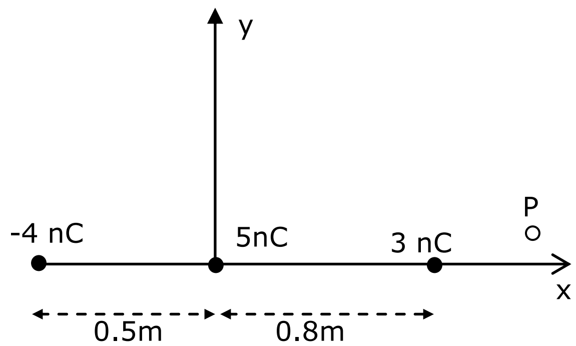
Q- Three point charges are aligned along the *x* axis as shown in Figure. Find the electric field at
(a) The position (2.00, 0)
(b) The position (0, 2.00).



The electric field due to a point charge at a point distance r is given by

$$\vec{E} = \frac{q}{4\pi \in_0 r^2}\hat{r}$$

Here $\hat{r}$ is the unit vector in the direction of the line joining the charge to the point.

The field strength at a point due to number of point charges is given by the superposition law means is resultant of the field strengths due to individual charges.

The distances of point P (2.00, 0) from the three charges are 2.00 + 0.5 m, 2.00 m and 2.00 - 0.800 m respectively hence the fields are

$$\vec{E}_1 = \frac{9*10^9(-4.00*10^{-9})}{(2.500)^2}\hat{i} = -5.76\hat{i} \text{ N/C}$$

Where $\hat{i}$ is the unit vector in the positive x direction. The negative sign shows that the field is attractive. Similarly

$$\vec{E}_2 = \frac{9*10^9(5.00*10^{-9})}{(2.00)^2}\hat{i} = 11.25\hat{i} \text{ N/C}$$

And $$\vec{E}_3 = \frac{9*10^9(3.00*10^{-9})}{(1.200)^2}\hat{i} = 18.75\hat{i} \text{ N/C}$$

Hence the resultant field will be

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 = (-5.76 + 11.25 + 18.75)\hat{i} = 24.24\hat{i} \text{ N/C}$$

Hence the field at (2.00, 0) is **24.24 N/C** and in positive x direction.

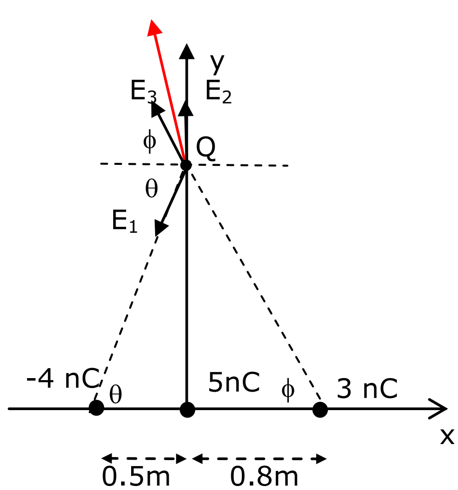
(b) the position (0, 2.00).

The distance r of point Q from the charge -4.0 nC is given by formula of right angled triangle as

$$r = \sqrt{0.500^2 + 2.00^2}$$

Hence the magnitude of the electric field at point Q on y axis due to -4.00 nC charge will be

$$E_1 = \frac{9*10^9(-4.00*10^{-9})}{(0.500^2 + 2.00^2)} = -8.47 \text{ N/C and is attractive.}$$



In component form the field can be written as

$$\vec{E}_1 = -8.47 * \cos\theta \hat{i} - 8.47 * \sin\theta \hat{j}$$

Or using the right angled triangle properties we have

$$\vec{E}_1 = -8.47 * \frac{0.500}{\sqrt{0.500^2 + 2.00^2}} \hat{i} - 8.47 * \frac{2.00}{\sqrt{0.500^2 + 2.00^2}} \hat{j}$$

Or $\vec{E}_1 = -2.054\hat{i} - 8..215\hat{j}$

Field due to charge 5.00 nC will be given by

$$E_1 = \frac{9*10^9 (5.00*10^{-9})}{2.00^2} = 11.25 \text{ N/C}$$

As this is repulsive and along positive y direction can be written as

$$\vec{E}_2 = 11.25\hat{j}$$

The distance r of point Q from the charge 3.00 nC is given by formula of right angled triangle as

$$r = \sqrt{0.800^2 + 2.00^2}$$

Hence the magnitude of the electric field at point Q on y axis due to 3.00 nC charge will be

$E_3 = \frac{9*10^9 * 3.00*10^{-9}}{(0.800^2 + 2.00^2)} = 5.819$ N/C and is repulsive.

In component form the field can be written as

$$\vec{E}_3 = -5.819 * \cos\phi \hat{i} + 5.819 * \sin\phi \hat{j}$$

Or using the right angled triangle properties we have

$$\vec{E}_3 = -5.819 * \frac{0.800}{\sqrt{0.800^2 + 2.00^2}} \hat{i} + 5.819 * \frac{2.00}{\sqrt{0.800^2 + 2.00^2}} \hat{j}$$

Or $\vec{E}_3 = -2.161\hat{i} + 5.403\hat{j}$

Hence the resultant field at Q is give by

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 = (-2.054 + 0 - 2.161)\hat{i} + (-8.215 + 11.25 + 5.403)\hat{j}$$

Or $\vec{E} = (-4.215)\hat{i} + (8.438)\hat{j}$

Hence magnitude of the resultant field will be

$$E = \sqrt{\left(-4.215\right)^2 + \left(8.438\right)^2} = 9.432 \text{ N/C}$$

And the direction will be given by

$$\tan\theta = \frac{8.438}{-4.215} = -2$$

Or $\theta = \tan^{-1}(-2) = 180 - 63.46 = 116.54^0$ with positive x direction