Answer on Question#70010 – Physics– Electric Circuits

$ABCD$ is a square of size 0.02m. Charges of 16×10^{-9}C and -16×10^{-9}C are 32×10^{-9}C are placed at points A, B and C, respectively. Determine the magnitude and direction of electric field at the at the point D.

Solution.

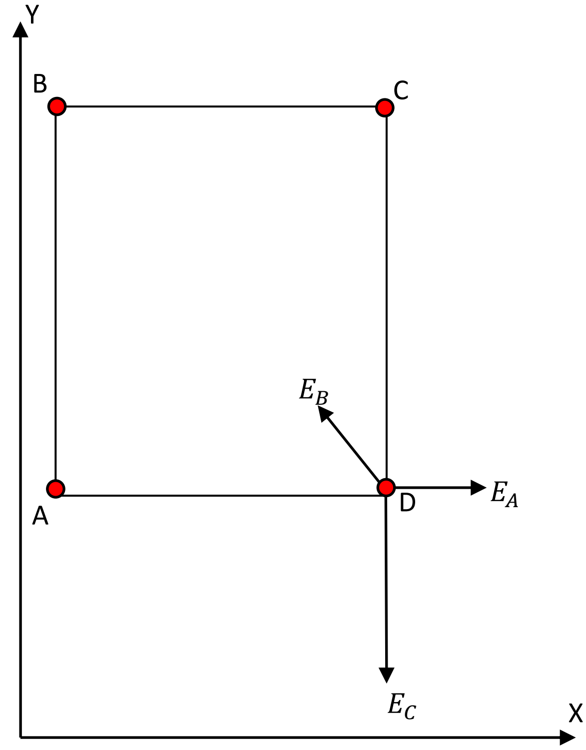
According to the condition of problem charges in points A, B, C are respectively equal to

$q_A = 16 \times 10^{-9} C$

$q_B = -16 \times 10^{-9} C$

$q_C = 32 \times 10^{-9} C$

$AB = BC = CD = DA = 0.02m$



Electric field is defined as the electric force per unit charge. The direction of the field is taken to be the direction of the force it would exert on a positive test charge. The electric field of a point charge can be obtained from Coulomb's law:

$$E = \frac{kQ}{r^2}, \text{ (for magnitude)}$$

where $k = 9 \cdot 10^9 \frac{N \cdot m^2}{C^2}$, Q – charge, r – the distance from the charge to the point at which the field is determined.

The electric field from multiple point charges can be obtained by taking the vector sum of the electric fields of the individual charges.

$$\vec{E} = \overrightarrow{E_A} + \overrightarrow{E_B} + \overrightarrow{E_C}$$

Consider the electric field in the coordinate system as shown in the figure.

$E_A = \frac{kq_A}{AD^2} = \frac{9 \cdot 10^9 \cdot 16 \cdot 10^{-9}}{0.02^2} = 360000 \frac{V}{m}$ (directed in the positive direction of the x axis).

$E_C = \frac{kq_C}{DC^2} = \frac{9 \cdot 10^9 \cdot 32 \cdot 10^{-9}}{0.02^2} = 720000 \frac{V}{m}$ (directed in the negative direction of the y axis)

$E_B = \frac{kq_B}{BD^2}$

We find the BD using the Pythagorean theorem

$BD^2 = AB^2 + AD^2 \rightarrow BD = \sqrt{AB^2 + AD^2} = 0.02\sqrt{2}$

$E_B = \frac{kq_B}{BD^2} = \frac{9 \cdot 10^9 \cdot 16 \cdot 10^{-9}}{2 \cdot 0.02^2} = 180000 \frac{V}{m}$

Let us find the components of the electric field E_B.

$E_{Bx} = E_B \cos 45^0 \approx 127279 \frac{V}{m}$ (directed in the negative direction of the x axis).
$E_{By} = E_B \sin 45^0 \approx 127279 \frac{V}{m}$ (directed in the positive direction of the y axis).
As a result, the electric field E has components
$E_x = 360000 - 127279 = 232721 \frac{V}{m}$ (directed in the positive direction of the x axis)
$E_y = 720000 - 127279 = 592721 \frac{V}{m}$ (directed in the negative direction of the y axis)
Hence the magnitude and direction of electric field at the at the point D:
$E = \sqrt{E_x^2 + E_y^2} = \sqrt{232721^2 + 592721^2} \approx 636771 \frac{V}{m}$.
$\tan \alpha = \frac{E_y}{E_x} = \frac{592721}{232721} \approx 2.55 \rightarrow \alpha \approx 68.6^0$ the angle in the direction of the clockwise direction between the $\overrightarrow{AD}$ vector and the electric field vector $\vec{E}$.
Answer. $E = 636771 \frac{V}{m}$ angled $\alpha \approx 68.6^0$ in the direction of the clockwise direction from the $\overrightarrow{AD}$.