Coulomb's law worksheet

1. Find the electrostatic force between charges of +2.0 C and +5.0 C separated by a distance of 75 m in a vacuum.

$F = K\frac{q_1 q_2}{r^2}$ $F = 9\times10^9 \times \frac{2\times5}{75^2} = 1.6\times10^7\ N$

repulsion

2. A negative charge of - 4.0 x 10^{-5} C and a positive charge of 7.0 x 10^{-5}C are separated by 0.15 m. What is the force between the two charges?

$F = 9\times10^9 \times \frac{4\times10^{-5}\times7\times10^{-5}}{0.15^2} = 1.12\times10^3\ N$

attraction

3. Calculate the force between charges of 5.0x10^{-8} C and 1.0x10^{-7} C if they are 2.0 cm apart.

$F = 9\times10^9 \times \frac{5\times10^{-8}\times1\times10^{-7}}{(0.02)^2} = 1.125\times10^{-1}\ N$

repulsion

4. Two negative charges that are both - 3.0 C push each other apart with a force of 19.2 N. How far apart are the two charges?

$19.2 = 9\times10^9\ \frac{3\times3}{r^2}$ $r^2 = \frac{9\times10^9\times3\times3}{19.2} = 4.2\times10^9$

$r =$ ~~2.05 m~~ 6.5×10^4 M

5. Two charges of +8.0 mC and -6.0 mC attract each other with a force of 3.0 x 10^3 N in a vacuum. What is the distance between the charges?

$3\times10^3 = 9\times10^9\ \frac{8\times10^{-3}\times6\times10^{-3}}{r^2}$ $r^2 = 1.44\times10^2$

$r = 12$ m

6. Two equal charges of 1.1x10^{-7} C experience an electrostatic force of 4.2x10^{-4} N. How far apart are the centers of the two charges?

$4.2\times10^{-4} = 9\times10^9\ \frac{(1.1\times10^{-7})^2}{r^2}$ $r^2 =$ ~~[illegible]~~ 2.6×10^{-1}

$r = 0.51$ m

7. A negative charge of - 0.0005 C exerts an attractive force of 9.0 N on a second charge that is 10 m away. What is the magnitude of the second charge?

$$9 = 9\times10^9 \times \frac{0.0005\, q}{10^2} \quad q = \frac{9\times10^2}{9\times10^9\times0.0005} = 2\times10^{-4}\ C$$

positive

8. A negative charge of - 8.0 x 10^{-6} C exerts an attractive force of 12 N on a second charge that is 0.050 m away. What is the magnitude of the second charge?

$$12 = 9\times10^9 \times \frac{8\times10^{-6} q}{0.05^2} \quad q = \frac{12\times0.05^2}{9\times10^9\times8\times10^{-6}} = 4.17\times10^{-7}\ C$$

positive

9. Two charged spheres, Q and 2Q, placed 4.0 cm apart, are attracted to each other with a force of 1.2x10^{-9} N. Calculate the magnitude of the charge on each sphere.

$$1.2\times10^{-9} = \frac{2Q^2}{(0.04)^2}\times9\times10^9 \quad Q^2 = \frac{1.2\times10^{-9}\times(0.04)^2}{2\times9\times10^9} = 1.1\times10^{-22}$$

$$Q = 1.04\times10^{-11}\ C$$

10. Two small charged spheres have their centres 0.05 m apart and repel each other with a force of 5 x 10^{-5} N. What would be the force of repulsion if the spheres were 0.10 m apart?

$$F_1 = K\frac{q_1 q_2}{0.05^2} \quad F_2 = K\frac{q_1 q_2}{0.1^2} \quad \frac{F_2}{F_1} = \frac{0.05^2}{0.1^2} \quad F_2 = \frac{1}{4}\times5\times10^{-5} = 1.25\times10^{-5}\ N$$

11. What happens to the force between two charged metal spheres in a vacuum if the charge on each is doubled and the distance between them is multiplied by three?

$$F_1 = k\frac{q_1 q_2}{r^2} \quad F_2 = k\frac{2q_1 2q_2}{(3r)^2} = k\frac{4q_1q_2}{9r^2} \quad \frac{F_2}{F_1} = \frac{4}{9}$$

12. Two charged spheres 10 cm apart are attracted to each other with an electrical force of 3.0x10^{-6} N. What happens to the force between the spheres if

(a) one of the charges is halved.

$$F_2 = \frac{1}{2}F_1$$

(b) the separation is decreased to 5 cm

$$F_2 = 4F_1$$

13. Two equal charges $+q$ are at the distance r. Distance between them decreased twice. What change must be done to one of them to keep repulsive force the same? Show your working.

$F_1 = F_2 \quad k\frac{q^2}{r^2} = k\frac{q\,q_1}{\left(\frac{r}{2}\right)^2} \quad q = 4q_1$

$q_1 = \frac{q}{4}$

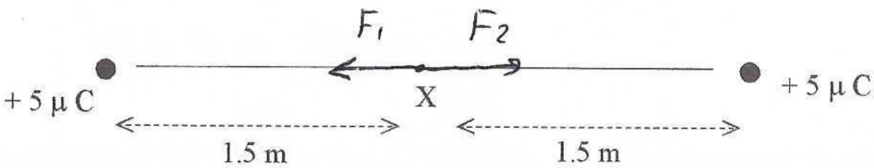
14. Two small objects with charges $q = 8 \times 10^{-6}\,C$ and $2 \times 10^{-6}\,C$ were briefly contacted each other and placed at the distance $r = 0.8\,m$. What force will be acting between them?

$\frac{8+2}{2} = 5 \quad F = 9\times10^9 \times \frac{(5\times10^{-6})^2}{0.8^2} = 3.5 \times 10^{-1}\,N$

$\approx 0.35\,N$

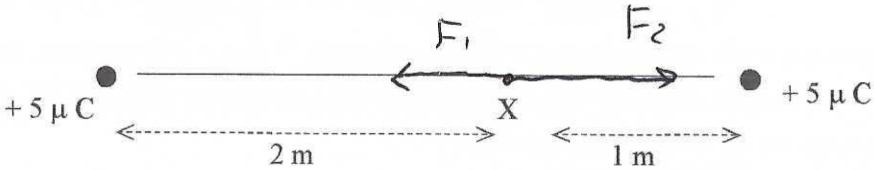
15. Find the magnitude and direction of the force on a charge of +10 μC placed at X in each of the following:

(a)



$F = 0$ as $F_1 = F_2$

(b)



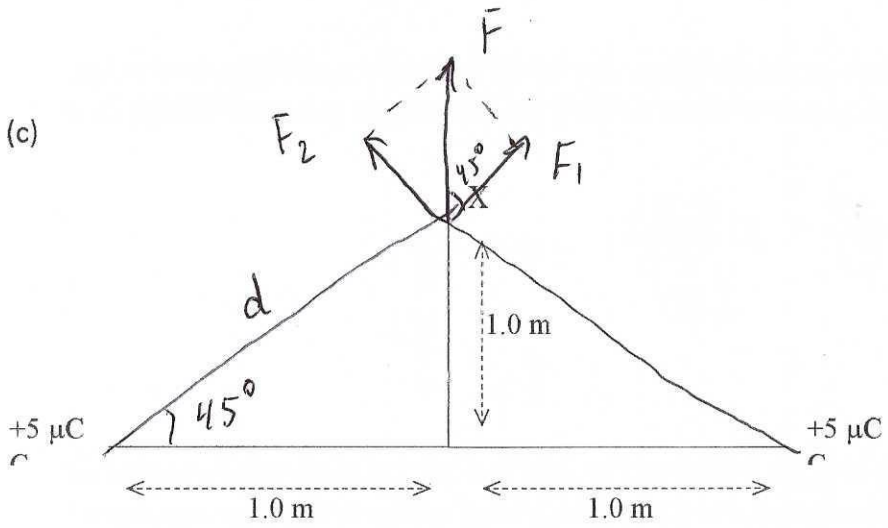
$F = F_2 - F_1$

$= 9\times10^9 \times 10\times10^{-6} \times 5\times10^{-6}\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$

$= 4.5\times10^{-1} \times \frac{3}{4}$

$= 0.3375\,N$ to the ~~right~~ left

(c)



$$F = F_1 \cos 45^\circ + F_2 \cos 45^\circ \qquad F_1 = F_2 = 9\times10^9 \times \frac{10\times10^{-6} \times 5\times10^{-6}}{2}$$

$$d = \sqrt{1^2+1^2} = \sqrt{2} \qquad = 2.25\times10^{-1}$$

$$F = 2\times 0.225 \times \frac{\sqrt{2}}{2}$$

$$= 0.225\sqrt{2} = 0.32\,N$$

16. Three objects of charge -4.0x10^{-6} C (q_1), -6.0x10^{-6} C (q_2) and +9.0x10^{-6} C (q_3) are placed in a line spaced equally with a distance 0.50 m between them. Calculate the magnitude and direction of the net force acting on each charge.

0.5   0.5

q_1 q_2 q_3 →

On q_1: $9\times10^9 \times \left(\frac{4\times10^{-6}\times 9\times10^{-6}}{1^2} - \frac{4\times10^{-6}\times6\times10^{-6}}{0.5^2}\right) = -5.4\times10^{-1}\,N$

On q_2: $9\times10^9 \times \left(\frac{4\times10^{-6}\times 6\times10^{-6}}{0.5^2} + \frac{6\times10^{-6}\times9\times10^{-6}}{0.5^2}\right) = 2.808\,N$

q_3: $-9\times10^9 \times \left(\frac{4\times10^{-6}\times 9\times10^{-6}}{1^2} + \frac{6\times10^{-6}\times9\times10^{-6}}{0.5^2}\right) = -2.268\,N$

17. Two small spheres with charges 1.6x10^{-5} C and 6.4x10^{-5} C are 2.0 m apart. Where, on the line joining the spheres, should a third charged sphere of charge -3.0x10^{-6} C be placed such that it experiences no net electrical force?

2 m, x

$1.6\times10^{-5}C$ $-3\times10^{-6}C$ $6.4\times10^{-5}C$

$$9\times10^9 \frac{1.6\times10^{-5}\times3\times10^{-6}}{x^2} = 9\times10^9 \frac{6.4\times10^{-5}\times3\times10^{-6}}{(2-x)^2}$$

$$\frac{1.6}{x^2} = \frac{6.4}{(2-x)^2} \qquad 6.4x^2 = 1.6(4-4x+x^2)$$

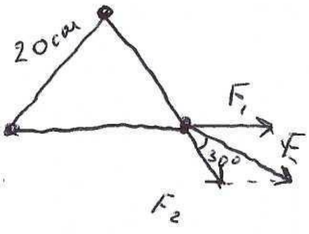
$$4.8x^2 + 6.4x - 6.4 = 0 \quad \div 1.6$$

$$3x^2 + 4x - 4 = 0$$

$$x = \frac{-4 \pm \sqrt{16+4\times3\times4}}{2\times3} = \frac{-4\pm\sqrt{64}}{6}$$

$$x = \sout{0.87\,m} \qquad \frac{-4\pm8}{6} \qquad 0.67\,m\,!$$

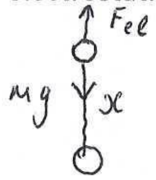
18. Three negatively charged spheres, each with a charge of -4.0×10^{-5} C, are fixed at the vertices of an equilateral triangle whose sides are 20.0 cm long. Calculate the magnitude and direction of the net electric force on each sphere.



$$F = 2 \times 9\times10^{9} \frac{(4\times10^{-5})^2}{0.2^2} \cos 30^\circ$$

$$= 6.2\times10^{2}\ N$$

19. A metal sphere of mass 6.0×10^{-3} kg is found to just float in air above a similar metal sphere when both have a charge of 4.0 mC. Assuming that the only upwards force is electrostatic repulsion, find the distance between the spheres.



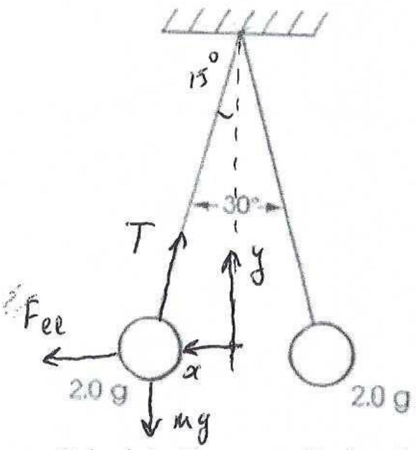
$$F_{el} = mg$$

$$9\times10^{9} \frac{(4\times10^{-3})^2}{x^2} = 6\times10^{-3} \times 9.8$$

$$x^2 = 2.449\times10^{6}$$

$$x = 1.56\times10^{3}\ m$$

20. Two identical, small spheres of mass 2.0 g are fastened to the ends of a 0.60 m long fishing line of negligible mass. The fishing line is suspended by a hook in the ceiling at its exact center. When the spheres are each given an identical electric charge, they separate as shown:



$$y: T\cos 15^\circ - mg = 0 \qquad T = \frac{mg}{\cos 15^\circ}$$

$$x: F_{el} - T\sin 15^\circ = 0$$

$$F_{el} = mg \tan 15^\circ$$

$$9\times10^{9} \frac{q^2}{(\cancel{0.155})^2 \ 0.31} = 0.002 \times 9.8 \tan 15^\circ$$

$$q^2 = 1.4\times10^{-14}\ \cancel{\times 1.5}\ 4$$

distance = $\cancel{2}\,0.6 \sin 15^\circ$ = $\cancel{2\times}\,0.155$ = 0.31

Calculate the magnitude of the charge on each sphere.

$$q = \cancel{1.18}\times10^{-7}\ C$$

2.36