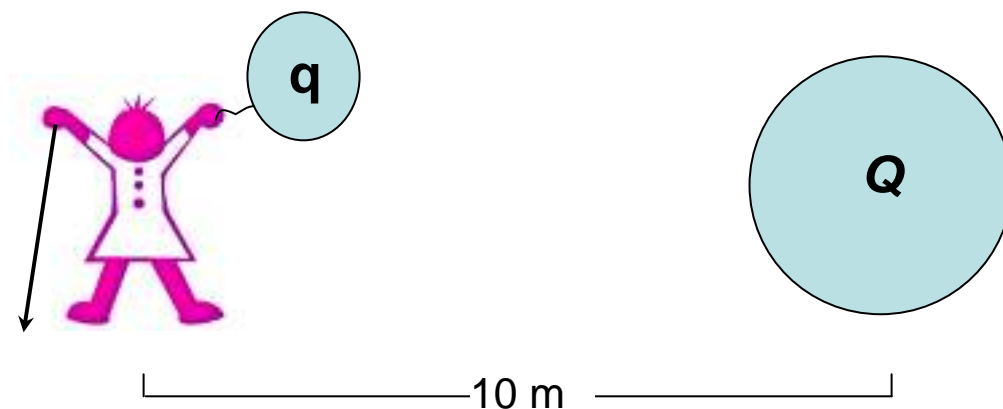**Discussion Question 4A**
P212, Week 4
Electric Potential and Work

Electric Potential Energy can be considered *unrealized* kinetic energy for a particle in a fixed location. It takes work to move a particle from a position of lower potential energy to a position of higher potential energy. This increase in potential energy at rest may be converted to (or "realized as") kinetic energy when the particle is allowed to move from the position of higher potential energy back to the position of lower potential energy.

Imagine that one of your hands is attached to a positive test charge q and the other hand holds a stake that can attach you to the ground. You are first staked to the ground at a distance 10 m from a positive charge Q. (Assume that gravity is zero for this problem, and that you and the test charge are small enough to be treated as point charges). Let's further assume, when you lift the stake, you (somehow) float without friction… The total mass of you + the mass of charge q + the mass of the stake is M.

(a) You lift the stake so that suddenly you are free to move. As a consequence, do you start to gain or to lose kinetic energy?

What does this imply about the sign of the work done by the field on you in the process ?
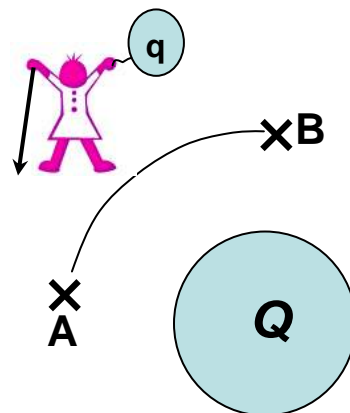
(b) You re-stake yourself at a distance 12 m from Q.

Has your (electric) potential energy increased or decreased?

How is the change in your potential energy, ΔU, related to the amount of work done by the field?

(c) You lift the stake again, and now walk radially around Q from A to B, as shown at right. What is the change in your potential energy?

Would the change in potential energy be different if you had walked from A to B in a straight line? Explain.

(d) You are still a distance 12 m from Q. You lift the stake again and, since you are now able to move without friction, find that you are moving with velocity v_0 as you pass a point 14 m from Q. How is your velocity related to the change in your potential energy?

(e) You re-stake yourself at 14 m from Q. You now change q from a <u>positive</u> to a <u>negative</u> charge, and un-stake yourself again.

What is the magnitude of your velocity as you pass a point at a distance 12 m from Q?

Does your potential energy increase or decrease as you move?

What is the sign of the work done by the field on you in this case?

(f) *Electric potential energy, U,* is a property of an object, while *electric potential, V = U/q* (where q is a test charge), is a property of space. Just as the electric field was defined as the force that would be exerted on a test charge ($\bar{E} = \bar{F} / q$), the change in electric *potential* can be defined as the **work** that would be exerted on a test charge, $\Delta V = -W_{AB}/q$, where W_{AB} is the work exerted by the field as particle q moves from A to B. Both *potential* and *potential energy* can only be defined with respect to a reference point.

Would your answer to (c) change if you considered *potential*, rather than *potential energy?*

For the case in part (e), if you doubled the value of q before you moved, how would ΔV change?

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