Quiz a

Problem 1

(a) Possible positions for charges are are on the left side of the two charges.

\[ \sum F = 0 \]

\[ \frac{Q_0 Q_2}{(X_0 - X_2)^2} + \frac{Q_0 Q_1}{(X_0 - X_1)^2} = 0 \]

\[ \frac{\sqrt{Q_2}}{X_2 - X_0} = \frac{\pm \sqrt{Q_1}}{X_1 - X_0} \]

\[ X_2 = \pm \frac{\sqrt{Q_2}}{\sqrt{Q_1}} (X_1 - X_0) + X_0 \]

\[ X_0 = 0 \]

\[ \Rightarrow X_2 = \pm \frac{\sqrt{Q_2}}{\sqrt{Q_1}} X_0. \]

Since \( X_2 < 0 \), \( X_2 = -\frac{\sqrt{Q_2}}{\sqrt{Q_1}} X_0. \)
So, \( X_2 = -X_1 \), when \( Q_2 = Q_1 \),

\[ X_2 = \frac{Q_1}{x_1} x_2, \text{ when } Q_2 = 2Q_1. \]

(b) Using the superposition principle.

For \( Q_2 = Q_1 \),

\[
    U(x) = \frac{Q_0 Q_2}{|x_2 - x_1|} + \frac{Q_0 Q_1}{|x_1 - x|}
    \]

\[
    = \frac{Q_0 Q_1}{|x_1 + x|} + \frac{Q_0 Q_1}{|x_1 - x|}
    \]

\[
    U(x) = \frac{2Q_1 Q_0}{|x_1|}
    \]

\[
    U(x) - U(0) = Q_0 Q_1 \left( \frac{1}{|x_1 + x|} + \frac{1}{|x_1 - x|} \right) - \frac{2Q_1 Q_0}{|x_1|}.
    \]

\[
    U(x) - U(0) = \frac{2Q_1 Q_0}{|x_1|}.
    \]
(c)
In this case, the total force will point to the right, so the Qo will move toward the positive X direction.
Problem 2.
If the object doesn't carry a third type of charge, only positive or negative, then if I measure the force between it and a positive charge, and the force between it and a negative charge, the two forces will be in the different direction. Otherwise, if the forces are both repulsive or attractive, then there must be something new on the charges.
Problem 3

(a) 

(b) If \(-Q\) was made more negative, the net force may be reversed. Then, if you rotate it again, it will move away from the original orientation.
Problem 4

(a) According to Gaussian theorem,

\[ E(r) = 0 \quad \text{for } r < R_0 \]

when \( r > R_0 \),

\[ E = \frac{\nabla \phi}{\varepsilon_0} \]

\[ \phi = \frac{Q}{\varepsilon_0} \frac{1}{r} \]

(b) \[ V(0) = -\int_0^\infty E \, dr \]

\[ V(r) = V(0) - \int_0^r E \, ds \]

\[ V(r) = \frac{Q}{\varepsilon_0} \left( \frac{1}{r} - \frac{1}{R_0} \right) \]

if \( r < R_0 \), \( V(r) = V(0) \)

\[ V(r) - V(0) = -\int_0^r E \, ds \]

if \( r > R_0 \), \( V(r) = V(0) - \frac{Q}{\varepsilon_0} \ln \frac{r}{R_0} \).