10. An electron and a proton are separated by a distance of 5.29×10^{-11} m in a hydrogen atom.

a. Determine the magnitude of the

i. electrostatic attractive force acting between the two particles using Coulomb's Law. [8.22×10^{-8} N]

ii. gravitational attractive force acting between the two particles using Newton's Universal Law of Gravitation: [3.63×10^{-47} N]

$$F_g = \frac{Gm_1 m_2}{r^2}$$

b. How many times larger is the electrostatic force? [2.27×10^{39}]

a)

i) $F_{el} = \frac{kq_1q_2}{R^2}$

$= \frac{(8.99\times10^{9})(1.60\times10^{-19}C)^2}{(5.29\times10^{-11})^2}$

$= 8.224\times10^{-8} N$

ii) $F_g = \frac{Gm_1m_2}{R^2}$

$= \frac{(6.67\times10^{-11})(9.11\times10^{-31}) \times (1.67\times10^{-27})}{(5.29\times10^{-11})^2}$

$= 3.62618\times10^{-47} N$

b) $\frac{F_{el}}{F_g} = \frac{8.224\times10^{-8} N}{3.626\times10^{-47} N} = 2.26795\times10^{39}$

2.27×10^{39} X

11. Two charged objects, A and B, separated by 40 cm, exert a force of 4.0×10^{-6} N on each other. If the distance between A and B were doubled, determine the magnitude of the resulting electric force. [1.0×10^{-6} N]

$F_{el} = \frac{kq_1q_2}{R^2}$ (kq_1q_2 kept constant) $\Rightarrow F_{el} \propto \frac{1}{R^2} \propto \frac{1}{(2)^2} \propto \frac{1}{4}$

$\frac{1}{4} \times 4.0\times10^{-6} N = 1.0\times10^{-6} N$

12. Two point charges produce an electrostatic force of attraction of 5.5×10^{-3} N. Determine the magnitude of the electrostatic force produced if the charge on each object is doubled and the distance between them is tripled. [2.4×10^{-3} N]

$F_{el} = \frac{k q_1 q_2}{R^2}$ (k = constant) $\Rightarrow F_{el} \propto \frac{q_1 q_2}{R^2}$

$\propto \frac{(2)(2)}{(3)^2} = \frac{4}{9} \times 5.5 \times 10^{-3}\ N = 2.4 \times 10^{-3}\ N$

13. Two point charges produce an electrostatic force of attraction of 3.5×10^{-6} N. Determine the magnitude of the electrostatic force produced if the charge on one object is doubled, the other is tripled and the charges are brought to halve their original distance. [8.4×10^{-5} N]

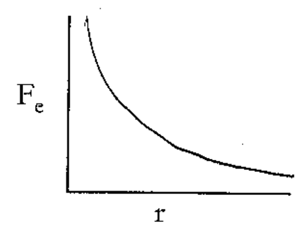
$F_{el} \propto \frac{q_1 q_2}{R^2}$

$\propto \frac{(2)(3)}{(.5)^2} = 24 \times 3.5 \times 10^{-6} = 8.4 \times 10^{-5}\ N$

14. Two equally charged identical pith balls are placed near each other and the electrostatic repulsive force is measured. Their position is changed and the force is again measured. This is repeated for a number of trials. [Appendix A]

a. Identify the formula that describes the information.

$F_{el} = k\frac{q_1 q_2}{R^2}$

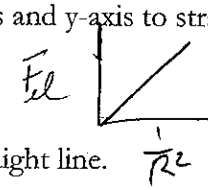


b. Sketch a graph of the relationship.

since $F_{el} \propto \frac{1}{R^2}$ hyperbola

c. Identify the graph's shape.

d. Identify what must be plotted on the x-axis and y-axis to straighten the graph.



$\Rightarrow$ slope $= \frac{F_{el}}{\frac{1}{R^2}}$ or $F_{el} \cdot R^2$

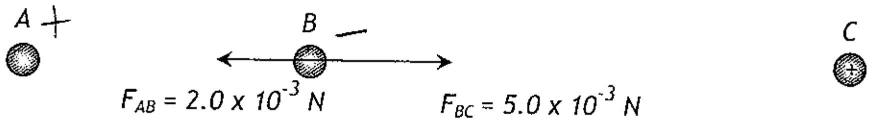
e. Predict the identity for the slope of the straight line.

Since $F_{el} = \frac{k q_1 q_2}{R^2} \Rightarrow$ slope $= k q_1 q_2$

f. Predict the identity for the intercept of the straight line.

origin is at 0,0

15. Three point charges, A, B, and C, are arranged in a line as shown.

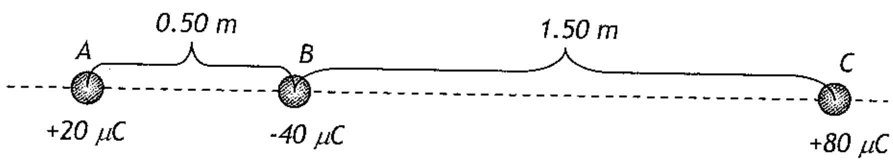


a. The charge on object C is positive. Determine the sign of the charge (+ or -) on object
   i. A. [Appendix A] +
   ii. B. [Appendix A] − law of charges

b. Determine the net electrostatic force acting on charge B. [3.0×10^{-3} N to the right]

$$F_{net} = F_{BC} - F_{AB}$$
$$= 5.0 \times 10^{-3} N - 2.0 \times 10^{-3} N$$
$$= 3.0 \times 10^{-3} N \; [E]$$

16. Three point charges, A, B, and C, are arranged in a line as shown.



Determine the net electrostatic force acting on charge
a. B. [1.6 N, left]
b. C. [9.2 N, left]

a) $F_{AB} = \frac{kq_1q_2}{r^2}$
$= \frac{k(20\times10^{-6})(40\times10^{-6})}{(0.50)^2}$
$= 28.768 N$

$F_{BC} = \frac{kq_1q_2}{r^2}$
$= \frac{k(40\times10^{-6})(80\times10^{-6})}{(1.50)^2}$
$= 12.786 N$

F_{AB} F_{BC}
A ← B → C
\+ − +

$F_{net} = F_{AB} - F_{BC}$
$= 28.768 - 12.786$
$= 15.982 N$
$= 16 N [W]$

A B ← C
\+ − +
F_{AC} F_{BC}

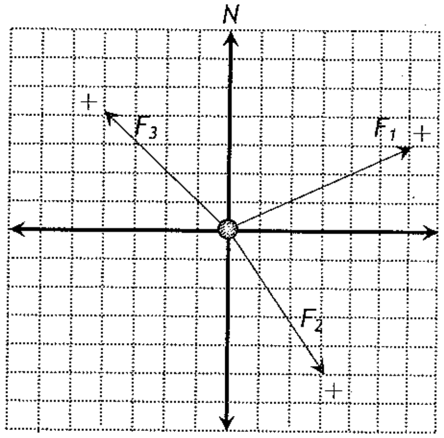
$F_{net} = F_{BC} - F_{AC}$
$= 12.786 - 3.596$
$= 9.19 N [W]$

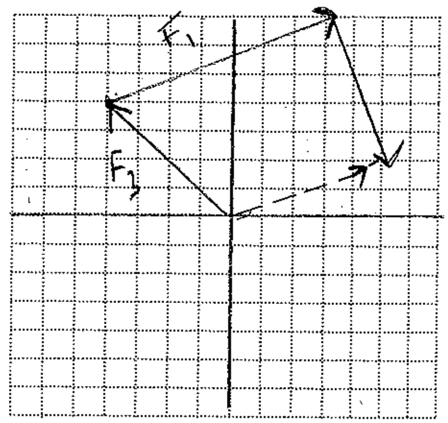
b) $F_{AC} = \frac{kq_1q_2}{r^2}$
$= \frac{k(20\times10^{-6})(80\times10^{-6})}{(2.00)^2}$
$= 3.596 N$

17. The vector nature of electrostatic forces may be communicated using scale diagrams as shown below.

a. Identify the nature of the charge, positive or negative, located at the origin of the grid. [Appendix A]

b. Use a ruler and protractor to draw the three force vectors head-to-tail and determine the resultant force. [~5.4 N, 22° N of E]





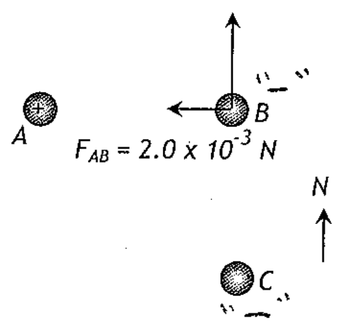
add vectors tip to tail

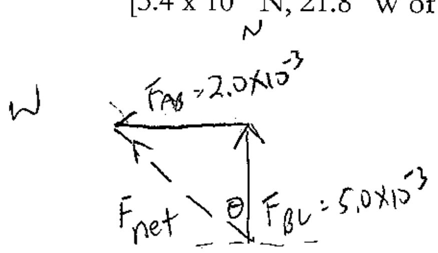
negative (the charge at the origin is attracted to + charges)

18. Three point charged objects are arranged in a right angle as shown in the diagram.

a. The charge on object A is positive. Identify the sign of the charge (+ or -) on object
   i. B. [Appendix A] "—"
   ii. C. [Appendix A] "—"

b. Determine the net electrostatic force acting on charge B. [5.4×10^{-3} N, 21.8° W of N]





$F_{net} = \sqrt{(5.0\times10^{-3})^2 + (2.0\times10^{-3})^2}$

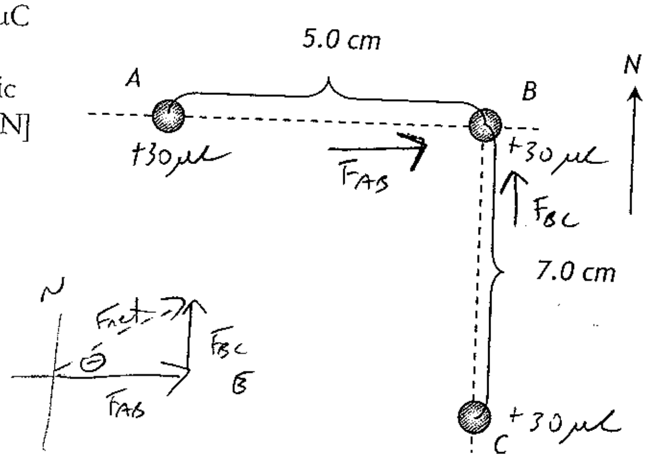
$= 5.385\times10^{-3}$ N

$= 5.4\times10^{-3}$ N

$\tan\theta = \frac{2.0\times10^{-3}}{5.0\times10^{-3}}$

$= 21.8°$ W of N

19. Three point charged objects of +30 μC each are arranged in a right angle as shown. Calculate the initial net electric force on charge B. [3.6 kN, 63° E of N]



$F_{BC} = \frac{k(30\times10^{-6})(30\times10^{-6})}{(0.07)^2}$

$= 1651.2\ N$

$F_{AB} = \frac{k(30\times10^{-6})(30\times10^{-6})}{(0.05)^2}$

$= 3236.4\ N$

$F_{net} = \sqrt{(1651.2)^2 + (3236.4)^2}$

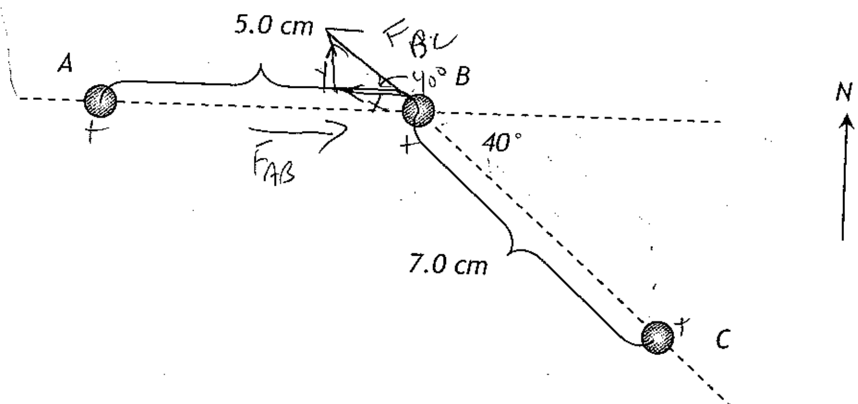
$= 3632.8\ N$

$= 3.6\times10^3\ N$

$\tan\theta = \frac{3236}{1651}$

$= 63°$ E of N

20. Three point charges, each having identical charges of +2.0 μC, are aligned as shown in the diagram below. Determine the initial net force acting on charge B due to charges A and C. [10 N, 28° N of E]



i) $F_{AB} = \frac{k(2.0\times10^{-6})^2}{(0.05)^2}$

$= 14.384\ N$

$F_{BC} = \frac{k(2.0\times10^{-6})^2}{(0.07)^2}$

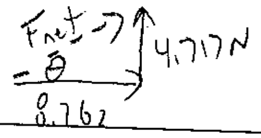
$= 7.339\ N$

ii)

X (N)	Y (N)
$F_{net} = F_{AB_x} - F_{BC_x}$	$F_{net} = F_{AB_y} - F_{BC_y}$
$= 14.384 - (\cos 40 \times 7.339)$	$= 0 + (\sin 40 \times 7.339)$
$= 8.762\ N$	$= 4.717\ N$

$\tan\theta = \frac{4.717}{8.762}$

$= 28.3°$ NE



$F_{net} = \sqrt{(8.762)^2 + (4.717)^2}$

$= 9.951\ N$