PROBLEMS RELATED TO COLOUMB'S LAW

Example Problem 1:

The force between two identical charges separated by 1 cm is equal to 90 N. What is the magnitude of the two charges?

DATA:

F = 90 N
q_1 = charge of first body
q_2 = charge of second body
r = 1 cm=$\frac{1}{100} m = 0.01m$

$K = 9x10^9\ N\ m^2/C^2$

Use the Coulomb's Law equation

Solution:

$$F = k\frac{q_1 q_2}{r^2}$$

The problem says the two charges are identical, so

$q_1 = q_2 = q$

Substitute this into the equation

$$F = k\frac{qq}{r^2}$$

$$F = k\frac{q^2}{r^2}$$

$$\frac{Fr^2}{k} = q^2$$

Taking square root on both sides

$$\sqrt{\frac{Fr^2}{k}} = q$$

$$q = \sqrt{\frac{90x(.01)^2}{9x10^9}}$$

$$q = \sqrt{\frac{90x\ 0.0001}{9x10^9}}$$

$$q = \sqrt{\frac{0.009}{9x10^9}}$$

$$q = \sqrt{0.001x10^{-9}}$$

$$q = \sqrt{0.001x10^{-9}}$$

$$q = \pm 0.0316x10^{-3}$$

$$q = \pm 31.6x10^{-6}\text{C}$$

$$q = \pm 31.6\ \mu\text{C}$$

Since the charges are identical, they are either both positive and both negative. This force will be repulsive.

Example Problem 2:

Two point charges, q_1 = +8 μC and q_2 = -5 μC, are separated by a distance r = 10 cm. What is the magnitude of the electric force? The constant $9x10^9\ N\ m^2/C^2$.

DATA:

F = 90 N
q_1 = +8 μC$= 8x10^{-6}C$
q_2 = -5 μC$= -5x10^{-6}C$
r = 10 cm$=\frac{10}{100}m = 0.1m$

$$K = 9x10^9\ N\ m^2/C^2$$

Solution:

Use the Coulomb's Law equation

$$F = k\frac{q_1 q_2}{r^2}$$

$$F = 9x10^9\frac{(8x10^{-6})(5x10^{-6})}{(0.1)^2}$$

$$F = 9x10^9 \frac{40x10^{-12}}{0.01}$$

$$F = 9x10^9 \frac{40x10^{-12}}{0.01}$$

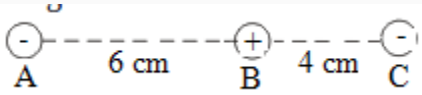
$$F = 36{,}000x10^{-12+9}$$

$$F = 36{,}000x10^{-3}$$

$$F = 360\ N$$

Example Problem 3:

Three charged particles are arranged in a line as shown in figure below. Charge A = $-5\mu C$, charge B = $+10\mu C$ and charge C = -12 μC. Calculate the net electrostatic force on particle B due to the other two charges.



DATA:

Charge A (q_A) = -5 μC = $-5x10^{-6}C$
Charge B (q_B) = +10 μC = $+10x10^{-6}C$ C
Charge C (q_C) = -12 μC = $-12x10^{-6}C$
$K = 9x10^9\ N\ m^2/C^2$

The distance between particle A and B (r_{BA}) = 6 cm = 0.06 m = 6 x 10^{-2} m
The distance between particle B and C (r_{BC}) = 4 cm = 0.04 m = 4 x 10^{-2} m

To Find:
The magnitude and the direction of net electrostatic force on particle =?
Solution:
The net force on particle B is the vector sum of the force FBA exerted on particle B by particle A and the force FBC exerted on particle B by particle C.
The force FBA exerted on particle B by particle A:

$$F_{AB} = k\frac{q_A q_B}{r_{AB}^2}$$

$$F_{AB} = 9x10^9 \frac{(5x10^{-6})(10x10^{-6})}{(6x10^{-2})^2} = \frac{(9x10^9)(50x10^{-12})}{36x10^{-4}}$$

$$F_{AB} = \frac{450x10^{-3}}{36x10^{-4}} = (12.5)(10^{-3})(10^4) = 12.5x10^1$$

$$F_{AB} = 125 \quad \text{Newton}$$

The direction of the electrostatic force points to particle A (point to left).

The force F_{BC} exerted on particle B by particle A :

$$F_{BC}=k\frac{q_B q_C}{r_{BC}^2}$$

$$F_{AB}=9x10^9\frac{(10x10^{-6})(12x10^{-6})}{(4x10^{-2})^2}=\frac{(9x10^9)(120x10^{-12})}{16x10^{-4}}$$

$$F_{AB}=\frac{1080x10^{-3}}{16x10^{-4}}=(67.5)(10^{-3})(10^4)=67.5x10^1$$

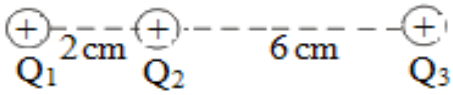
$$F_{AB}=675\,N$$

The direction of the electrostatic force points to particle C (point to right).

The net electrostatic force on particle B :
F_B = F_{AB} – F_{BC} = 675 N – 125 N = 550 Newton.
The direction of the net electrostatic force on particle B points to particle C (points to the right).

Example Problem 4:

$+q_1$ = 10 μC, $+q_2$ = 50 μC and Q_3 are separated as shown in the figure below. What is the electrostatic charge on particle 3 if the net electrostatic force on particle 2 is zero.



Known :
Charge 1 (q_1) = +10 μC = +10 x 10-6 C
Charge 2 (q_2) = +50 μC = +50 x 10-6 C
The distance between charge 1 and 2 (r_{12}) = 2 cm = 0.02 m = 2 x 10-2 m
The distance between charge 2 and charge 3 (r_{23}) = 6 cm = 0.06 m = 6 x 10-2 m
The net electrostatic force on particle 2 (F_2) = 0
Wanted : charge 3 (q_3)
Solution :
The net force on particle 2 is the vector sum of the force F_{21} exerted on particle 2 by particle 1 and the force F_{23} exerted on particle 2 by particle 3.
The force F_{21} exerted on particle 2 by particle 1 :

$$F_{21}=k\frac{q_1q_2}{r_{12}^{\ 2}}$$

$$F_{21}=k\frac{(10x10^{-6})(50x10^{-6})}{(2x10^{-2})^2}=\frac{k(500x10^{-12})}{4x10^{-4}}=k(125)(10^{-12})(10^{4})$$

$$F_{21}=k(125x10^{-8})$$

The direction of the electrostatic force points to particle 3 (point to right).

The force F_{23} exerted on particle 2 by particle 3

$$F_{23}=k\frac{q_2q_3}{r_{23}^{\ 2}}$$

$$F_{23}=k\frac{(50x10^{-6})(q_3)}{(6x10^{-2})^2}=\frac{k(50x10^{-6})(q_3)}{36x10^{-4}}$$

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The direction of the electrostatic force points to particle 1 (point to left).

The net electrostatic force on particle 2 = 0 :

$$F_{23}-F_{12}=0$$

$$F_{23}=F_{12}$$

$$\frac{k(50x10^{-6})(q_3)}{36x10^{-4}}=k(125x10^{-8})$$

$$\frac{k(50x10^{-2})(q_3)}{36}=k(125x10^{-8})$$

$$k(50x10^{-2})(q_3)=k(4500x10^{-8})$$

$$(50)(q_3)=4500x10^{-6}$$

$$q_3=90x10^{-6}$$

Example Problem 5:

Two balloons are charged with an identical quantity and type of charge: -0.0025 C. They are held apart at a separation distance of 8 m. Determine the magnitude of the electrical force of repulsion between them.

$$F = k\frac{q_1q_2}{r^2}$$

$$= (9\times10^9)\frac{(0.0025)(0.0025)}{(8)^2}$$

$$= 879\text{N}$$