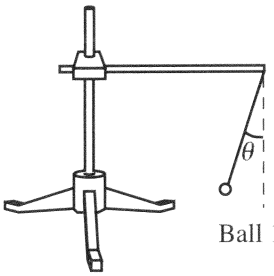
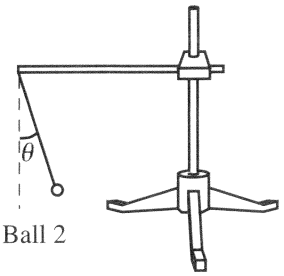
CHARGE

Name _____

1. Two identical metal balls are suspended by insulating threads. Both balls have the same net charge. In this problem, do not assume the balls are point charges.



Ball 1



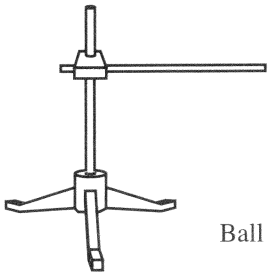
Ball 2

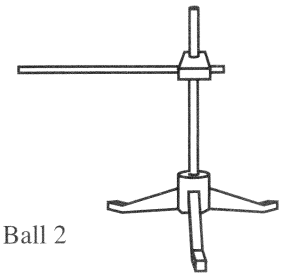
a. Draw a separate free-body diagram for each ball. Label the forces to indicate:

- the object exerting the force,
- the object on which the force is exerted,
- the type of force (gravitational, normal, *etc.*), and
- whether the force is a contact or a non-contact force.

Free-body diagram for ball 1	Free-body diagram for ball 2
●	●

b. Suppose the charge on the second ball is reduced slightly, so that it is less than that on the first ball.

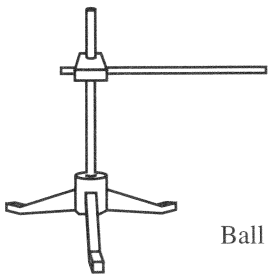

Ball 1

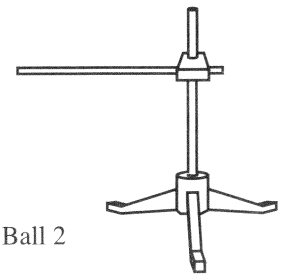

Ball 2

Predict whether the angle that ball 1 makes with the vertical will be *greater than, less than,* or *equal to* the angle that ball 2 makes with the vertical. Explain. Sketch your answer above.

How does the free-body diagram for each ball in this case compare to the corresponding free-body diagram that you drew in part a? If the magnitudes or directions of any of the forces change, describe how they change.

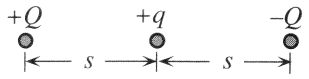
c. Predict what will happen if the net charge on ball 2 is reduced to zero. Make a sketch to illustrate your answer.


Ball 1


Ball 2

2. *Coulomb's law* allows us to find the force between two *point* charges.

   Three point charges are held fixed in place as shown.



   Consider the following comment about this situation:

   "There will be zero net electric force on the charge in the middle due to the other charges. Using Coulomb's law, the force due to the +Q charge is positive, and the force due to the -Q charge is negative. The forces cancel."

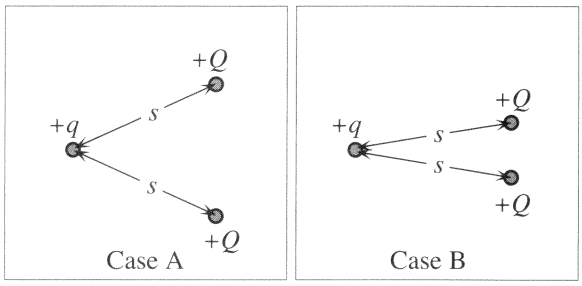
   a. Do you agree with this statement? Explain.

   b. How does Coulomb's law apply to situations in which there are more than two point charges?

3. Each of the following parts involves a comparison of the net electric force exerted on a positive charge $+q$ in two different cases.

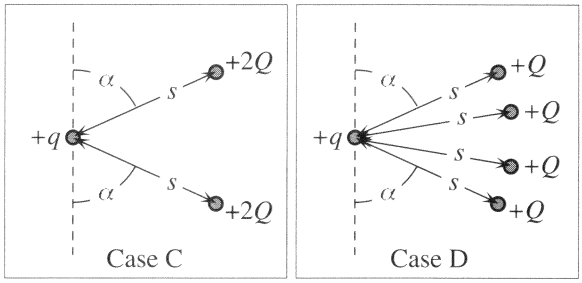
   a. In cases A and B shown at right there are two positive point charges $+Q$ each a distance s away from a third positive point charge $+q$.

   Is the net electric force on the $+q$ charge in case A *greater than, less than,* or *equal to* the net electric force on the $+q$ charge in case B? Explain.

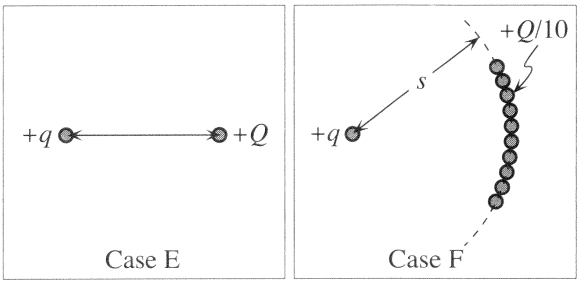


   b. In case C, two positive point charges $+2Q$ are each a distance s away from a third positive point charge $+q$. In case D, four positive point charges $+Q$ are each a distance s away from a fifth positive point charge $+q$. (The angle α shown is the same in both cases.)

   Is the net electric force on the $+q$ charge in case C *greater than, less than,* or *equal to* the net electric force on the $+q$ charge in case D? Explain.

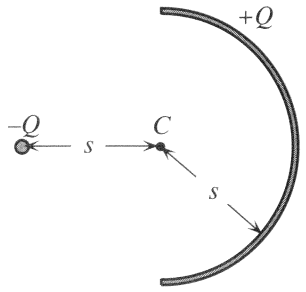


c. In case E a positive point charge with $+Q$ is a distance s away from a third positive point charge $+q$. In case F ten positive point charges, each with charge $+Q/10$, lie along an arc of radius s centered on a positive point charge $+q$.



Is the net electric force on the $+q$ charge in case E *greater than, less than,* or *equal to* the net electric force on the $+q$ charge in case F? Explain.

4. A thin semicircular rod has a total charge $+Q$ uniformly distributed along it. A negative point charge $-Q$ is placed as shown. A test charge $+q$ is placed at point C. (Point C is equidistant from $-Q$ and from all points on the rod.)

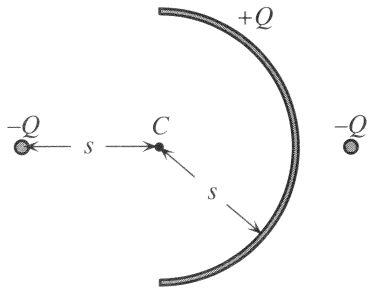


Let F_P and F_R represent the force on the test charge due to the point charge and the rod respectively.

a. Is the magnitude of F_P *greater than, less than,* or *equal to* the magnitude of F_R? Explain how you can tell.

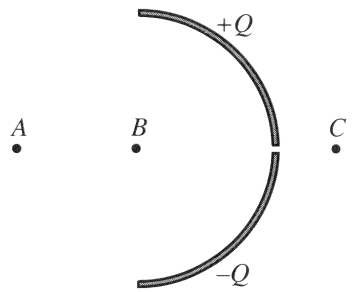
b. Is the magnitude of the *net* force on $+q$ *greater than, less than,* or *equal to* the magnitude of F_P? Explain.

c. A second negative point charge $-Q$ is placed as shown.



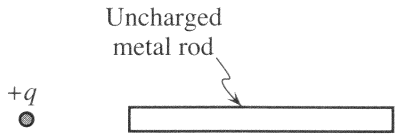
Is the magnitude of the *net* electric force on $+q$ *greater than, less than,* or *equal to* the magnitude of the net electric force on $+q$ in part b? Explain.

5. A thin semicircular rod like the one in problem 4 is broken into two halves. The top half has a total charge $+Q$ uniformly distributed along it, and the bottom half has a total charge $-Q$ uniformly distributed along it.



On the diagram, indicate the direction of the net electric force on a positive test charge placed in turn at points *A*, *B*, and *C*. Explain how you determined your answers.

6. A positive point charge $+q$ is placed near an uncharged metal rod.



a. Sketch the charge distribution on the rod.

b. Is there a non-zero net electric force on the rod? Explain.

c. Is there a non-zero net electric force on the point charge? Explain.

7. State whether the magnitude of the net electric force on the charge labeled $+Q_o$ in case A is *greater than, less than,* or *equal to* the magnitude of the net electric force on the charge labeled $+Q_o$ in case B. Explain how you determined your answer.