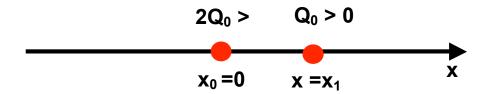
Practice Quiz #1b

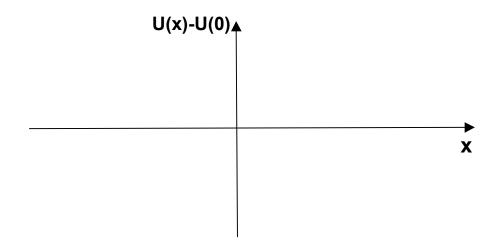
The quiz has four questions. It is a closed book quiz. No calculators are allowed. A letter-size formula sheet can be used, but has to be signed and submitted together with the quiz.

Problem 1 (25 points)

This problem deals with 3 positive charges, Q_0 , $2Q_0$ and $3Q_0$. Consider the configuration shown below, with a $+2Q_0$ at position x_0 =0 and a positive charge Q_0 at position x_1 along the x-axis

- (a) Find a position x_2 where the third positive charge $Q_3 = 3Q_0$ could be added, such that the total force on Q_3 is 0?
- (b) Suppose Q_3 was moved a small distance Dx to the right (towards positive x) and then released from rest. What would the subsequent motion of Q_3 be?
- (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.)?

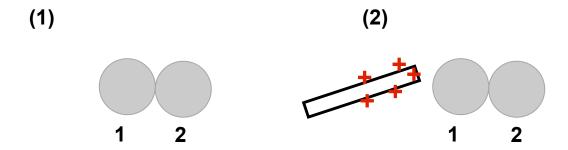


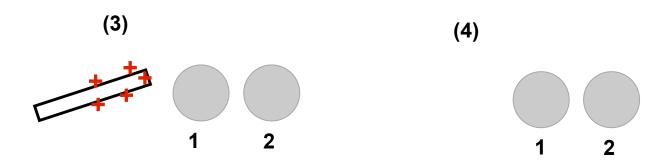


Problem 2 (25 points)

Consider the sequence of events (1) to (4) shown below. We start with 2 neutral conducting spheres that touch each other, but are insulated from the rest of the world (1). Then a positively charged rod is brought close to sphere 1, while sphere 1 and sphere 2 still touch. The rod does not touch the spheres(2). In the next step, the spheres are separated (3). Finally, the charged rod is removed (4).

- (a) For each of the 4 steps, sketch the charge distribution on the spheres on the pictures below.
- (b) After the rod has been removed (step (4)), consider the charges Q_1 on sphere 1 and Q_2 on sphere 2. Which of the following statements is true:
 - (i) $Q_1 = Q_2 = 0$
 - (ii) $|Q_1| > |Q_2|$
 - (iii) $|Q_2| < |Q_1|$
 - (iv) $Q_1 = -Q_2, Q_1 < 0$
 - (v) $Q_1 = -Q_2, Q_1 > 0$

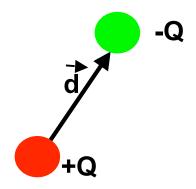




Problem 3 (25 points)

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 electric field with |E| > 0. The dipole does not feel a net torque. The dipole does not feel a net force. 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 electric field that is compatible with this description.
- (b) Qualitatively, describe what would happen if the positive charge +Q was doubled, while keeping the negative charge the same (two sentences max.)?



Problem 4 (25 points)

Shown below is a thin conducting spherical shell of radius r_0 , carrying a total charge Q > 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 shell. Determine E(r) both for $r < r_0$ and for $r > r_0$
- (b) Determine the corresponding electric potential V(r) as a function of r, relative to V(r=0) = 0.
- (c) On the graph below, sketch the potential energy U(r) for a negative point-charge $q_0 < 0$ in the field created by the shell.

