Name: Key

Practice - 18.3 Coulomb's Law

1. What is the repulsive force between two pith balls that are 8.00 cm apart and have equal charges of -30.0 nC?

$$F = \frac{kq_1q_2}{r^2} = \frac{\left(8.99\times10^{9}\frac{Nm^2}{C^2}\right)\left(30.0\times10^{-9}C\right)\left(30.0\times10^{-9}C\right)}{\left(8.00\times10^{-2}m\right)^2}$$

$$= \boxed{1.26\times10^{-3}N}$$

2. Two point charges exert a 5.00 N force on each other. What will the force become if the distance between them is increased by a factor of three?

Since $F \propto \frac{1}{r^2}$, when $r \uparrow 3X$, $F \downarrow 9X$

$$F = \frac{5.00N}{9} = \boxed{0.556N}$$

3. Two point charges are brought closer together, increasing the force between them by a factor of 25. By what factor was their separation decreased?

When $F \uparrow 25X$, $r \downarrow 5X$ $\boxed{5X}$

4. How far apart must two point charges of 75.0 nC (typical of static electricity) be to have a force of 1.00 N between them?

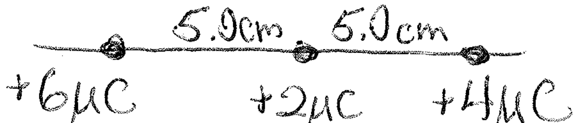
$$F = \frac{kq_1q_2}{r^2} \Rightarrow r = \sqrt{\frac{kq_1q_2}{F}} = \sqrt{\frac{\left(8.99\times10^{9}\frac{Nm^2}{C^2}\right)\left(75.0\times10^{-9}C\right)\left(75.0\times10^{-9}C\right)}{1.00N}}$$

$$= \boxed{7.11\times10^{-3}m}$$ 7.11 mm

5. If two equal charges each of 1 C each are separated in air by a distance of 1 km, what is the magnitude of the force acting between them? You will see that even at a distance as large as 1 km, the repulsive force is substantial because 1 C is a very significant amount of charge.

$$F = \frac{kq_1q_2}{r^2} = \frac{\left(8.99\times10^{9}\,\frac{Nm^2}{C^2}\right)(1.00\,C)(1.00\,C)}{(1.00\times10^{3}\,m)^2} = \boxed{8.99\times10^{3}\,N}$$

6. A test charge of +2 μC is placed halfway between a charge of +6 μC and another of +4 μC separated by 10 cm. What is the magnitude and direction of the force on the test charge?



$$F_{NET} = F_{6-2} - F_{4-2}$$

$$= \left(8.99\times10^{9}\,\frac{Nm^2}{C^2}\right)\left(\frac{(6.00\times10^{-6}\,C)(2.00\times10^{-6}\,C)}{(5.00\times10^{-2}\,m)^2} - \frac{(4.00\times10^{-6}\,C)(2.00\times10^{-6}\,C)}{(5.00\times10^{-2}\,m)^2}\right)$$

$$= \boxed{14.4\,N}$$

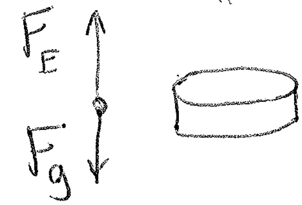
7. Find the ratio of the electrostatic to gravitational force between two electrons.

$$\frac{F_E}{F_G} = \frac{\frac{kq_1q_2}{r^2}}{\frac{Gm_1m_2}{r^2}} = \frac{(8.99\times10^{9})(1.60\times10^{-19}\,C)(1.60\times10^{-19}\,C)}{(6.67\times10^{-11})(9.11\times10^{-31}\,kg)(9.11\times10^{-31}\,kg)}$$

$$= \boxed{4.16\times10^{42}}$$

8. A certain five cent coin contains 5.00 g of nickel. What fraction of the nickel atoms' electrons, removed and placed 1.00 m above it, would support the weight of this coin? The atomic mass of nickel is 58.7, and each nickel atom contains 28 electrons and 28 protons.

$$F_E = F_g \Rightarrow \frac{kq^2}{r^2} = mg$$



$$q = \sqrt{\frac{mgr^2}{k}} = \sqrt{\frac{(5.00\times10^{-3}\,kg)(9.80\,\frac{m}{s^2})(1.00\,m)}{(8.99\times10^{9}\,\frac{Nm^2}{C^2})}} = 2.335\times10^{-6}\,C$$

$$\#e^- = 2.335\times10^{-6}\,C\left(\frac{1e^-}{1.60\times10^{-19}\,C}\right) = 1.459\times10^{13}\,e^-$$

$$\#e^- \text{ in } 5.00\,g \text{ of Ni} = \left(\frac{5.00\,g}{58.7\,\frac{g}{mole}}\right)\left(\frac{6.02\times10^{23}\text{ atoms}}{1\text{ mole}}\right)\left(\frac{28e^-}{\text{atom}}\right) = 1.436\times10^{24}\,e^-$$

$$\text{Fraction} = \frac{\#e^-\text{ to support}}{\#e^-\text{ total}} = \frac{1.459\times10^{13}}{1.436\times10^{24}} = \boxed{1.02\times10^{-11}}$$

9. What is the net force (magnitude and direction) on q_2?

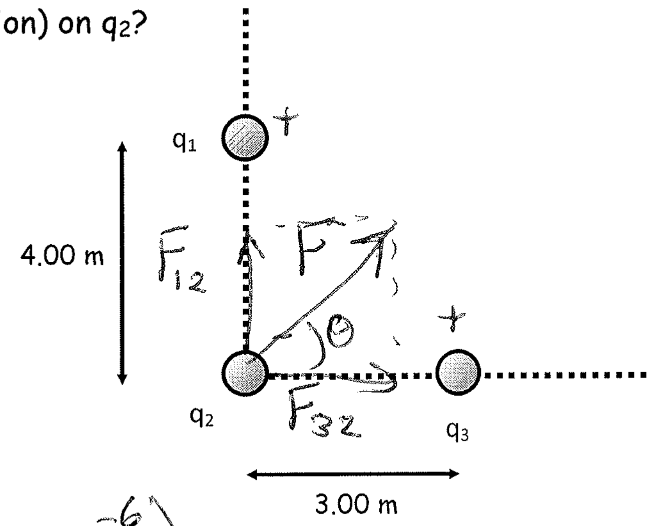
$q_1 = +6.00\ \mu C$

$q_2 = -2.00\ \mu C$

$q_3 = +4.00\ \mu C$

$r_{12} = 4.00$ m

$r_{32} = 3.00$ m



$$F_{12} = \frac{k q_1 q_2}{r_{12}^2} \qquad F_{32} = \frac{k q_3 q_2}{r_{32}^2}$$

$$F_{12} = \frac{\left(8.99\times10^{9}\,\frac{Nm^2}{C^2}\right)\left(6.00\times10^{-6}C\right)\left(2.00\times10^{-6}C\right)}{(4.00m)^2} = 6.743\times10^{-3}N = F_y$$

$$F_{32} = \frac{\left(8.99\times10^{9}\,\frac{Nm^2}{C^2}\right)\left(4.00\times10^{-6}C\right)\left(2.00\times10^{-6}C\right)}{(3.00m)^2} = 7.991\times10^{-3}N = F_x$$

$$F = \sqrt{F_x^2 + F_y^2} = \sqrt{\left(7.991\times10^{-3}N\right)^2 + \left(6.743\times10^{-3}N\right)^2} = \boxed{1.05\times10^{-2}N}$$

$$\theta = \tan^{-1}\frac{F_y}{F_x} = \tan^{-1}\frac{6.743\times10^{-3}N}{7.991\times10^{-3}N} = \boxed{40.2^\circ}$$