Electrostatics

* Constant electric field which is not changing with time.

(i) $\vec{E} = r \cos\theta \, \hat{r}$ ✓

(ii) $\vec{E} = r \cos\omega t \, \hat{r}$

(iii) $\vec{E} = r t \, \hat{r}$

(iv) $\vec{E} = c t \, \hat{r}$

(v) $\vec{E} = c \, \hat{r}$ ✓

(vi) $\vec{E} \quad c \, \hat{\theta}$ ✓

Here (i), (v) & (vi) are constant electric field.

* If ~~space~~ electric field is not changing with space – uniform.
  Changing with space – Non uniform.
  $(x, y, z, r, \theta, \phi)$

(i), (ii), (iii) $\rightarrow$ Non-uniform
(iv), (v), (vi) $\rightarrow$ Uniform

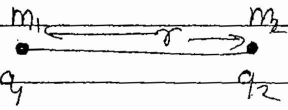
* If a func^n is constant with space & time (x, y, z, t) then it will be uniform & constant.

Coulomb Force :-

4 fundamental forces
EM (∞), gravitational (∞), strong, weak

$\rightarrow$ Coulomb force comes under Electromag force.
Its range is ∞.

Note :- magnitude of gravitational force is very smaller than magnitude of EM force. That's why effect of gravitational force can be seen on massive bodies.



$$F_G \propto \frac{M_1 M_2}{r^2} \quad \& \quad F_c = \frac{q_1 q_2}{r^2}$$

Force → Vector quantity

$F_G = G\frac{m_1 m_2}{r^2}$ This is primarily attractive

$F_c = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$ It is attractive as well as repulsive depending on the nature of charge

If q_1, q_2 are of same sign then repulsive.
" " " opposite " " attractive.

Note:- Strong & weak forces are of short range, so these forces found in nucleus.

Energy quanta of EM force is photon. In b/w two charged bodies there will be exchange of photons. & energy quanta of gravitational force is graviton.

Ques 1- Two free charges $+4q$ & $+q$ are placed at a distance r apart. find the coulomb force b/w them. Also find magnitude, sign & location of 3rd charge q' such that

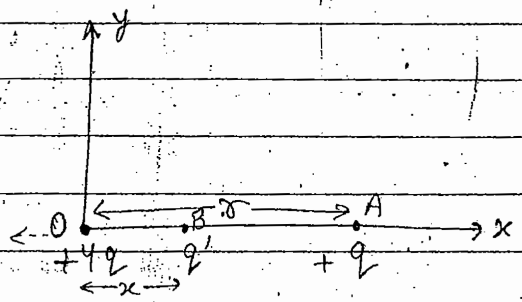
(i) No force on q'

(ii) No force on either of the charge $+4q$, $+q$ & q'.

This is called Entire system is in equilibrium.

$$\vec{F}_{4q} = \frac{1}{4\pi\epsilon_0}\frac{4q\cdot q}{r^2}\hat{r}$$

$$= \frac{1}{4\pi\epsilon_0}\frac{4q^2}{r^2}(-\hat{x})$$



$$\vec{F}_q = \frac{1}{4\pi\epsilon_0}\frac{4q^2}{r^2}(+\hat{x})$$

(i) Suppose $q' = +ve$

$$\vec{F}_{q'} = \frac{1}{4\pi\epsilon_0}\frac{4qq'}{x^2}(+\hat{x}) \quad \text{---(1)}$$

$$\vec{F}_{q'} = \frac{1}{4\pi\epsilon_0} \frac{qq'}{(r-x)^2} (-\hat{x}) \quad \text{———} (2)$$

There will be no force on q' if magnitude of the forces ((1) & (2)) are same bcz dir^n are already opposite.

Note :- If there are more than 1 force on a point then total force at this point will be vector sum of these forces. $\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \cdots \vec{F}_n$

(1) + (2)

$$\Rightarrow \quad \vec{F}_{q'} + \vec{F}_{q'} = 0$$

$$\frac{1}{4\pi\epsilon_0} \frac{4qq'}{x^2} \hat{x} = \frac{1}{4\pi\epsilon_0} \frac{qq'}{(r-x)^2} (-\hat{x})$$

$$\Rightarrow \quad 4(r-x)^2 = x^2$$

$$4r^2 + 4x^2 - 8rx = x^2$$

$$3x^2 - 8rx + 4r^2 = 0$$

$$\Rightarrow \quad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{8r \pm \sqrt{64r^2 - 48r^2}}{6} = \frac{8r \pm 4r}{6}$$

$$= 2r \text{ or } \frac{2r}{3}$$

$x = 2r$ is not acceptable.

So $x = \frac{2r}{3}$ distance of q' from $+4q$.

i.e. if $x = \frac{2r}{3}$ then there will be no force on q'

Now if q' is $-$ve

then force b/w $4q$ & q' and also b/w q' & q is attractive.

$$\vec{F}_{q'} = \frac{1}{4\pi\epsilon_0} \frac{4qq'}{x^2} (-\hat{x})$$

$$\vec{F}_{q'} = \frac{1}{4\pi\epsilon_0} \frac{qq'}{(r-x)^2} (\hat{x})$$