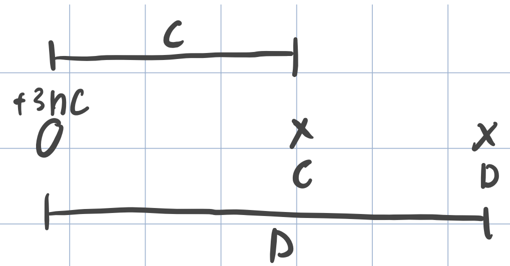
Location *C* is 0.022 m from a small sphere that has a charge of 3 nC uniformly distributed on its surface. Location *D* is 0.056 m from the sphere. What is the change in potential along a path from *C* to *D*?

[ ] V

$V = -\vec{E} \cdot \vec{r}$



Electric field is not constant so integration is required

$$V = -\int_C^D \frac{1}{4\pi\varepsilon_0} \frac{Q}{r^2}\, dr$$

$$= -\frac{Q}{4\pi\varepsilon_0} \int_C^D r^{-2}\, dr$$

$$= -\frac{Q}{4\pi\varepsilon_0} \left(-r^{-1} \Big|_C^D \right)$$

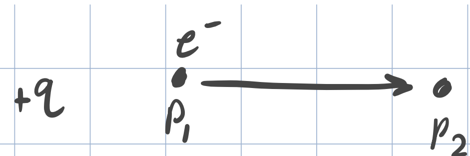
$$= \frac{Q}{4\pi\varepsilon_0} \left(\frac{1}{D} - \frac{1}{C} \right)$$

$$= -745.1299\, V$$

An electron is initially at rest. It is moved from a location 3.8×10^{-10} m from a proton to a location 5.5×10^{-10} m from the proton. What is the change in electric potential energy of the system of proton and electron?

[ ] J

Use the equation above



$$V = \frac{Q}{4\pi\varepsilon_0} \left(\frac{1}{P_2} - \frac{1}{P_1} \right)$$

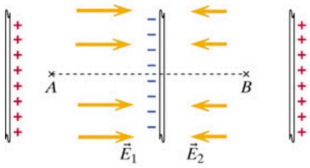
$$V = \frac{\Delta U}{q}$$

$$\Delta U = V_q$$

Q = Charge creating electric field
q = Charge of object with potential energy in the field.

$$= \frac{Qq}{4\pi\varepsilon_0}\left(\frac{1}{r_2} - \frac{1}{r_1}\right)$$

$$= 1.874e-19 \text{ J}$$



As shown in the diagram, three large, thin, uniformly charged plates are arranged so that there are two adjacent regions of uniform electric field. The origin is at the center of the central plate. Location *A* is < -0.2, 0, 0>m, and location *B* is < 0.2, 0, 0>m. In region 1 the electric field is $\vec{E}_1$ = < 575, 0, 0> V/m. In region 2 the electric field is $\vec{E}_2$ = < -275, 0, 0> V/m.

(a) Consider a path from *A* to *B*. Along this path, what is the change in electric potential?
ΔV = [ ] ---Select---

(b) What is the change in electric potential along a path from *B* to *A*?
ΔV = [ ] ---Select---

(c) There is a tiny hole in the central plate, so a moving particle can pass through the hole. If a proton started at *A* and moved to *B* along the path shown, what would be the change in its kinetic energy?
ΔK = [ ] ---Select---

If the proton had kinetic energy 2e-18 J when it is at location *A* what would the kinetic energy of the proton be upon reaching location *B*?
K = [ ] ---Select---

Would it be possible for the proton actually to reach location *B*? Note that if you find the final kinetic energy to be negative, that means the proton will not actually get to location *B* (a negative kinetic energy is impossible).

- ○ No
- ○ Yes

Part One

$$V = V_{a \text{ to origin}} + V_{b \text{ to origin}}$$

$$= -\vec{E}_A \vec{r}_a - \vec{E}_B \vec{r}_B$$

$$= -(575)(0 - A) - (-275)(B - 0)$$

$$= -(575)(0.2) - (-275)(0.2)$$

$$= -60 \text{ V}$$

Part Two

$V = 60\,v$

Part Three

$$V = \frac{\Delta U}{q}$$

$$\Delta U = Vq$$

$$\Delta U = -\Delta k$$

$$-\Delta k = Vq$$

$$\Delta k = -Vq$$

$$= 9.6e-18\ J$$

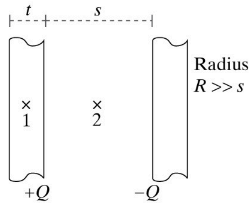
Part Far

$$k = k_o + \Delta k$$

$$= 11e-18\ J$$

Part Five

Yes



Potential difference in a capacitor

A capacitor consists of two large metal disks placed a distance *s* apart (see the figure). The radius *R* of each disk is 6.6 m, the gap *s* between the disks is 1.2 mm, and the thickness *t* of each disk is 0.4 mm. The disk on the left has a net charge of 3.6×10^{-4} C and the disk on the right has a net charge of -3.6×10^{-4} C. Calculate the potential difference $V_2 - V_1$, where location 1 is inside the left disk at its center, and location 2 is in the center of the air gap between the disks. Use $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/(N \cdot m^2)$.

$V_2 - V_1 =$ ______ V

$V = V_2 - V_1$

$V_1 = 0$ because its in a conductor

$V = V_2$

$V = -|E_{cap}|\Delta x$

$|E_{cap}| \approx \frac{Q}{A\varepsilon_0}$

$\approx \frac{Q}{\pi r^2 \varepsilon_0}$

$V = -\frac{Q}{\pi r^2 \varepsilon_0} \Delta x$

$= -\frac{Q}{\pi r^2 \varepsilon_0} \frac{s}{2}$

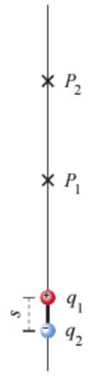
$= -178.350$ V

A dipole is centered at the origin, with its axis along the y axis, so that at locations on the y axis, the electric field due to the dipole is given by

$$\vec{E} = \left\langle 0, \frac{1}{4\pi\varepsilon_0}\frac{2qs}{y^3}, 0 \right\rangle \frac{\text{V}}{\text{m}}$$

The charges making up the dipole are $q_1 = +8$ nC and $q_2 = -8$ nC, and the dipole separation is $s = 8$ mm (see figure below). What is the potential difference along a path starting at location $P_1 = \langle 0, 0.04, 0 \rangle$ m and ending at location $P_2 = \langle 0, 0.07, 0 \rangle$ m?

[ ] V



$V = -|\vec{E}_{dipole}|\Delta r$ a constant electric field

$$V = -\int_{P_1}^{P_2} \frac{1}{4\pi\varepsilon_0}\frac{2qs}{r^3}\,dr$$

$$= -\frac{2qs}{4\pi\varepsilon_0}\int_{P_1}^{P_2} r^{-3}\,dr$$

$$= -\frac{2qs}{4\pi\varepsilon_0}\left(-\frac{1}{2}r^{-2}\Big|_{P_1}^{P_2}\right)$$

$$= \frac{2qs}{8\pi\varepsilon_0}\left(\frac{1}{r^2}\Big|_{P_1}^{P_2}\right)$$

$$= \frac{qs}{4\pi\varepsilon_0}\left(\frac{1}{P_2^2} - \frac{1}{P_1^2}\right)$$

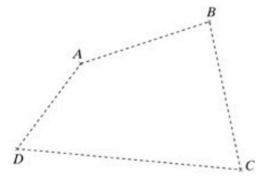
$$= -242.449\,\text{V}$$

In a region of space there are several stationary charged objects. Along a path from *A* - *B* - *C* - *D* as shown in the figure below, you measure the following potential differences:

$V_B - V_A = 12$ V

$V_C - V_B = -4$ V

$V_D - V_C = -16$ V



(a) What is the potential difference $V_A - V_D$?

$V_A - V_D =$ [ ] V

(b) Which of the following concepts are important in finding the answer to part (a)?

- [ ] The potential inside a metal at equilibrium is constant.
- [ ] The sum of the potential differences along a round-trip path must be zero.
- [ ] The potential near a point charge is proportional to $1/r$.
- [ ] The potential near a negative point charge is negative.
- [ ] Change in potential energy = $q\Delta V$.

Part One

$$V_A - V_D = -(V_D - A)$$

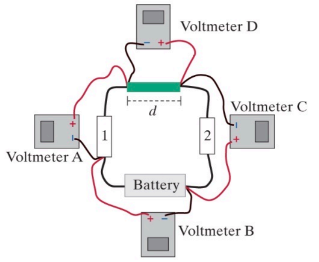
$$= -(V_{ab} + V_{bc} + V_{CD})$$

$$= -((V_B - V_A) + (V_C - V_B) + (V_D - V_C))$$

$$= 8V$$

Part Two

Only 2 matters in finding the answer above



Four voltmeters are connected to a circuit as shown in the diagram. As is usual with voltmeters, the reading on the voltmeter is positive if the negative lead (black wire, usually labeled COM) is connected to a location at lower potential, and the positive lead (red) is connected to a location at higher potential.

The circuit contains two devices whose identity is unknown, and a rod of length d = 5 cm made of a conducting material. At a particular moment, the readings observed on the voltmeters are:
Voltmeter A: -1.7 volts
Voltmeter B: -4 volts
Voltmeter C: -2.5 volts

At this moment, what is the reading on Voltmeter D, both magnitude and sign?
ΔV = ______ volts
What is the magnitude of the electric field inside the bar?
$|\vec{E}|$ = ______ V/m
What is the direction of the electric field inside the bar?
---Select---

Part One

$$V_A + V_B + V_C + V_D = 0$$

$$V_D = -V_A - V_B - V_C$$

$$= 8.2\text{ V}$$

Part Two

$$V = -E\Delta r$$

$$E = -\frac{V}{\Delta r}$$

$$= -164 \text{ V/m}$$

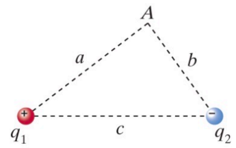
$$|E| = 164 \text{ V/m}$$

Part Three

To the left because E is negative

Calculate the potential at location A in the figure. Assume that q_1 = 3 nC, q_2 = -8 nC, a = 12 cm, b = 9 cm and c = 15 (1 nC is 10^{-9} C.)

[ ] V



$$V_A = V_1 + V_2$$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{a} + \frac{q_2}{b}\right)$$

$$= -575\ V$$

A highly charged piece of metal (with uniform potential throughout) tends to spark at places where the radius of curvature is small, or at places where there are sharp points. The breakdown electric field strength for air is about 3 × 10^6 V/m.

(a) What is the maximum possible potential of a metal sphere of 18 cm radius in air? (That is, what is the potential at the surface of the sphere, relative to infinity?)

[ ] volts

(b) What is the maximum possible potential of a metal sphere of only 0.7 mm radius?

[ ] volts

Part One

$\vec{E}$ is 3e6 V/m because that is the point that current starts arcing into the air

$$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$$ radius not position

$$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$

$$Q = 4\pi\varepsilon_0 E r^2$$

$$V = \frac{1}{\cancel{4\pi\varepsilon_0}}\frac{\cancel{4\pi\varepsilon_0} E r^{\cancel{2}}}{\cancel{r}}$$

$= Er$

$= 540000\,V$

Part Two

Same equation as above

$V = 2100\,V$