COULOMB'S LAW - SOLUTIONS

1. a) $F_e = K\frac{q_1 q_2}{r^2}$

$F_e' = K\frac{(2q_1)q_2}{r^2}$

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

$= 2F_e$ DOUBLES

b) $F_e' = K\frac{(2q_1)(2q_2)}{r^2}$

$= 4K\frac{q_1 q_2}{r^2}$

$= 4F_e$ INCREASES BY A FACTOR OF 4

c) $F_e' = K\frac{q_1 q_2}{(3r)^2}$

$= \frac{1}{9}K\frac{q_1 q_2}{r^2}$

$= \frac{1}{9}F_e$ DECREASES BY A FACTOR OF $\frac{1}{9}$

d) $F_e' = K\frac{q_1 q_2}{(\frac{1}{2}r)^2}$

$= 4K\frac{q_1 q_2}{r^2}$

$= 4F_e$ INCREASES BY A FACTOR OF 4

e) $F_e' = K\frac{(2q_1)(2q_1)}{(2r)^2}$

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

$= F_e$ NO CHANGE

f) $F_e' = k\frac{(2q_1)(2q_2)}{(\frac{1}{2}r)^2}$

$= 16\,k\frac{q_1q_2}{r^2}$

$= 16\,F_e$

INCREASED BY A FACTOR OF 16

2. GIVEN:

$q_1 = +1.00\times10^{-6}$ C

$q_2 = -1.00\times10^{-6}$ C

$r = 1.00$ m

$F_e = ?$

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

$= (9.00\times10^9)\frac{(+1.00\times10^{-6})(-1.00\times10^{-6})}{(1.00)^2}$

$= -9.00\times10^{-3}$ N

9.00×10^{-3} N ATTRACTIVE

3. GIVEN:

$q_1 = q_2 = +6.0\times10^{-6}$ C

$r = 1.0\times10^{-6}$ m

$F_e = ?$

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

$= (9.00\times10^9)\frac{(+6.0\times10^{-6})(+6.0\times10^{-6})}{(1.0\times10^{-6})^2}$

$= 3.2\times10^{11}$ N

4. GIVEN:

$r = 0.50$ m

$F_e = 5.0$ N

$q_1 = q_2 = q = ?$

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

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

$q = \sqrt{\frac{F_e r^2}{k}}$

$= \sqrt{\frac{(5.0)(0.50)^2}{9.00\times10^9}}$

$= 1.2\times10^{-5}$ C $= 12\,\mu$C

5. a) $q_{TOTAL} = 1.0\,kg \times \frac{1\ \text{electron}}{9.11\times10^{-31}\ kg} \times \frac{-1.60\times10^{-19}\,C}{1\ \text{electron}}$

$= -1.756\times10^{11}\,C$

$\boxed{-1.8\times10^{11}\,C}$

b) GIVEN:

$q_1 = q_2 = -1.756\times10^{11}\,C$

$r = 1.0\,m$

$F_e = ?$

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

$= (9.00\times10^{9})\frac{(-1.756\times10^{11})(-1.756\times10^{11})}{(1.0)^2}$

$= +2.776\times10^{32}\,N$

$\boxed{2.8\times10^{32}\,N}$ REPULSIVE

c) GIVEN:

$m_1 = m_2 = 1.0\,kg$

$r = 1.0\,m$

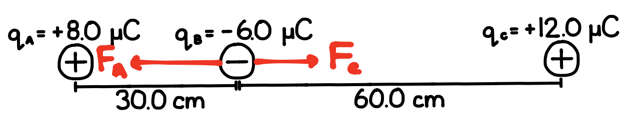
$F_g = ?$

$F_g = G\frac{m_1 m_2}{r^2}$

$= (6.67\times10^{-11})\frac{(1.0)(1.0)}{(1.0)^2}$

$= \boxed{6.67\times10^{-11}\,N}$

MUCH WEAKER!

6. 

GIVEN:

$q_A = +8.0\times10^{-6}\,C$

$q_B = -6.0\times10^{-6}\,C$

$r = 0.300\,m$

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

$= (9.00\times10^{9})\frac{(8.0\times10^{-6})(-6.0\times10^{-6})}{(0.300)^2}$

$= -4.8\,N$

$\rightarrow$ 4.8 N LEFT

given:

$q_B = -6.0\times10^{-6}\,C$

$q_c = +12.0\times10^{-6}\,C$

$r = 0.600\ m$

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

$$= (9.00\times10^{9})\frac{(-6.0\times10^{-6})(12.0\times10^{-6})}{(0.600)^2}$$

$$= -1.8\ N$$

$\rightarrow$ 1.8 N RIGHT

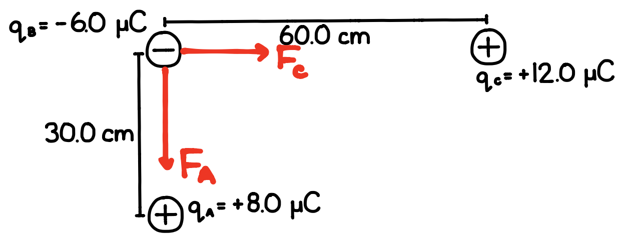
$$F_{NET} = F_c - F_A$$

$$= 1.8 - 4.8$$

$$= -3.0\ N$$

$\rightarrow$ 3.0 N LEFT

7.



given:

$q_A = +8.0\times10^{-6}\,C$

$q_B = -6.0\times10^{-6}\,C$

$r = 0.300\ m$

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

$$= (9.00\times10^{9})\frac{(8.0\times10^{-6})(-6.0\times10^{-6})}{(0.300)^2}$$

$$= -4.8\ N$$

$\rightarrow$ 4.8 N SOUTH

given:

$q_B = -6.0\times10^{-6}\,C$

$q_c = +12.0\times10^{-6}\,C$

$r = 0.600\ m$

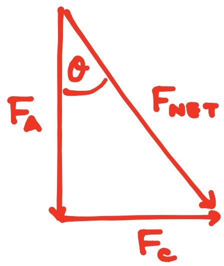
$$F_e = k\frac{q_1 q_2}{r^2}$$

$$= (9.00\times10^{9})\frac{(-6.0\times10^{-6})(12.0\times10^{-6})}{(0.600)^2}$$

$$= -1.8\ N$$

$\rightarrow$ 1.8 N EAST

$$\vec{F}_{NET} = \vec{F}_A + \vec{F}_e$$



$$F_{NET}^2 = F_A^2 + F_e^2$$

$$F_{NET} = \sqrt{F_A^2 + F_e^2}$$

$$= \sqrt{(4.8)^2 + (1.8)^2}$$

$$= 5.1\ N$$

$$\theta = \tan^{-1}\left(\frac{F_e}{F_A}\right)$$

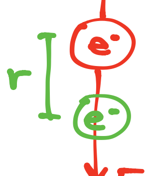
$$= \tan^{-1}\left(\frac{1.8}{4.8}\right)$$

$$= 21°$$

5.1 N 21° EAST OF SOUTH

8.

$$F_e = K\frac{q_e q_e}{r^2} = K\frac{q_e^2}{r^2}$$



$$F_g = m_e g$$

BECAUSE THE TWO ELECTRONS WILL REPEL, PLACING THE SECOND ELECTRON DIRECTLY BELOW WILL CAUSE AN UPWARDS FORCE ON THE FIRST ELECTRON.

$$F_{NET} = 0$$

$$F_g - F_e = 0$$

$$F_e = F_g$$

$$K\frac{q_e^2}{r^2} = m_e g$$

$$r^2 = \frac{kq_e^2}{m_e g}$$

$$r = \sqrt{\frac{kq_e^2}{m_e g}}$$

$$= \sqrt{\frac{(9.00\times10^9)(1.60\times10^{-19})^2}{(9.11\times10^{-31})(9.8)}}$$

$$= 5.1\ m$$

5.1 m BELOW

9. a) GIVEN:

$m_e = 9.11\times10^{-31}\,kg$

$q_e = 1.60\times10^{-19}\,C$

$q_n = 9.6\times10^{-19}\,C$

$r = 2.0\times10^{-10}\,m$

$v = ?$

$$F_c = F_e$$

$$m_e\frac{v^2}{r} = k\frac{q_e q_n}{r^2}$$

$$v^2 = k\frac{q_e q_n}{r m_e}$$

$$v = \sqrt{k\frac{q_e q_n}{r m_e}}$$

$$= \sqrt{(9.00\times10^9)\frac{(1.60\times10^{-19})(9.6\times10^{-19})}{(2.0\times10^{-10})(9.11\times10^{-31})}}$$

$$= 2.8\times10^6\ \frac{m}{s}$$

b) GIVEN:

$m_e = 9.11\times10^{-31}\,kg$

$q_e = 1.60\times10^{-19}\,C$

$q_n = 9.6\times10^{-19}\,C$

$r = 2.0\times10^{-10}\,m$

$T = ?$

$$F_c = F_e$$

$$m_e\frac{4\pi^2 r}{T^2} = k\frac{q_e q_n}{r^2}$$

$$T^2 = \frac{m_e 4\pi^2 r^3}{k q_e q_n}$$

$$T = \sqrt{\frac{m_e 4\pi^2 r^3}{k q_e q_n}}$$

$$= \sqrt{\frac{(9.11\times10^{-31})4\pi^2(2.0\times10^{-10})^3}{(9.00\times10^9)(1.60\times10^{-19})(9.6\times10^{-19})}}$$

$$= 4.6\times10^{-16}\,s$$

10. $F_c = F_e$

$$m_e \frac{v^2}{r} = k \frac{q_e q_n}{r^2}$$

$$v^2 = k \frac{q_e q_n}{m_e r}$$

$$v = \sqrt{k \frac{q_e q_n}{m_e r}}$$

$$v' = \sqrt{k \frac{q_e q_n}{m_e (2r)}}$$

$$= \frac{1}{\sqrt{2}} \sqrt{k \frac{q_e q_n}{m_e r}}$$

$$= \frac{v}{\sqrt{2}} = 0.707\, v$$