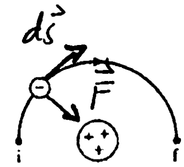
Solns

PHYS 121 — Tutorial #2 – group problem solving

1.



An electron ($q = -e$) completes half of a circular orbit of radius r around a nucleus with $Q = +3e$.

a. How much work is done on the electron as it moves from i to f? Give either a numerical value or an expression from which you could calculate the value if you knew the radius. Justify your answer.

$W = \int_i^f \vec{F}\cdot d\vec{s}$ $\vec{F} \perp d\vec{s}$ $\therefore \vec{F}\cdot d\vec{s} = 0$ $\therefore \boxed{W = 0}$

b. By how much does the electric potential energy change as the electron moves from i to f?

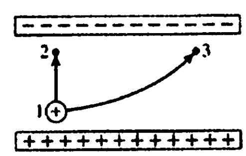
$W = -\Delta U$, but $W = 0$. $\therefore U_i = U_f \rightarrow$ P.E. is const.

c. Is the electron's speed at f greater than, less than, or equal to its speed at i?

If P.E. is const, then so is K.E.

$\therefore$ speed at i & speed at f are equal.

2.



Inside a parallel-plate capacitor, two protons are launched with the same speed from point 1. One proton moves along the path from 1 to 2, the other from 1 to 3. Points 2 and 3 are the same distance from the negative plate.

a. Is $\Delta U_{1\rightarrow 2}$, the change in potential energy along the path $1 \rightarrow 2$, larger than, smaller than, or equal to $\Delta U_{1\rightarrow 3}$? Explain.

Same. $\Delta U_{1\rightarrow 2} = \Delta U_{1\rightarrow 3}$

$\Delta U = -W$. Electric force is conservative.

$\therefore$ work is path indep s.t. $W_{1\rightarrow 2} = W_{1\rightarrow 3}$ $\therefore \Delta U_{1\rightarrow 2} = \Delta U_{1\rightarrow 3}$.

b. Is the proton's speed v_2 at point 2 larger than, smaller than, or equal to v_3? Explain.

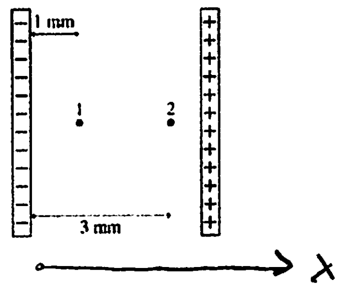
$W = \Delta K$

$\therefore \Delta K_{1\rightarrow 2} = \Delta K_{1\rightarrow 3}$

$\therefore$ if particles had same initial speed, then they have the same final speed.

3.

The figure shows two points inside a capacitor. Let $V = 0$ V at the negative plate.



a. What is the ratio V_2/V_1 of the electric potentials at these two points? Explain.

$$\Delta V = -\int_0^x \vec{E}\cdot d\vec{x} = -Ex \qquad V(0) = 0$$

$$\therefore V = -Ex \qquad \therefore \frac{V_2}{V_1} = \frac{x_2}{x_1} = 3$$

b. What is the ratio E_2/E_1 of the electric field strengths at these two points? Explain.

Between the plates of a capacitor, $E = $ const.

$$\therefore \frac{E_2}{E_1} = 1.$$

4.

A capacitor with plates separated by distance d is charged to a potential difference ΔV_C. All wires and batteries are disconnected, then the two plates are pulled apart (with insulated handles) to a new separation of distance $2d$.

a. Does the capacitor charge Q change as the separation increases? If so, by what factor? If not, why not?

$$C = \frac{Q}{\Delta V_C}$$

If plates are not connected to anything, there can be no flow of charge. Q does <u>not</u> change.

b. Does the electric field strength E change as the separation increases? If so, by what factor? If not, why not?

For large charged sheets, E is indep. of position.

$\therefore$ E does <u>not</u> change.

c. Does the potential difference ΔV_C change as the separation increases? If so, by what factor? If not, why not?

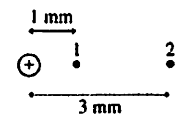
$$\Delta V_C = \frac{Q}{C} \qquad C = \varepsilon_0 \frac{A}{d}$$

if d doubles, then C is cut in half.

If C decreases by 2, then **ΔV_C doubles.**

5.

The figure shows two points near a positive point charge.



a. What is the ratio V_1/V_2 of the electric potentials at these two points? Explain.

$$V = \frac{kQ}{r} \quad \therefore \frac{V_1}{V_2} = \frac{r_2}{r_1} = 3$$

b. What is the ratio E_1/E_2 of the electric field strengths at these two points? Explain.

$$E = \frac{kQ}{r^2} \quad \therefore \frac{E_1}{E_2} = \left(\frac{r_2}{r_1}\right)^2 = 9$$

6.

An inflatable metal balloon of radius R is charged to a potential of 1000 V. After all wires and batteries are disconnected, the balloon is inflated to a new radius $2R$.

a. Does the potential of the balloon change as it is inflated? If so, by what factor? If not, why not?

To make it easy, treat balloon as a sphere.

$V_1 = \frac{kQ}{R}$ If balloon is isolated from surroundings, the Q is const.

$\therefore V_2 = \frac{kQ}{2R}$ $\therefore$ balloon's potential decreases by a factor of 2.

b. Does the potential at a point at distance $r = 4R$ change as the balloon is inflated? If so, by what factor? If not, why not?

For a point outside a charged sphere, potential is like that of a pt. charge at centre of sphere.

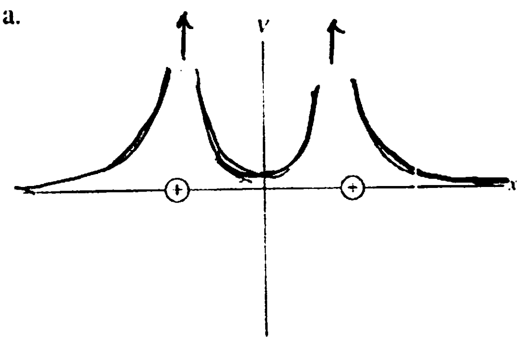
$V = \frac{kQ}{r}$ $\therefore$ at $r = 4R$, it doesn't matter if balloon radius is R or 2R.

Potential is still $\frac{kQ}{4R}$

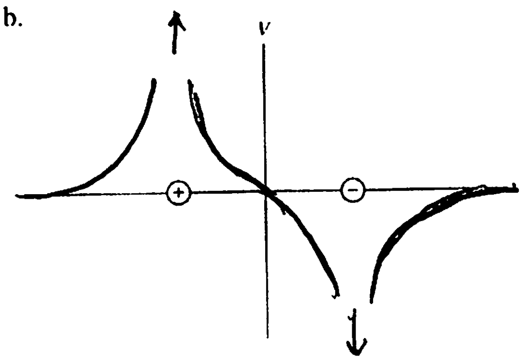
7.

On the axes below, draw a graph of V versus x for the two point charges shown.

a.



b.



For a single pt. charge $V = \frac{KQ}{r}$

i.e. $V \to \infty$ for $r \to 0$ if $Q > 0$

$V \to -\infty$ for $r \to 0$ if $Q < 0$.