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?

$$F = \frac{kq_1q_2}{r^2} = 8.99\times10^9 \frac{N\cdot m^2}{C^2}\left(\frac{(30\times10^{-9}\,C)^2}{(0.08\,m)^2}\right) = 1.26\times10^{-3}\,N$$

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?

$F = 5N = \frac{kq_1q_2}{r^2}$ ← substituting $3r$ for r ⇒ $\frac{kq_1q_2}{(3r)^2} = \frac{1}{9}\frac{kq_1q_2}{r^2}$ so $F = \frac{1}{9}(5N)$

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?

$F = \frac{kq_1q_2}{r^2} \Rightarrow r^2F = kq_1q_2 \Rightarrow r_0 = \sqrt{\frac{kq_1q_2}{F}}$

→ Substituting $25F$ for F ⇒ $r = \sqrt{\frac{kq_1q_2}{25F}} = \frac{1}{5}\sqrt{\frac{kq_1q_2}{F}}$

$r = \frac{1}{5}r_0$

4. If two equal charges each of 1.00 C each are separated in air by a distance of 1.00 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.

$$F = \frac{kq_1q_2}{r^2} = 8.99\times10^9 \frac{N\cdot m^2}{C^2}\left(\frac{(1.00\,C)(1.00\,C)}{(10^3\,m)^2}\right) = 8.99\times10^3\,N$$

5. Suppose a coin is made of 5.00 g of pure nickel. How many electrons, removed and placed 1.00 m above the coin, would support the weight of this coin? Assume that the mass of an electron is negligible.

unpaired electrons

1 m

$F_{electrons}$

unpaired protons → $W = mg = 0.005\,kg\,(9.8\,m/s^2) = 0.049\,N$

5g Nickel

$mg = F_{electrostatic} = k\frac{q^2}{r^2}$ ← q = charge of electrons = charge of protons

$0.049N = 8.99\times10^9 \frac{N\cdot m^2}{C^2}\left(\frac{q^2}{(1m)^2}\right)$

$q = 2.33\times10^{-6}\,C$

$2.33\times10^{-6}\,C\left(\frac{1e}{1.6\times10^{-19}\,C}\right) = 1.46\times10^{13}\,e$

Answers:

1. 1.26×10^{-3} N
2. 0.556 N
3. 5
4. 8.99×10^{3} N
5. 1.46×10^{13} electrons