charge density

linear charge density $= \lambda = \frac{q}{\text{length}}$

surface charge density $= \sigma = \frac{q}{\text{area}}$

volume charge density $= \rho = \frac{q}{\text{volume}}$

2- you find a direction of $\vec{E}$ at a point

3- you use integration Because it's not a Point charges

4- You hope That your answer is right :)

The Rod is an exampl

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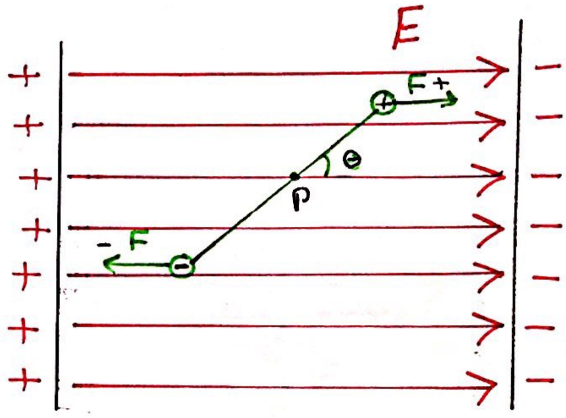
A uniform Electric field

- E is equal in magnitude and direction at every point
- $F = q\vec{E}$ — $q > 0$: E same direction F; $q < 0$: E opposite direction F
- $ma = q\vec{E}$

$$\vec{a} = \frac{q\vec{E}}{m}$$

$\vec{a}$ → constant



dipole in uniform $\vec{E}$

- $\vec{P}$ will Rotate around Origin

$$\tau_{net} = \vec{P} \times \vec{E}$$

- There will be a Potential Energy

$$W_{conservative} = -\Delta U \quad \text{Joul}$$

$$U = -\vec{P} \cdot \vec{E} \quad \text{Joul}$$

- معنى ان هذا هو الشغل الذي يحدث بدون تأثير قوة خارجية

$$W_{external\ agent} = +\Delta U$$

- الشغل الذي يحدث بتأثير قوة خارجية

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