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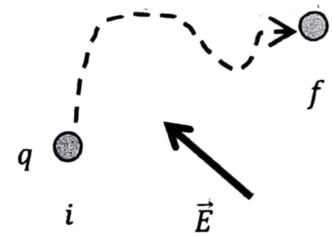
After this activity you should know: *• Relation between electric voltage and electric potential energy. • Use electric potential to solve conservation of energy problems. • Find the potential difference created by a uniform electric field. • The direction charges would move if release from rest in regions of changing potential.*

Work done against the electric force can be stored as electric potential energy U. The change in electric potential energy when a charge q is moved from point i to point f is:

$$\Delta U = -W_E = -\int_i^f q\vec{E}\cdot d\vec{s}.$$



The electric potential (or voltage) is defined as the potential energy per charge

$$V = \frac{U_q}{q},$$

where U_q is the part of the energy involving charge q. Therefore the change in electric potential energy is related to change in electric potential as

$$\Delta U = q\Delta V$$

We can use this in conservation of energy and work-energy problems.

1. The SI unit of the electric potential is the volt = Joule/Coulomb.

   a. What is volt in terms of kilograms (kg), meters (m), seconds (s) and Coulombs (C)? Show work.

   $$\frac{J}{C} = \frac{N\cdot m}{C} = \frac{kg\, m^2}{C\, s^2}$$

   b. Usually the units of the electric field is written as V/m. Show that this is the same as N/C. Show work.

   $$\frac{V}{m} = \frac{J}{Cm} = \frac{N\cdot \cancel{m}}{C\cdot \cancel{m}} = \frac{N}{C}$$

2. A $+2\mu C$ charge moves from a point where the voltage is 8 Volts to a point where the voltage is 5 Volts. $\boxed{-6\cdot 10^{-6}\ J}$

   a. What is the change in electric potential energy during this process?

   $$\Delta U = q\Delta V$$

   $$2\cdot 10^{-6}\,(3) =$$

   b. The kinetic energy of the charge at the first position is 20 μJ. What is the kinetic energy of the charge at the second position? Assume that only electric forces act on the charge during this process. *Reminder: what happens to the kinetic energy if the potential energy increases?*

   $$\Delta KE = \Delta U$$

   $$KE_f - 20\,\mu J = -6\cdot 10^{-6}\ J \qquad KE_f = 2.6\cdot 10^{-5}\ J$$

Electric potential energy and electric potential (voltage) due to a uniform electric field:

For a uniform electric field, the change in electric potential energy during a process is

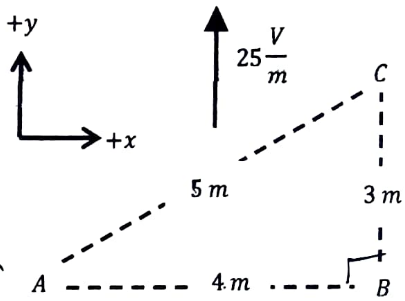
$$\Delta U = -W_E = -\vec{F}_E \cdot \Delta\vec{r} = -q\vec{E} \cdot \Delta\vec{r}$$

The change in voltage between the beginning and end points is (recall how to calculate scalar products):

$$\Delta V = \frac{\Delta U}{q} = -\vec{E} \cdot \Delta\vec{r} = -E_x\Delta x - E_y\Delta y - E_z\Delta z = -|\vec{E}|\,|\Delta\vec{r}|\cos\theta$$

where θ is the angle between $\vec{E}$ and $\Delta\vec{r}$ when you place their tails together. Note that only the component of the displacement $\Delta\vec{r}$ in the direction $\vec{E}$ affects the change in voltage. For example, if the electric field is in the z direction, the voltage difference does not depend on Δx or Δy.

3. A region has a uniform electric field as shown.



   a. What is the voltage difference $V(B) - V(A)$? *Hint: use components.*

   0

   b. What is the voltage difference $V(C) - V(B)$?

   $\Delta V = -E\Delta y = -25(3) = -75\text{ V}$

   c. A $-4\ C$, 5 kg charge is moving at 20 m/s at point A. It is at moving at an angle so that it reaches point C with only electric forces acting on the charge. Use conservation of energy to determine the speed of the charge when it reaches point C.

   $\cancel{}\ 300 - 1000 = -\frac{1}{2}\cdot 5 \cdot v_f^2$

   $\Delta U = \Delta V q$

   $\sqrt{\frac{+1400}{5}}$

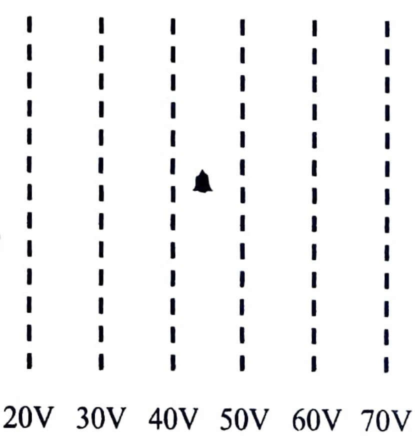
   $\Delta U = q(-75)(-4)$

   $v_f = \sqrt{280}$

   $\approx 16.73\ \frac{m}{s}$

   $\Delta U = 300\text{ J} = -\Delta KE = \frac{1}{2}5(20)^2 - \frac{1}{2}5 \cdot v_f^2$

4. The figure shows the equipotential lines (lines where the voltage is constant) in a region of space.



   a. A proton is released from rest at point A. Which way (left/right/top/bottom) will the charge move?

   Left

   b. A electron is released from rest at point A. Which way will the charge move?

   Right

   c. What is the direction of the electric field in this region of space?

   Left

   $\leftarrow$ potential