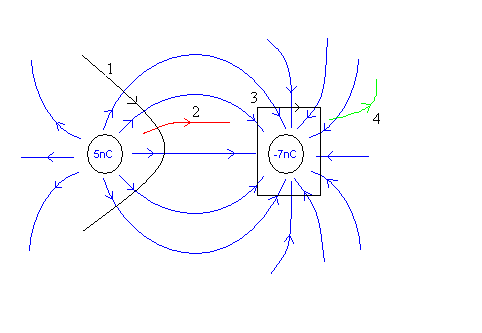
Potential Problems

**Problem**

Consider the electric field, **E**, below, and the 4 paths indicated. Which one most closely approximates an equipotential? Which one has negative change in potential? Which positive? Which zero overall change?

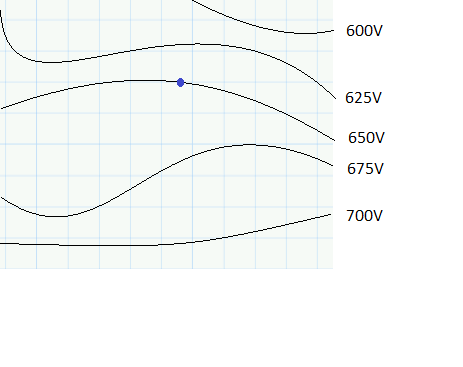


**Solution**

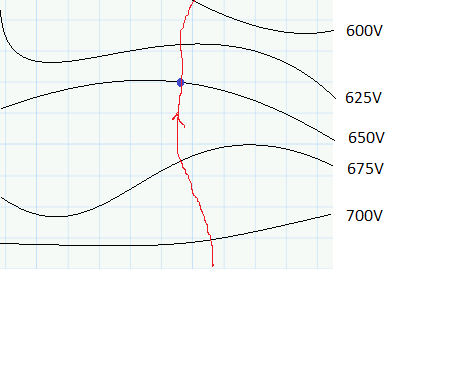
1 is equipotential, 2 is negative, 4 is positive, 3 is zero net.

**Question 4 (20 points)**

Suppose each square is 1cm by 1cm. Draw the field line, intersecting the dot, through all equipotentials. Label the direction of the field line with an arrow, and estimate the magnitude of the electric field between the 650 and 675 Volt equipotentials.



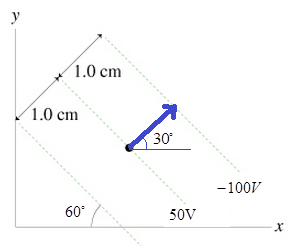
We have:



and the length of the path between the equipotentials is roughly 2.5cm, so the field strength would be E = -(650V – 675V)/(2.5cm) = 1000V/m.

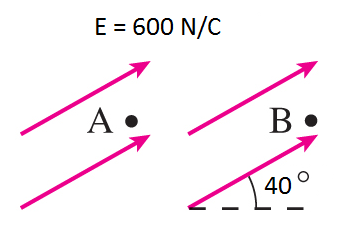
**Problem 5 (10 pts.)**

What is the magnitude and direction (specified as an angle CCW w/r to the positive x axis) of the electric field in the figure?



and E = ΔV/Δs = 150V/0.01m = 15 000 V/m.

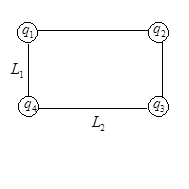
**Question 2.** The potential at point B is VB = 10V. If A is 3mm away from B, what is the potential at point A?





**Problem**

3 positive charges q1 = 1μC, q2 = 2μC, q3 = 3μC sit at the vertices of a rectangle with dimensions L1 = 5m and L2 = 10m. What is the electric potential at the location of charge 4, and what is charge 4’s potential energy? If charge 4 was suddenly released, what would be its kinetic energy infinitely far away (supposing its mass to be m = 2g)?



**Solution**

Electric potential is just:



and so the potential energy of charge 4 is:

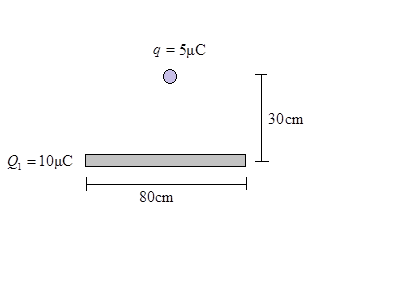


At infinity, all of its PE will be converted to KE. And so we’ll have:



**Question 5 (20 points)**

Similar to problem 1, an 80cm rod is uniformly charged to Q = 10μC, and a point charge q = 5μC (and m = 0.063kg) is sitting 30cm above the midpoint of the rod. When the point charge is released, it will accelerate away from the rod. What speed will it ultimately reach, once it gets infinitely far away? You may assume that the rod is held stationary. And also may neglect any gravitational force.



First have to find the rod’s potential at the location of the point charge. This is:



And so the potential energy of the point charge is:

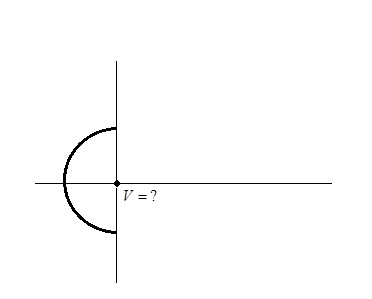


Now using the work-energy equation, we have:



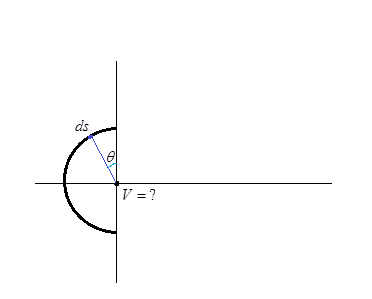
**Problem**

Consider a semicircular rod of radius R and charge Q evenly distributed along its length, pictured as shown. What is the potential at the center?



**Solution**

We start by isolating a tiny point charge on the semi-circle, and determine the potential created by it at the origin:



We have:



Integrating,



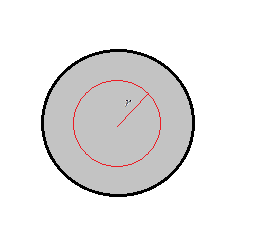
where we’ve used the fact that λ = Q/L = Q/πR.

**Problem**

A non-conducting sphere has radius *R* = 3cm and uniformly distributed charge *q* = 6 fC. Take the electric potential at the sphere's center to be *V*0 = 0. What is *V* in volts at radial distance from the center *r* = 2cm? To answer this you will need the electric field E inside the sphere at radius r.

**Solution**

Situation looks like this…



To calculate potential difference we first need to calculate the field at a given point (radius). So let us draw a Gaussian sphere of arbitrary radius r (not 2cm yet). The field at this point would be:



Then the potential difference between center and the radius r = 2cm is:



Filling in the numbers…

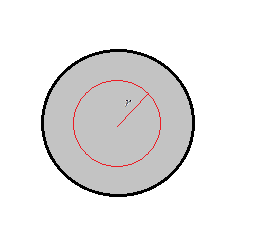


**Example**

Suppose the potential is zero at ∞. What is the potential at the center? A non-conducting sphere has radius *R* = 3cm and uniformly distributed charge *q* = 6nC. Take the electric potential at ∞ to be zero. What is *V* in volts at radial distance from the center *r* = 3cm? What is it at the center? To answer this you will need the electric field E inside the sphere at radius r.

**Solution**

At r = 3cm, it would just be V = kQ/r = 1800V.



At the center we use:



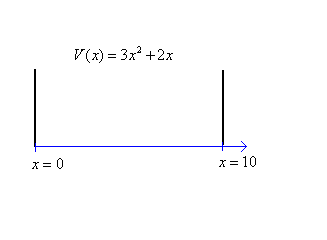
Then the potential difference between r = R and 0 is:



and so potential at the middle would be V = 2700V.

**Problem**

Say the electric potential between the two plates is given by V(x) = 3x2 + 2x. In that case, what is the strength and direction of the electric field at the point x = 5?



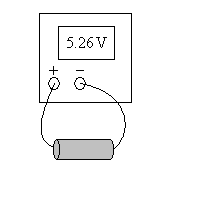
**Solution**

We have:



**Problem**

Suppose you take this reading from a voltmeter across a resistor. If the resistor is 2.2cm long, what is the strength and direction of the **E** field in the resistor?



**Solution**

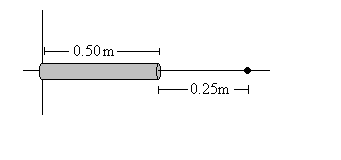
We have:



and so points to the right.

**Problem**

Calculuate the electric potential at the point indicated, supposing that a total charge of 2μC is uniformly distributed over the length of the wire. Be sure to show the work, from the integral expression for V to the solution.



**Solution**

Let L = 0.50m, and r = 0.75m. Then,

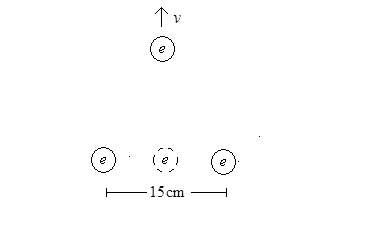


Now λ = 2μC/0.5m = 4×10-6C/m. And so:



**Problem**

Two electrons are fixed 15cm apart, and another is placed directly in between them. If give the middle one a slight push in the y direction, keeping the other two fixed, what will be its speed infinitely far away? Start with the work-energy equation and work your way to the answer.



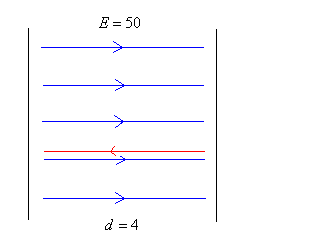
**Solution**

We have from the WE equation….



**Problem**

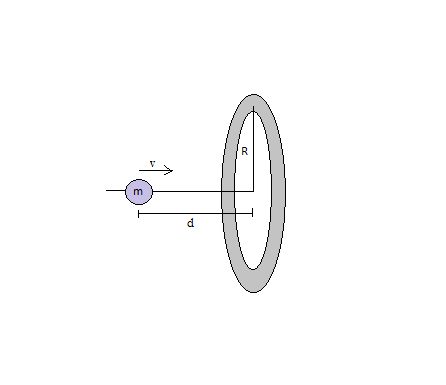
Let’s calculate how much work is required to move an electron from one plate to another (not changing its KE)



**Solution**

.

**Question 3**. A charge q = 5μC with mass m = 0.078kg sits a distance d = 12cm away from a charged ring with radius R = 8cm and total charge Q = 17μC. What minimum velocity does q need to be given so that it will *just* make it through the ring?





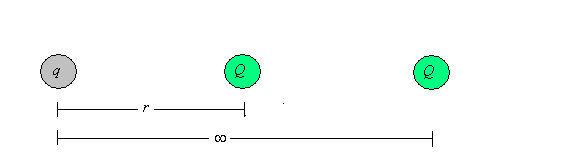
**Question 5**. The electric field along the x-axis is given by E(x) = 3x2 + 4x (N/C). How much work would be required to move a 2C charge from xA = -5cm to xB = 7cm?

Work is equal to ΔKE + ΔPE = 0 + ΔPE = qΔV = q(-∫Exdx). And so we have:



**Problem**

Suppose we have two charges q and Q separated by a distance r. How much work is required to bring the two together from infinitely far away (not changing its KE)?



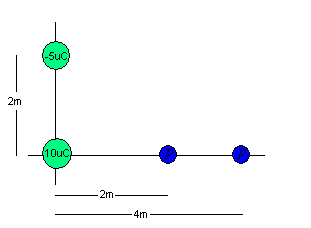
**Solution**

Well, W = ΔPEe = QΔV,



**Problem**

Suppose we have,



Determine work required to move bluey from far away to closer (again not changing its KE).

**Solution**

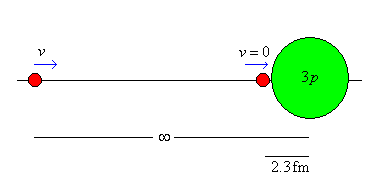
We would have,



Ask them if it matters which way we go from initial to final.

**Problem**

To initiate the radioactive decay of a Li isotope to another element we need to bombard it with protons. Specifically the proton needs to get inside the nucleus. The radius of the nucleus is roughly 2.3fm. To what speed do we need to accelerate the proton (red circle) so that it can get this close to the Li nucleus? What potential difference would be required?

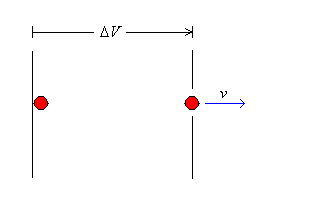


**Solution**

We have,



What potential difference is required?



Ask direction. Of course the field will point left to right.



So the potential decreases from left to right, which is consonant with the fact that **E** must point left to right.

**Problem**

e- orbits the p at distance of around 1A. What is the total energy of the atom?

**Solution**

So the total energy is:



But now r is related to υ via N2L. We have,



Therefore,



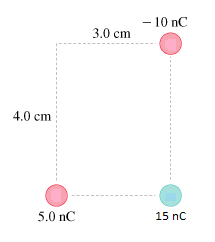


If r = 10-10, then,



which is also therefore the energy required to ionize the H-atom. This is close to the actual value of -13.6eV. eV = 1.6×10-19 J.

**Question 3**. If the 5nC charge is released from rest, how fast will it be going very far away from the other two charges? You may take the charge as having a mass m = 67mg.



Energy is conserved and so we have:



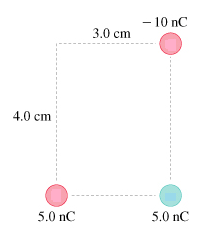
Initial potential is given by:



Plugging this into the equation for v we have:



**Question 6**. If the 5nC charge is released from rest, how fast will it be going very far away from the other two charges?



I just might have made a mistake on this one. Maybe. Maybe. So what we would’ve done is this. Since there is no non-conservative force acting on/in the system, mechanical energy is conserved. And so we have:



Inititial potential is given by:



Since Vi < 0, there will not be a real velocity v. And this is because the charge doesn’t fly off towards infinity (and beyond?), but rather get’s drawn towards the negative charge. When I was putting the numbers together in my head, I was accidentally squaring the r’s, in which case it works out. Apparently even brilliant physicists *occasionally* make mistakes. So….free points!

**Question 7**. In the problem above, what is the total potential energy of the three charges?

Can’t screw this one up at least. Potential energy is given by:



**Problem 7 (10 pts.)**

In order to initiate decay of a *235U* nucleus (charge *92e*), an α particle (charge *2e*, mass 6.67×10-27 kg) must get within 2fm of the nucleus. What initial speed must the α particle be given to accomplish this?

Using conservation of energy we have:

