Q1- Three charges q_1= +10*10^{-6} C, q_2 = -5*10^{-6} C and q_3 = +20*10^{-6} C are placed in a straight line as bellow.

• 2cm • 3cm •

q_1 q_2 q_3

a) Find the magnitude and direction of the force on q_2

b) Find the magnitude and direction of the field at the position of q_2 due to q_1 and q_3.

Force on q_2 due to charge q_1 is given by

$$\vec{F}_1 = \frac{q_1 q_2}{4\pi\epsilon_0 {r_1}^2}\hat{\imath} = 9*10^9\ \frac{10*10^{-6}*(-\ 5*10^{-6})}{0.02^2}\ \hat{\imath}\ =\ -1125\,\hat{\imath}\ N$$

Force on q_2 due to charge q_3 is given by

$$F_3 = -\ \frac{q_3 q_2}{4\pi\epsilon_0 {r_2}^2} = 9*10^9\ \frac{20*10^{-6}*(-\ 5*10^{-6})}{0.03^2}(-\hat{\imath})\ =\ 1000\,\hat{\imath}\,N$$

($-\hat{\imath}$ because q_2 is on left side of q_3)

Thus net force in q_2 is given by

F = F_1 +F_2 = -1125 + 1000 = - 125 N

Hence the magnitude of the force on q_2 will be 125 N and it is towards left.

b) The electric field at the location E is given by

E = F/q_2

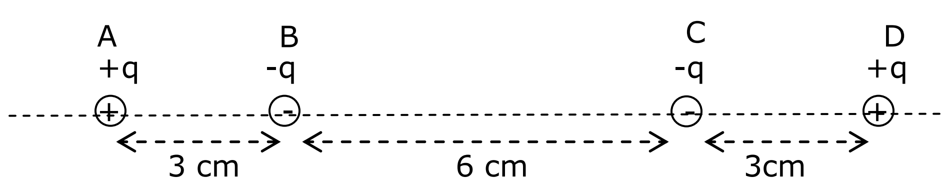
Or $E = \frac{-\ 125}{-5*10^{-6}} = 2.5*10^7\ N/C$ (to the right)

Q2- Two dipoles with charge 1*10^{-12} C and length 3 cm are placed on a straight line in such a way that their negative charges facing each other. The distance between the negative charges is 6 cm. Find the net force(magnitude and direction) exerted by one diapole on the other.

Coulombs law gives the force between two point charges and the magnitude of the force is given by

$$\vec{F} = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}\ \hat{r}$$

Where q_1 and q_2 are the charges, r is the distance between them and ϵ_0 is the permittivity of free space. $\hat{r}$ is the unit vector in the direction of line joining the charges.



Now we will consider the net force on the dipole on the right due to dipole on the left.
Force on the positive charge of the dipole on the right

1. Due to positive charge of the left dipole on left

$$\vec{F}_1 = \frac{q*q}{4\pi\epsilon_0 r_{AD}{}^2}\,\hat{r} = \frac{1}{4\pi\epsilon_0}\,\frac{q^2}{r_{AD}{}^2}\,\hat{\imath}$$

Or $\vec{F}_1 = 9*10^9*\frac{(1*10^{-12})^2}{(0.12)^2}\,\hat{\imath} = 6.25*10^{-13}\,\hat{\imath}\,N$

2. Due to negative charge of the left dipole on left

$$\vec{F}_2 = \frac{(-q)*q}{4\pi\epsilon_0 r_{BD}{}^2}\,\hat{r} = -\frac{1}{4\pi\epsilon_0}\,\frac{q^2}{r_{BD}{}^2}\,\hat{\imath}$$

Or $\vec{F}_2 = -9*10^9*\frac{(1*10^{-12})^2}{(0.09)^2}\,\hat{\imath} = -1.11*10^{-12}\,\hat{\imath}\,N$

[Negative means attractive force]

Force on the negative charge of the dipole on the right

3. Due to positive charge of the left dipole

$$\vec{F}_3 = \frac{q(-q)}{4\pi\epsilon_0 r_{AC}{}^2}\,\hat{\imath} = -\frac{1}{4\pi\epsilon_0}\,\frac{q^2}{r_{AC}{}^2}\,\hat{\imath}$$

Or $\vec{F}_3 = -9*10^9*\frac{(1*10^{-12})^2}{(0.09)^2}\,\hat{\imath} = -1.11*10^{-12}\hat{\imath}\;N$

[Negative means attractive force]

Force on the negative charge of the dipole on the right

4. Due to negative charge of the left dipole A

$$\vec{F}_4 = \frac{(-q)(-q)}{4\pi\epsilon_0 r_{BC}{}^2}\,\hat{\imath} = \frac{1}{4\pi\epsilon_0}\,\frac{q^2}{r_{BC}{}^2}\,\hat{\imath}$$

Or $\vec{F}_4 = 9*10^9*\frac{(1*10^{-12})^2}{(0.06)^2}\,\hat{\imath} = 2.50*10^{-12}\,\hat{\imath}\;N$

Hence the net force on the dipole on the right is given by

$$\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \vec{F}_4$$

Or $\vec{F} = 6.25*10^{-13}\,\hat{\imath} - 1.11*10^{-12}\,\hat{\imath} - 1.11*10^{-12}\,\hat{\imath} + 2.50*10^{-12}\,\hat{\imath}$

Or $\vec{F} = 9.05*10^{-13}\,\hat{\imath}$

The positive sigh shows that the force on the right dipole is to the right.
(The dipole on the left will experience a reactionary force equal in magnitude but to the left direction.)

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