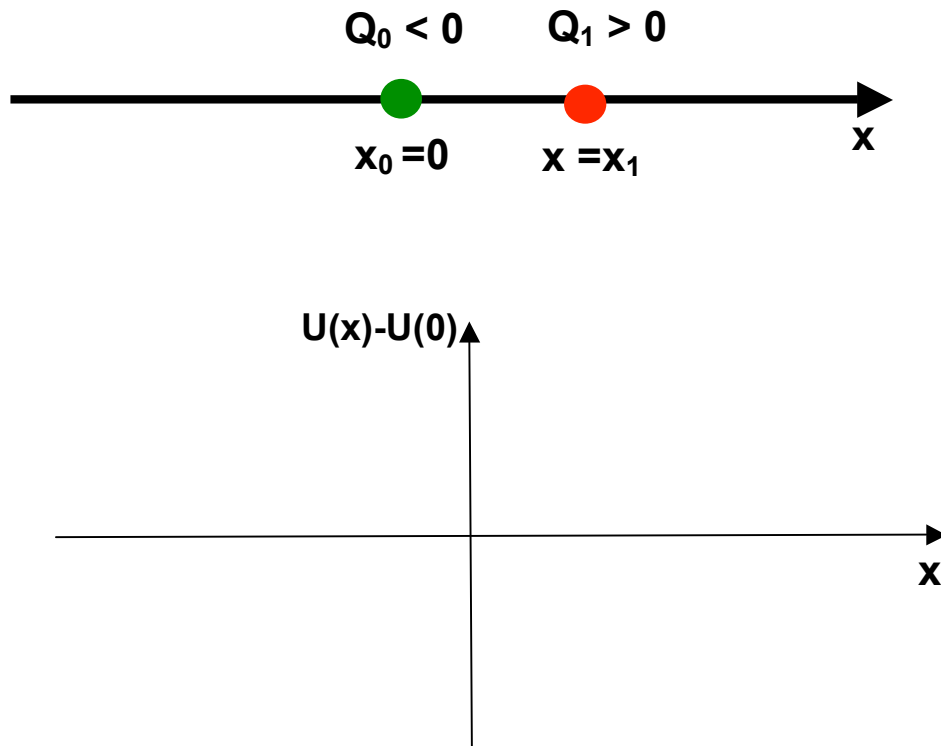


Problem 1 (25 points)

Consider the configuration shown below, with a negative charge Q_0 at position $x_0=0$ and another positive charge Q_1 at position x_1 along the x-axis.

- (a) At which position x_2 could another positive charge Q_2 be added, such that the total force on Q_0 is 0? Give two examples of x_2 and corresponding Q_2 , in terms of x_0 , x_1 , Q_0 and Q_1 (or a subset of these variables).
- (b) Suppose Q_0 is free to move along the x-direction, while Q_1 and Q_2 are fixed. For one of your examples, draw a sketch on the graph below, showing the change in electric potential energy $U(x) - U(0)$ for Q_0 as a function of position in x .
(Hint: Consider the potential energy due to Q_1 and Q_2 separately and remember the superposition principle)
- (c) Qualitatively, describe what would happen if Q_0 was displaced by a small distance Δx from $x_0=0$ to $x=\Delta x$ and then released (two sentences max.)?



Problem 2 (25 points)

Suppose I brought an object to class and claimed that this object carries a third type of charge (i.e. neither 'positive' nor 'negative', but a third type of electric charge). Given what you know about the attraction/repulsion between like and unlike charges and between charged and neutral objects, describe the steps you would take to verify or dispute my claim. Assume you have positively and negatively charged objects and neutral objects at hand and that you have a device to measure the force between any two objects.

Your answer should have no more than 5 or 6 sentences.

Quiz a

Problem 1

(a) Possible positions for charge 3 ~~are~~ are on the ~~left~~ left side of the two charges.

$$\sum \vec{F} = 0$$

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

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

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

~~Let~~ $X_0 = 0$

$$\Rightarrow X_2 = \pm \frac{\sqrt{Q_2}}{\sqrt{Q_1}} X_1$$

Since $X_2 < 0$, $X_2 = -\frac{\sqrt{Q_2}}{\sqrt{Q_1}} X_1$

So ~~Q_2~~ $X_2 = -X_1$ when $Q_2 = Q_1$

$X_2 = -\sqrt{2}X_1$ when $Q_2 = 2Q_1$

(b)

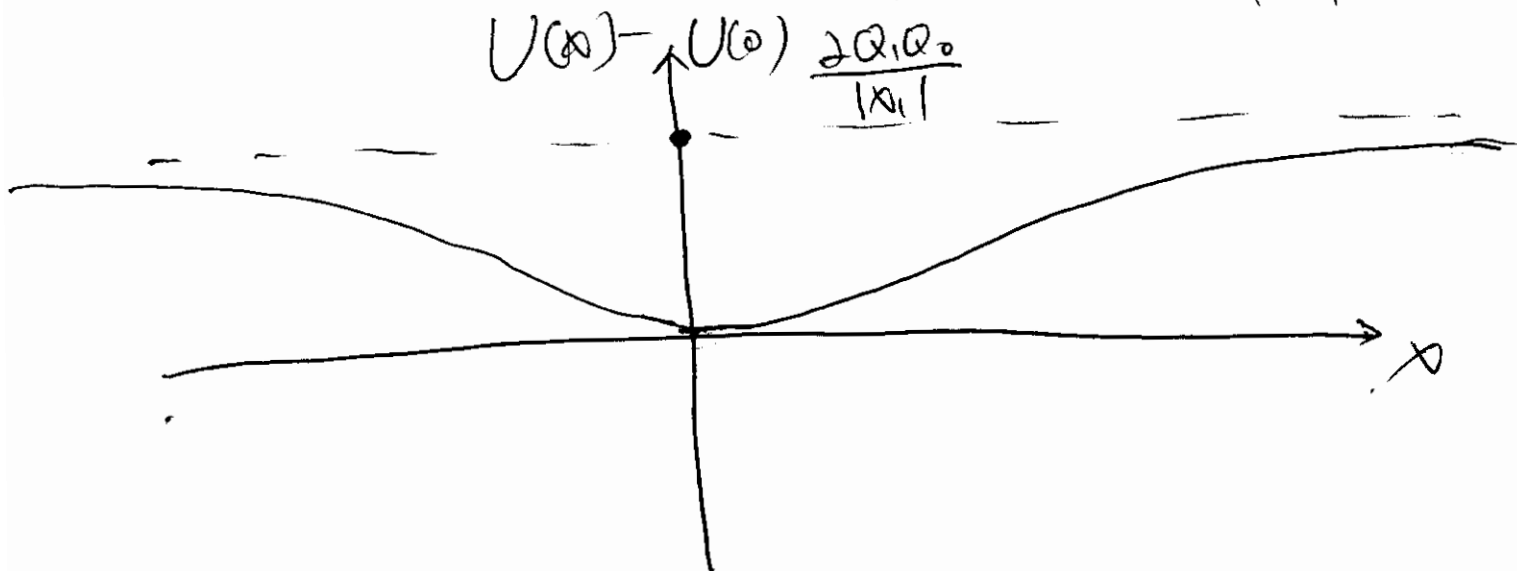
Using the superposition principle
For $Q_2 = Q_1$

$$U(x) = \frac{Q_0 Q_2}{|X_2 - X_1|} + \frac{Q_0 Q_1}{|X_1 - X_2|}$$

$$= \frac{Q_0 Q_1}{|X_1 + X_1|} + \frac{Q_0 Q_1}{|X_1 - X_1|}$$

$$U(0) = \frac{2Q_1 Q_0}{|X_1|}$$

$$U(x) - U(0) = Q_0 Q_1 \left(\frac{1}{|X_1 + x|} + \frac{1}{|X_1 - x|} \right) - \frac{2Q_1 Q_0}{|X_1|}$$



(C)

In this case, the ~~the~~ total force will point to the right, so the

Q_0 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~~ 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~~ repulsive or attractive, then there must be some ~~thing~~ new ~~on the~~ charges