## 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.

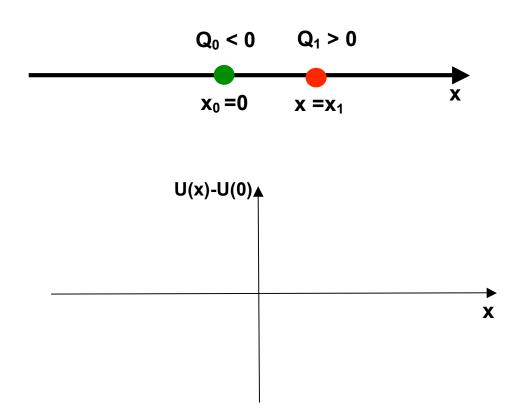
Problem 1 (25 points)

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 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  $\Delta x$  from  $x_0=0$  to  $x=\Delta x$  and then released (two sentences max.)?



Problem 2 (25 points)

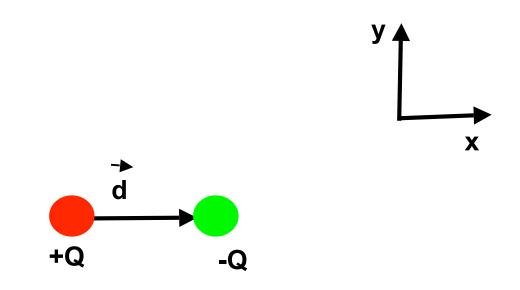
Suppose I brought an object to class and claimed that this object carries a third type of charge (i.e. neither 'positive' nor 'negative', but a third type of electric charge). Given what you know about the attraction/repulsion between like and unlike charges and between charged and neutral objects, describe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

U(r)-U(0)

r

