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Applied Physics

CSC-20S-104

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Problem 1-1

Consider a copper penny that contains both positive and negative charges, each of magnitude 1.83×10^6 C. Suppose that these charges could be concentrated into two separate bundles, held 100 m apart which attractive force would act on each bundle?

Data:- Copper penny positive charge, $q_1 = 1.83 \times 10^6$ C
Copper penny negative charge, $q_2 = -1.83 \times 10^6$ C
Separation b/w charges, $r = 100$ m

Required:- $F = ??$

Formula:- $$F = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1 q_2}{r^2}\right) = K\frac{q_1 q_2}{r^2}$$

Solution:-

Using Colomb's law formula,

Colomb's Constant $1/4\pi\varepsilon_0 = 8.99 \times 10^9 \ N\cdot m^2/C^2$

Putting values in formula,

$$F = \frac{(8.99 \times 10^9 \ N\cdot m^2/C^2)(1.83 \times 10^6 C)(-1.83 \times 10^6 C)}{(100 \ m)^2}$$

$$F = -3.01 \times 10^{18} \ N$$

Result:- The attractive force that acts on each bundle is. $\boxed{F = -3.01 \times 10^{18} \ N}$

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Problem 1-2

The average distance r between the electron and the Proton an atom is 7.4×10^{-11} m. what is the magnitude of the average electrostatic force that acts between these two Particles?

Data:- Charge on electron, $q_e = 1.60 \times 10^{-19}$ C
Charge on Proton, $q_P = 1.60 \times 10^{-19}$ C
Distance, $r = 7.4 \times 10^{-11}$ m

Required:- $F = ??$

Formula:- $F = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1 q_2}{r^2}\right) = K\frac{q_1 q_2}{r^2}$

Solution:-
Coulumb's Constant $1/4\pi\varepsilon_0 = 8.99 \times 10^9\ N.m^2/C^2$
Putting values in formula,

$$F = \frac{(8.99 \times 10^9)(1.60 \times 10^{-19} c)(1.6 \times 10^{-19} c)}{(7.4 \times 10^{-11} m)^2}$$

$$F = 4.20 \times 10^{-8}\ N$$

Result:-
The Electrostatic force acts b/w to Particles.

$$\boxed{F = 4.20 \times 10^{-8}\ N}$$

Problem 1-3

The nucleus of an atom has a radius of about 6×10^{-15} and contains 26 protons. What repulsive electrostatic force act b/w two protons in such a nucleus that are separated by a distance of one radius?

Data:- Separation $r = 6\times10^{-15}$ m

Charg on proton, $q_P = 1.60\times10^{-19}$ C

Required:- Repulsive Force = ??

Formula:- $F = \frac{1}{4\pi\epsilon_0}\left(\frac{q_1 q_2}{r^2}\right) = K\frac{q_1 q_2}{r^2}$

Solution:-

Colomb's Constant $1/4\pi\epsilon_0 = 8.99\times10^{9}\ N.m^2/C^2$

Putting values in formula,

$$F = \frac{(8.99\times10^{9}\ N.m^2/C^2)(1.60\times10^{-19}C)(1.60\times10^{-19}C)}{(6\times10^{-15}m)^2}$$

$$F = 6.39N$$

Result:-

The Repulsive Force b/w Protons

$$\boxed{F = 6.39N}$$

Problem 1-4

Figure shows three charged particles, held in placed by forces not shown. what electrostatic force owing to the other charges, act on q_1? (find the value of F_{12} & F_{13})?
Take $q_1 = 4.2\,\mu C$, $q_2 = 8.4\,\mu C$, $q_3 = 3.4\,\mu C$, $r_{12} = 19\,cm$, $r_{13} = 19\,cm$

Data available in Problem question.

Required:- Electrostatic Force $(F_{12}$ & $F_{13}) = ??$

Formula:
$$F = \frac{1}{4\pi\varepsilon}\left(\frac{q_1 q_2}{r^2}\right)$$

Solution: Colomb's Constant $1/4\pi\varepsilon_0 = 8.99 \times 10^9\ Nm^2/C^2$

Putting value in Formula,
$$F_{12} = \frac{(8.99\times10^9\,Nm^2/C^2)(4.2\times10^{-6}\,c)(8.4\times10^{-6}\,c)}{(0.19\,m)^2}$$

$$F_{12} = 8.78\,N$$

The charges q_1 and q_2 have opposite signs so that the force b/w them is attractive. Hence F_{12} points to the right shown in figure.

We also have F_{13}.
$$F_{13} = \frac{(8.99\times10^9\,Nm^2/C^2)(4.2\times10^{-6}\,c)(3.4\times10^{-6}\,c)}{(0.19\,m)^2}$$

$$F_{13} = 3.55\,N$$

Result:- Electrostatic force is owing from other charges.

$\boxed{F_{12} = 8.78\,N}$ $\boxed{F_{13} = 3.55\,N}$

Problem 1-5

What must be the distance b/w point charge $q_1 = 96.7\,\mu C$ and $q_2 = 87.7\,\mu C$ in order that the attractive electrical force between them has a magnitude of $7.98N$?

Data: Point charge $q_1 = 96.7\,\mu C = 96.7 \times 10^{-6}\,C$

Point charge $q_2 = 87.7\,\mu C = 87.7 \times 10^{-6}\,C$

Attractive Electrical Force $= F = 7.98\,N$

Coulomb's Constant $1/4\pi\varepsilon_0 = 8.99 \times 10^{9}\,Nm^2/C^2$

Required: Distance b/w Point charges, $r = ??$

Formula: $$F = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1 q_2}{r^2}\right) = K\frac{q_1 q_2}{r^2}$$

Solution: Rearranging formula and we get,

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

$$r = \sqrt{\frac{K q_1 q_2}{F}} \quad \text{------} \; (i)$$

Putting values in formula

$$r = \sqrt{\frac{(8.99 \times 10^{9})(96.7 \times 10^{-6} c)(87.7 \times 10^{-6} c)}{(7.98)}}$$

$$r = \sqrt{9.55} \Rightarrow 3.090$$

Result:

Distance between Point Charges is

$$\boxed{r = 3.090m}$$

$r = 3.090m$

Problem 1-6

A Point charge of $+7.12\times10^{-6}$ C is 13.4 cm distant from a Second point charge of -2.48×10^{-6} C. Calculate the magnitude of the force on each charge.

Data:-

Point Charge $q_1 = +7.12\times10^{-6}C$

Point Charge $q_2 = -2.48\times10^{-6}C$

Separation, $r = 13.4\,cm = 13.4\times10^{-2}\,m$

Coulomb's Constant $1/4\pi\varepsilon_0 = 8.99\times10^{9}\,Nm^2/C^2$

Required:- $F = ??$

Formula:-

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

Solution:-

Putting values in formula,

$$F = \frac{(8.99\times10^{9}\,Nm^2/C^2)(+7.12\times10^{-6}C)(-2.48\times10^{-6}C)}{(13.4\times10^{-2}\,m)^2}$$

$$F = -8.840N$$

Result:- Magnitude of the force of each charge is

$$\boxed{F = -8.840N}$$

$F = -8.840N$

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Problem 1-7

A Point charge of $+4.00 \times 10^{-6}$ C is 13.0 cm distant from a Second point charge of 6.50×10^{-6} C. Calculate the magnitude of the force on each charge.

Data:- Point charge $q_1 = +4.00 \times 10^{-6}$ C

Point charge $q_2 = 6.50 \times 10^{-6}$ C

Sepration, $r = 13.0 = 13.0 \times 10^{-2}$ m

Coulomb's Constant $1/4\pi\varepsilon_0 = 8.99 \times 10^{9}$ Nm^2/C^2

Required:- $F = ??$

Formula:- $$F = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1 q_2}{r^2}\right) = K \frac{q_1 q_2}{r^2}$$

Solution:- Putting values in formula,

$$F = \frac{(8.99 \times 10^{9}\,Nm^2/C^2)(+4.00 \times 10^{-6}\,C)(6.50 \times 10^{-6}\,C)}{(13.0 \times 10^{-2}\,m)^2}$$

$$F = 13.83\,N$$

Result:- Magnitude of the force of each charge is

$$\boxed{F = 13.83\,N}$$

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Problem 1-8

What must be the distance b/w point charge $q_1 = 23.0\,\mu C$ and $q_2 = 25.0\,\mu C$ for the electrostatic force b/w them to have a magnitude of 7.50 N?

Data:- Point charge $q_1 = 23.0\,\mu C = 23.0 \times 10^{-6}\,C$

Point charge $q_2 = 25.0\,\mu C = 25.0 \times 10^{-6}\,C$

Electrostatic force $F = 7.50\,N$

Coulomb's Constant $1/4\pi\varepsilon_0 = K = 8.99 \times 10^9\,Nm^2/C^2$

Required:- Distance b/w Point charges, $r = ??$

Formula:-

$$F = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1 q_2}{r^2}\right) = K\frac{q_1 q_2}{r^2}$$

Rearranging

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

$$r = \sqrt{\frac{K q_1 q_2}{F}} \quad \text{------ (i)}$$

Solution:- Putting values in formula.

$$r = \sqrt{\frac{(8.99 \times 10^9)(23.0 \times 10^{-6})(25.0 \times 10^{-6})}{(7.50)}}$$

$$r = \sqrt{\frac{5.16925}{7.50}} \Rightarrow 0.830$$

Result:- Distance b/w Point charge is

$$\boxed{r = 0.830\,m}$$