

8.02X Electricity and Magnetism

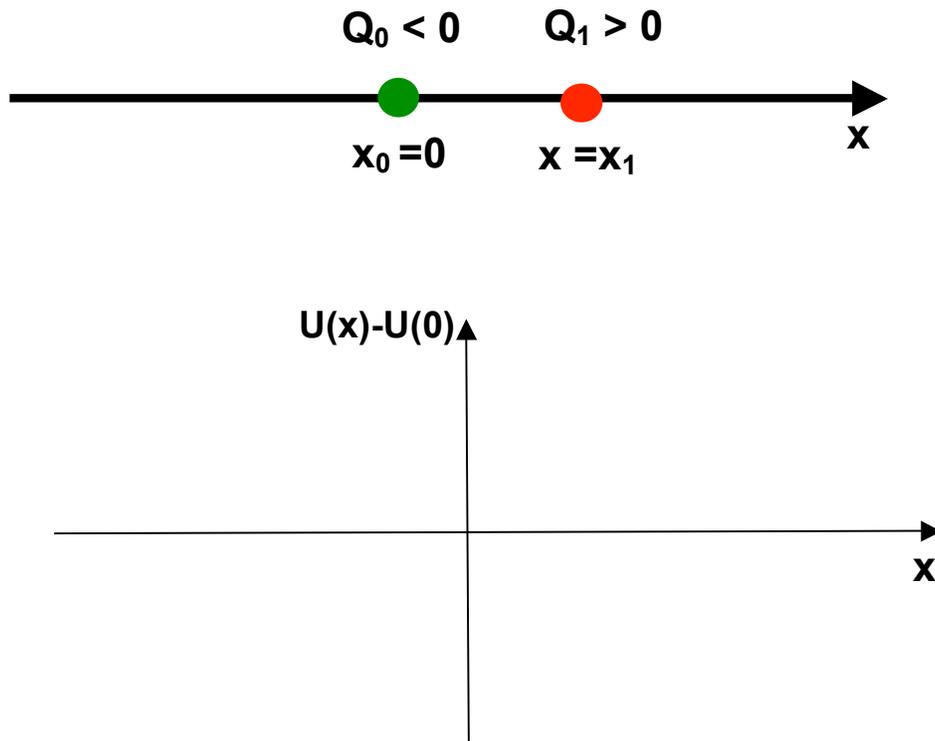
Practice Quiz #1a

*The quiz has four questions. It is a closed book quiz. No calculators are allowed.
A letter-size formula sheet can be used, but has to be signed and submitted together with
the quiz.*

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)

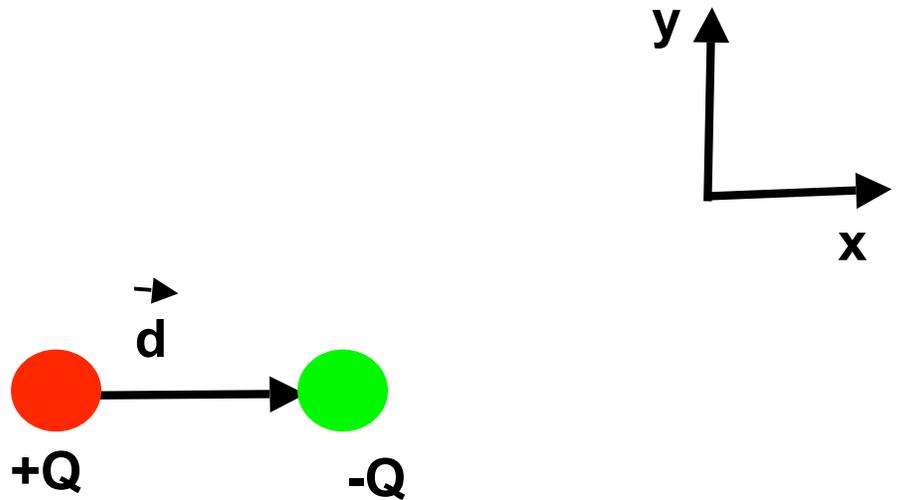
Suppose I brought an object to class and claimed that this object carries a third type of charge (i.e. neither 'positive' nor 'negative', but a third type of electric charge). Given what you know about the attraction/repulsion between like and unlike charges and between charged and neutral objects, describe 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.

Problem 3 (25 points)

Shown below is an electric dipole with equal charges $+Q$ and $-Q$ separated by a distance d . The dipole is free to rotate or move. Consider the following information: The dipole sits inside an external electric field with $|E| > 0$. The dipole does not feel a net torque. The dipole feels a net force in the $-x$ direction. When rotated from its original orientation and released, the dipole moves back towards the original orientation.

- (a) On the picture below, sketch field lines corresponding to an external electric field that is compatible with this description. Do not include the field due to the dipole charges.
- (b) How would the force and torque on the dipole change if the magnitude of the negative charge was increased, i.e. if the charge $-Q$ was made more negative? (two sentences max.)?



Problem 4 (25 points)

Shown below is a thin conducting cylindrical shell of radius r_0 , carrying a surface charge density $\sigma > 0$ (the thickness of the shell can be neglected).

- (a) Find the electric field $E(r)$ created by the charged shell as a function of r , where r is the distance to the center of the cylinder (neglect edge effects, i.e. assume the shell is infinitely long). Determine $E(r)$ both for $r < r_0$ and for $r > r_0$. Show work.
- (b) Determine the corresponding electric potential $V(r)$ as a function of r .
- (c) On the graph below, sketch the potential energy $U(r)$ for a positive point-charge $q_0 > 0$ in the field created by the shell.

