1) Find the magnitude of the electric force between two 1.00-C charges separated by 1.00m.

\[ F_{elec} = \frac{kQ_1Q_2}{R^2} = \frac{(9 \cdot 10^9 \text{ N} \cdot \text{m}^2 \cdot \text{C}^2)(1\text{C})(1\text{C})}{(1\text{m})^2} = 9 \cdot 10^9 \text{ N} \]

2) A charge \( q_1 = -5.4 \mu \text{C} \) is at the origin, and a charge \( q_2 = -2.2 \mu \text{C} \) is on the x axis at \( x=1.00 \). Find the net force acting on a charge \( q_3 = 1.6 \mu \text{C} \) located at \( x = 0.75 \text{m} \)

\[ F_{13} = -\frac{(9 \cdot 10^9 \text{ N} \cdot \text{m}^2 \cdot \text{C}^2)(5.4 \cdot 10^{-6} \text{ C})(1.6 \cdot 10^{-6} \text{ C})}{(0.75\text{m})^2} = -0.14 \text{ N} \]

\[ F_{23} = +\frac{(9 \cdot 10^9 \text{ N} \cdot \text{m}^2 \cdot \text{C}^2)(2.2 \cdot 10^{-6} \text{ C})(1.6 \cdot 10^{-6} \text{ C})}{(0.25\text{m})^2} = +0.51 \text{ N} \]

\[ F_{total} = 0.37 \text{ N} \]

3) An electron and a proton, initially separated by a distance \( d \), are released from rest simultaneously. The two particles are free to move. When they collide, are they (a) at the midpoint of their initial separation, (b) closer to the initial position of the proton, or (c) closer to the initial position of the electron?

Answer (b) – the forces are equal magnitude, so the acceleration of the proton is much slower due its larger mass. So the electron moves much faster, putting the collision nearer to the proton’s initial position.

4) A charge \(-q\) is to be placed at either point A or point B in the figure below. Assume points A and B lie on a line that is midway between the two positive charges. Is the magnitude of the net force experienced at point A (a) greater than, (b) equal to, or (c) less than the net force experienced at point B?

Answer (c) – The net force on \(-q\) when it is placed at point A is zero. The other charges both pull on \(-q\), and their forces cancel out.

However, at point B the forces do not cancel. The horizontal components cancel, but both pulls have a downward vertical component so the net force is downward (toward point A).
5) Find the magnitude of the electric field produced by a 1.0 μC point charge at a distance of (a) 0.75 m and b) 1.5 m.

\[ E = \frac{kQ}{R^2} \]

With \( R = 0.75 \text{ m} \)

\[ E = \frac{(9 \cdot 10^9 \text{ N} \cdot \text{m}^2) \cdot (1 \cdot 10^{-6} \text{ C})}{(0.75 \text{ m})^2} = 16,000 \text{ N/C} \]

With \( R = 1.5 \text{ m} \), \( E = 4,000 \text{ N/C} \) (No need to recalculate – you know that when the distance doubles, the field strength will drop by a factor of 4.)

6) In a certain region of space, a uniform electric field has a magnitude of \( 4.60 \times 10^4 \text{ N/C} \) and points in the positive x-direction.

Find the magnitude and direction of the force this field exerts on charges of (a) +2.80 μC and (b) -9.30μC

\[ F_{\text{elec}} = E \cdot Q \]

(a) \( F_{\text{elec}} = (4.6 \times 10^4 \text{ N/C}) \cdot (2.8 \times 10^{-6} \text{ C}) = 0.129 \text{ N} \) positive x-direction

(b) \( F_{\text{elec}} = (4.6 \times 10^4 \text{ N/C}) \cdot (-9.3 \times 10^{-6} \text{ C}) = -0.428 \text{ N} \) negative x-direction

7) Two charges \( q_1 \) and \( q_2 \), have equal magnitudes and are placed as shown in the figure below. The net electric field at point P is vertically upward. We must conclude that

(a) \( q_1 \) is positive and \( q_2 \) is negative.

(b) \( q_1 \) is negative and \( q_2 \) is positive.

(c) \( q_1 \) and \( q_2 \) are both negative.

(d) \( q_1 \) and \( q_2 \) are both positive.

Answer: (b) \( q_1 \) is negative and \( q_2 \) is positive

The total field will be the sum of 2 vectors – one toward \( q_1 \) and one away from \( q_2 \). The horizontal parts cancel out and the vertical parts are both upward.

Note that (a) will give a downward field, (c) will give a net field to the left, and (d) will give a net field to the right.