Name: ______________________ **Problems Solved __/ 11**

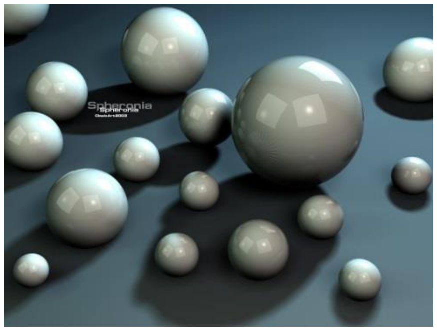
A weightlifter lifts a mass *m* a distance *d* above the ground.

a) Calculate the work done be gravity during the lift by solving the *Work Integral*.
b) What is ΔU, the change in potential energy during the lift?
c) After the lift, the weightlifter drops the weights. Use the *Work Energy Theorem* to calculate the velocity of the weights as they hit the ground assuming that they start from rest and fall a distance *d*.

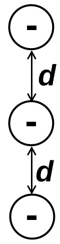
A Weight Lifting Space Ant (there is no gravity) is standing on Very Large Charged Plate with surface charge density $+\sigma$ lifting a barbell with a total charge *-q*.

a) Use the Work Integral to calculate the work done by the electric force if he lifts the barbell a distance *d*.
b) What is ΔU, the change in potential energy during the lift?
c) After the lift, the Weight Lifting Space Ant drops the barbell. Use the *Work Energy Theorem* to calculate the velocity of the barbell as it hits the ground, assuming that it starts from rest and falls a distance *d*.

The Sphericons are negatively charged creatures who live on a positively charged sphere with a radius R and a total charge Q. They are under attack from their evil neighbors, the Cubicons, who are dropping negatively charged bullets on them from a very long way away. Assume that the bullets have a mass m, charge $-q$ and that they start from rest at an effective distance of infinity. Use the Conservation of Energy to determine the velocity of the bullets as they impact the surface of Spheronia.



Three electrons are spaced 1.0 mm apart along a vertical line. The outer two electrons are fixed in position, and the center one is free to move.



(a) Is the center electron at a point of stable or unstable equilibrium? Why?

(b) If the center electron is displaced horizontally by an infinitesimal distance, what will be its speed when it is very far away ($r = \infty$)?

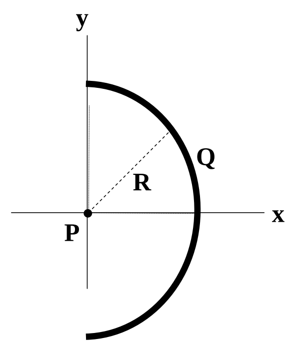
Two point charges, each of magnitude 2 μC, are located on the *x*-axis. One is at $x = 1.0$ m, and the other is at $x = -1.0$ m.

(a) Determine the electric potential on the *y*-axis at $y = 0.50$ m. Draw a sketch.

(b) Calculate the change in electric potential energy of the system if a third particle of charge -3 μC is brought from infinitely far away and placed on the *y*-axis at 0.50 m.

A uniformly charged insulating rod of length 14 cm is bent into the shape of a semicircle. If the rod has a total charge of -7.5 μC, find the electric potential at the center of the semicircle (point *P*).

Hint: The procedure is very similar to the one you followed when finding electric field, but now you don't have to worry about *x*- or *y*-components because *V* is a scalar. Easier! Show all steps.



Explore the relationships among $\vec{F}, \vec{E}, V, U$.

(a) The electric potential due to a collection of charged particles is $V(x) = (5x^3 + 4x + 2)$ volts along the *x* axis. Calculate the electric field vector at $x = 2$ m. Then calculate the electric force vector acting on a 3.0 μC charge at that location.

(b) The electric potential energy due to a collection of charged particles is $U(x) = (4x^4 - 6)$ Joules along the *x* axis. Calculate the electric force vector acting on a charge at $x = -3$ m. Then calculate the electric field vector at that location if the charge is 5.0 μC.

(c) The electric force vector on a charged particle is $\vec{F}(x) = (5x + 3)\hat{i}$ Newtons along the *x* axis. Calculate the change in electric potential energy when the particle moves from $x = 2$ m to $x = 4$ m. By how much does the voltage change in that region if the particle's charge is 4.0 μC?

(d) The electric field vector along the x axis is $\vec{E}(x) = (9x^3 + 7x)\hat{i}$. Calculate the change in voltage a charge experiences when moving from $x = -7$ m to $x = 2$ m.

1. Wolfson, Volume II, 2nd Edition, 22.29

2. Wolfson, Volume II, 2nd Edition, 22.50

3. Wolfson, Volume II, 2nd Edition, 22.56

Hints: First draw a sketch of the ring with the *x*-axis as the ring's axis. Next, label the elemental charge *dq* and geometric parameters, and then find a general expression for *V* in terms of *k*, *Q*, *x*, and *R*. The procedure is very similar to the one you followed when finding electric field, but now you don't have to worry about *x*- or *y*-components because *V* is a scalar. Show all steps.

You should get this: $V = \frac{kQ}{\sqrt{x^2 + R^2}}$. After you've proven this result, answer the question in the book.

4. Wolfson, Volume II, 2nd Edition, 22.57

Hint: As we did when finding electric field, integrate over thin rings (but now there are no vector components, and the bounds of your integral aren’t 0 and *R*).