9th foundation

colocumb's inverse square law

Task

(1)

Given $F = 10N$. let distance $r_1 = r$

Given $r_2 = \frac{r}{2}$

From colocumb's inverse square law

$$F \propto \frac{1}{r^2}$$

$$\Rightarrow \frac{F'}{F} = \left(\frac{r_2}{r_1}\right)^2 \Rightarrow \frac{F}{F'} = \left[\frac{\frac{r}{2}}{r}\right]^2 = \frac{1}{4}$$

$$\Rightarrow \frac{10}{F'} = \frac{1}{4} \Rightarrow F' = 40N \rightarrow D$$

(2)

Given $F = 20N$; $r' = 3r$.

New force $F' = ?$

From colocumb's inverse square law

$$F \propto \frac{1}{r^2}$$

$$\cancel{\Rightarrow \frac{F'}{F} = \left[\frac{r}{r'}\right]^2} \Rightarrow \frac{F'}{20} = \left[\frac{r}{3r}\right]^2 = \frac{1}{9}$$

$$\Rightarrow F' = \frac{20}{9} = 2.22N. \rightarrow D$$

3.

let q_1, q_2 are original charges.

Then New charges are $q_1' = 3q_1$; $q_2' = 3q_2$

From coloumb's inverse square law

$F \propto q_1 q_2$, let $F_1 = F$

$$\Rightarrow \frac{F_1}{F_2} = \frac{q_1 q_2}{q_1' q_2'}$$

$$\Rightarrow \frac{F}{F_2} = \frac{\cancel{q_1}\cancel{q_2}}{3\cancel{q_1}\, 3\cancel{q_2}} = \frac{1}{9}$$

$$\Rightarrow F_2 = 9F \rightarrow A$$

4.

let $q_1 = 10\mu C$: $F = 2N$: $d = 0.2m$

From coloumb's inverse square law

$$F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{d^2}$$

$$\Rightarrow 2 = 9\times10^9 \times \frac{10 \times q_2}{(0.2)^2}$$

$$\Rightarrow 2 = 9\times10^9 \times \frac{10 \times q_2 \times 10^{-6}}{4\times10^{-2}}$$

$$\Rightarrow q_2 = \frac{8}{9} \times 10^{-6} = 0.88\,\mu C \rightarrow B$$

5.

let $q_1 = 5\mu c$; $q_2 = 5\mu c$; $d = 0.3m$.

According to colomb's inverse square law

$$F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{d^2}$$

$$\Rightarrow F = 9\times10^9 \times \frac{5\times10^{-6}\times5\times10^{-6}}{(0.3)^2} = \frac{9\times10^9\times10^{-12}\times25}{9\times10^{-2}}$$

$$\Rightarrow F = 2.5\ N.$$

If one of the ~~force~~ charge is doubled then force also doubled Then $F' = 2F = 2\times2.5$

$F' = 5N. \rightarrow A.$

6.

Given if $r_1 = 2m \rightarrow F_1 = 18N$

$r_2 = 1m \rightarrow F_2 = ?$

According to coloumb's inverse square law

$$F \propto \frac{1}{r^2} \Rightarrow \frac{F_2}{F_1} = \left(\frac{r_1}{r_2}\right)^2$$

$$\Rightarrow \frac{F_2}{18} = \left(\frac{2}{1}\right)^2 \Rightarrow \frac{F_2}{18} = 4$$

$$\Rightarrow F_2 = 72\ N.$$

7.

Given $\epsilon_w = 80$

we know Dielectric constant $\epsilon = \frac{\epsilon_w}{\epsilon_0}$

$$\epsilon_w = \epsilon\,\epsilon_0 = 80\,\epsilon_0.$$

From colomb's inverse square law $F = \frac{1}{4\pi\epsilon_w} \frac{q_1 q_2}{r^2}$

$$F = \frac{1}{\varepsilon_\omega 4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$$ $q_1 = 1\mu c;\ q_2 = 1\mu c$

$r = 1m.$

$$\Rightarrow F = \frac{9\times10^9}{\varepsilon_\omega} \frac{10^{-12}}{1^2}.$$

$$= \frac{9\times10^9}{80} \times 10^{-12} \Rightarrow \frac{9}{80}\times10^{-3}$$

$$F = 1.25\times10^{-4}\ N$$

ie) $F \propto \frac{1}{\varepsilon_\omega}$ As medium changes from air to water the force between the two charges do becomes 80 times less.

8.

Given

Force in medium $F_m = 2.5 N.$

Force in vacumn $F_{v} = 10 N.$

$\therefore$ Dielectric constant $k = \frac{F_v}{F_m} = \frac{10}{2.5} = 4.$

9

We know Force between the two charges in a medium $F_m \propto \frac{1}{k}$ ['k' is Dielectric constant]

For $k_1 = 3 : F_1 = 13.5 N.$

$k_2 = 6 : F_2 = ?$

$$\Rightarrow \frac{F_2}{F_1} = \frac{k_1}{k_2} \quad \Rightarrow F_2 = \frac{k_1}{k_2} \times F_1$$

$$= \frac{3}{6} \times 13.5$$

$$= 6.75N \rightarrow A$$

(10).

Given If $k_1 = 3$; $F_1 = 4N$.

$k_2 = 12$. ; $F_2 = ?$

we know that force between the two charges in a medium $F_m \propto \frac{1}{k}$.

$$\Rightarrow \frac{F_2}{F_1} = \frac{k_1}{k_2} \quad \Rightarrow F_2 = \frac{k_1}{k_2} \times F_1$$

$$\Rightarrow F_2 = \frac{3}{12} \times 4 = 1N \rightarrow A$$

(12)

The Electrostatic force between the charges depends on medium present between the charges so when medium changes from air to water the force between the charges decreases because $k_w > k_{air}$. and $F \propto \frac{1}{k}$

(14)

From coloumb's inverse square law

$$F = \frac{1}{k 4\pi \varepsilon_0} \frac{q_1 q_2}{r^2}$$

$\varepsilon \rightarrow$ medium permitivity.

i.e) $F \propto q_1 q_2$; $F \propto \frac{1}{k}$

$F \propto \frac{1}{r^2}$; $F \propto \frac{1}{\varepsilon_0}$ or $\frac{1}{\varepsilon}$

(16)

For air as medium $F_{air} = 12\,N$.

dielectric constant $k_{air} = 1$

if $k_2 = 6$. $F_m = ?$

we know $F \propto \frac{1}{k}$

$\Rightarrow \frac{F_m}{F_{air}} = \frac{k_{air}}{k_m} =$

$\Rightarrow \frac{F_m}{12} = \frac{1}{6} \Rightarrow F_m = \frac{12}{6} = 2\,N$

(17)

let $q_1 = 2\mu C$; $q_2 = 2\mu C$. ; $d = 0.5\,m$.

From coloumb's inverse square law

$$F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$$

$$= 9\times10^9 \times \frac{2\times10^{-6}\times2\times10^{-6}}{(0.5)^2}$$

$$\Rightarrow \frac{36\times10^{-3}}{\frac{1}{4}}$$

$$\Rightarrow 144\times10^{-3}\,N$$

$$= 0.144\,N.$$

LTask

Jee Main's level

(1)

Given $q_1 = 4\mu C$; $q_2 = 6\mu C$, $d = 0.2\,m$

From coloumb's inverse square law

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{d^2}$$

$$\Rightarrow F = 9\times10^9 \frac{4\times10^{-6}\times6\times10^{-6}}{(0.2)^2}$$

$$\Rightarrow F = 9\times10^9 \times \frac{24}{\frac{1}{25}} \times 10^{-12}$$

$$= 25\times9\times24\times10^{-3}$$

$$= 5.4\,N \simeq 5.39\,N \rightarrow A$$

(2)

Given $F_1 = 2.5\,N$; $r_1 = 0.3\,m$

$F_2 = ?$ $r_2 = 0.6\,m$

From coloumb's inverse square law

$$F \propto \frac{1}{r^2}$$

$$\Rightarrow \frac{F_1}{F_2} = \left[\frac{r_2}{r_1}\right]^2$$

$$\Rightarrow \frac{2.5}{F_2} = \left[\frac{0.6}{0.3}\right]^2$$

$$\Rightarrow F_2 = \frac{2.5}{4} = 0.625\,N$$

(3)

let $q_1 = 3\mu c$; $q_2 = 3\mu c$; $d = 0.1\,m$

From coloumb's inverse square law

$$F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$$

$$\Rightarrow F = 9\times10^9 \times \frac{3\times10^{-6}\times3\times10^{-6}}{(0.1)^2}$$

$$= 9\times10^9 \times \frac{9\times10^{-12}}{10^{-2}}$$

$$= 8.1\,N \rightarrow A$$

(4)

Given $q_1 = 2\mu c$; $q_2 = -3\mu c$ $d = 15\times10^{-2}\,m$

From coloumb's inverse square law

$$F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{d^2}$$

$$F = 9\times10^9 \times \frac{2\times10^{-6}\times3\times10^{-6}}{(15\times10^{-2})^2}$$

$$\Rightarrow F = \cancel{\frac{54}{225} \times \frac{10^{-3}}{10^{-4}}} = \frac{540}{225} = 2.4\,N \rightarrow A$$

Here the two charges are unlike so the nature of force is attractive.

(5)

Given $F_1 = 6N$ For $r_1 = 30\,cm$

$F_2 = ?$ For $r_2 = 10\,cm$

From coloumb's inverse square law

$$F \propto \frac{1}{r^2}$$

$$\Rightarrow \frac{F_2}{F_1} = \left(\frac{r_1}{r_2}\right)^2$$

$$\Rightarrow \frac{F_2}{6} = \left[\frac{30}{10}\right]^2 = 9$$

$$\Rightarrow F_2 = 54N \rightarrow A$$

(6)

Given $q_1 = 8\mu c = 8\times10^{-6}c$; $d = 0.2m$

$q_2 = 5\mu c = 5\times10^{-6}c.$

$$F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$$

$$\Rightarrow F = 9\times10^9 \times \frac{8\times10^{-6}\times5\times10^{-6}}{(0.2)^2} = \frac{9\times40\times10^{-3}}{4\times10^{-2}}$$

$$F = 9N \rightarrow B$$

(7)

Given $q_1 = 1\mu c = 10^{-6}c$; $q_2 = 5\mu c = 5\times10^{-6}c.$

$F = 2N.$ let $r_1 = r.$ If $r_2 = \frac{r}{2}.$ Then $F_2 = ?$

From coloumb's inverse square law $F \propto \frac{1}{r^2}$

$$\frac{F}{F'} = \left(\frac{r_2}{r_1}\right)^2 \Rightarrow \frac{2}{F'} = \left(\frac{\frac{r}{2}}{r}\right)^2 = \frac{1}{4}$$

$$\Rightarrow F' = 8N \rightarrow B.$$

(8)

If $r_1 = 0.5m \rightarrow F_1 = 12\ N$

If $r_2 = 1.5m$ (Tripled) $\rightarrow F_2 = ?$

From coloumb's inverse square law

$$F \propto \frac{1}{r^2}$$

$$\Rightarrow \frac{F_1}{F_2} = \left(\frac{r_2}{r_1}\right)^2 = \left(\frac{\cancel{1.5}\ 3}{\cancel{0.5}}\right)^2$$

$$\Rightarrow \frac{12}{F_2} = 3^2 \Rightarrow F_2 = \frac{12}{9} = \frac{4}{3} = 1.33\ N.$$

$\rightarrow C$

(9)

let $q_1 = q_2 = 6\mu c = 6 \times 10^{-6} c.$

$d = 0.1\ m.$; $k = 2$.

From coloumb's inverse square law

$$F = \frac{1}{k4\pi\varepsilon_0} \frac{q_1 q_2}{d^2}$$

$$\Rightarrow F = \frac{9 \times 10^9}{2} \frac{6 \times 10^{-6} \times 6 \times 10^{-6}}{(0.1)^2} = \frac{9 \times 18 \times 10^{-3}}{10^{-2}}$$

$$\Rightarrow F = 9 \times 1.8 = 16.2\ N \rightarrow A$$

(10)

let $q_1 = q_2 = q$; $d = 0.4\ m$; $F = 1N$

From $F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$

$$\Rightarrow 1 = 9 \times 10^9 \frac{q^2}{16 \times 10^{-2}}$$

$$\Rightarrow \frac{16}{9} \times 10^{-11} = q^2$$

$$\Rightarrow q^2 = 1.8 \times 10^{-11}$$
$$= 18 \times 10^{-12}\ c.$$

$$\Rightarrow q = 4.24\ \mu c$$

(16)

$F_v = 9\,N \qquad k_v = 1$

$F_m = 3\,N \qquad k_m = ?$

Dielectric constant $k = \frac{F_v}{F_m} = \frac{9}{3} = 3$

(17)

let $q_1 = 1\,\mu C$; $q_2 = 4\,\mu C$; $d = 30\times10^{-2}\,m$

From $F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$

$F = 9\times10^9 \times \frac{10^{-6}\times4\times10^{-6}}{(30\times10^{-2})^2}$

$= \frac{9\times10^9\times4\times10^{-12}}{9\times10^{-2}} = 0.4\,N$

(18)

let $q_1 = 5\,\mu C$; $F = 0.2\,N$; $d = 0.1\,m$
$= 5\times10^{-6}$

From $F = \frac{q_1 q_2}{r^2}\times\frac{1}{4\pi\epsilon_0}$

$\Rightarrow 0.2 = \frac{5\,q_2}{(0.1)^2}\times9\times10^9\times10^{-6}$

$\Rightarrow q_2 = \frac{0.2\times(0.1)^2}{5\times9\times10^9\times10^{-6}} = \frac{2\times10^{-3}}{45\times10^3}$

$\Rightarrow q_2 = \frac{2}{45}\times10^{-6} = 0.04\times10^{-6}$

$= 0.04\,\mu C$

(19)

Given $F_1 = 1N \rightarrow d_1 = 1m$

$F_2 = ? \rightarrow d_2 = 0.5m$

we know $F \propto \frac{1}{d^2}$

$\Rightarrow \frac{F_1}{F_2} = \left[\frac{d_2}{d_1}\right]^2$

$\Rightarrow \frac{1}{F_2} = \left[\frac{0.5}{1}\right]^2 \Rightarrow F_2 = 4N \rightarrow A$

(20)

Given $q_1 = 1\mu C = 10^{-6}C$; $q_2 = 5\mu C = 5\times10^{-6}C$

$d = 0.2m = 2\times10^{-1}m$

From $F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$

$= 9\times10^9 \times \frac{5\times10^{-6}\times10^{-6}}{(2\times10^{-1})^2}$

$= \frac{9\times5\times10^{-3}}{4\times10^{-2}} = \frac{45}{4}\times10^{-1} = 1.125N$

Thank

18. let $q_1 = 2\times10^{-6}C$: $q_2 = -3\times10^{-6}C$. : $d = 0.1m$

From = $F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{d^2}$

$= 9\times10^9 \times \frac{2\times10^{-6}\times3\times10^{-6}}{(0.1)^2} = \frac{54\times10^{-3}}{10^{-2}}$

$= 5.4N.$

(19)

Given $F_1 = 0.05N \rightarrow r_1 = 0.2\,m$

$F_2 = ? \rightarrow r_2 = 0.1\,m$

We know $F \propto \frac{1}{r^2}$

$$\Rightarrow \frac{F_1}{F_2} = \left[\frac{r_2}{r_1}\right]^2$$

$$\Rightarrow \frac{0.05}{F_2} = \left[\frac{0.1}{0.2}\right]^2 = \frac{1}{4}$$

$$\Rightarrow F_2 = 0.05 \times 4 = 0.2\,N.$$

(20)

Given $F_1 = 20N$; $r_1 = 0.5\,m$

$F_2 = ?$ $\Rightarrow r_2 = 2.5\,m$

We know $F \propto \frac{1}{r^2}$

$$\Rightarrow \frac{F_1}{F_2} = \left(\frac{r_2}{r_1}\right)^2$$

$$\Rightarrow \frac{20}{F_2} = \left(\frac{\cancel{2.5}\;5}{\cancel{0.5}}\right)^2$$

$$\Rightarrow \frac{20}{F_2} = 25 \Rightarrow F_2 = \frac{20}{25} = \text{[illegible]}$$

$$= \frac{4}{5} = 0.8\,N.$$