III. [25 points total] In parts A and B below, ignore interactions between the metal balls suspended from strings (i.e., between balls A and B and between balls D and E).

A. [6 pts] Two small metal balls, A and B, are suspended from insulating strings. Ball C is mounted on an insulating stand. Balls A and B are observed to repel from ball C, as shown at right.

Is it possible that the sign of the net charge on ball A is the same as that on ball B? Explain.

Since balls A and C repel, they could have the same sign net charge. Similarly, balls B and C could have the same sign net charge. Therefore, it is possible for all three balls (in particular, balls A and B) to have the same sign net charge.

B. [6 pts] Two small metal balls, D and E, are suspended from insulating strings. Ball F is mounted on an insulating stand. Ball D is attracted to ball F, whereas ball E is repelled from ball F, as shown at right.

Is it possible that the sign of the net charge on ball D is opposite that on ball E? Explain.

Since balls E and F repel, they could have the same sign net charge. Since balls D and F attract, they could have net charges of opposite signs. Thus, (since ball E could have the same sign net charge as ball F, and ball D could have the opposite sign as ball F,) balls D and E could have net charges of opposite signs.

C. Two point charges, +Q and +10Q, are placed near a neutral metal rod, as shown in the top-view diagram at right.

i. [7 pts] On the diagram at right, draw a qualitatively correct charge distribution on the rod. Explain your reasoning.

A neutral metal rod has an equal number of positive and negative charges that are free to move. A negative point charge in the center of the metal rod is the same distance from +Q and +10Q. However, the charge of +10Q is greater than that of +Q. Thus, the attractive force between +10Q and the negative charge will be greater than that between +Q and the negative charge. Therefore, the charge will move in the direction of +10Q. Similarly, a positive point charge in the center of the rod will experience a greater repulsive force from +10Q than from +Q. (Similar reasoning applies for other charges within the rod: although these charges are different distances from +Q and +10Q, the difference in charge dominates.)

ii. [6 pts] Is there a net electric force on the +Q charge by the rod? If so, state whether the force is attractive or repulsive, and explain your reasoning. If not, state so explicitly and explain why not.

By the principle of superposition, the net electric charge on +Q by the rod will be equal to the sum of the electric forces exerted by the individual point charges in the rod. There are the same number of positive charges on the end closer to +Q as there are negative charges on the opposite end. However, the positively charged end of the rod is closer to +Q. Therefore, the repulsive forces from the point charges there will have greater magnitudes than the attractive forces from the negative point charges at the opposite end of the rod. Thus, the net electrical force on the +Q charge by the rod is repulsive.