Phys 112 2019

Lecture 8

Weds / Thurs LABS – prelab

Fri: HW due by 5pm

Supp Ex 29, 30, 31, 32, 33a

Ch 21 Q 5

Prob 19, 79

Fri: Physics candidate seminar WS 264

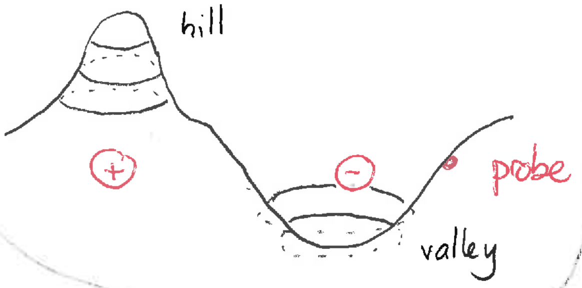
Energy in electrostatics

The basic scheme regarding energy in electrostatics is:

Probe in the vicinity of sources. Speed of probe?

→ Sources establish electric potential, V :

- one value at each location
- energy "landscape"

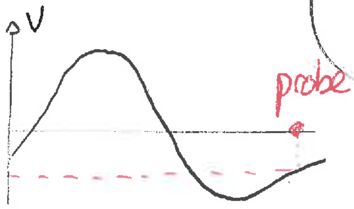


← Probe placed in landscape has electric potential energy

$U_{elec} = q\,V$

probe charge

V



→ Conservation of energy

$\Delta K + \Delta U_{elec} = 0$

Demo: PhET Charges + fields

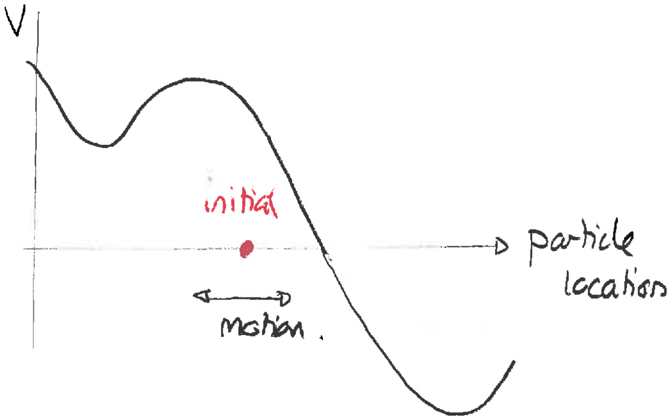
- Place various charges - observe red / blue
  - use meter to observe V
  - describe hills / valleys

Demo: Video Khutoryansky : 0:27, 0:59, 1:50
Quiz 1 20% - 50%

Recall that the electric potential only depends on the arrangement of source charges.

Motion of a probe in an electric potential

Consider the situation where a collection of hidden sources produces an electric potential as illustrated. Suppose that a probe can move along one line. At an initial instant the particle is given a kick either left or right. How does the potential describe its subsequent motion?



Here

$$\Delta K + \Delta U_{elec} = 0$$

$$\Rightarrow \Delta K + q \Delta V = 0$$

$$\Rightarrow \Delta K = -q \Delta V$$

where q is the probe charge. We can now observe how V changes. The key factors are:

* Is ΔV positive, negative ?
* Is q " " ?

} What does this say about ΔK.

Quiz 2 – 50% → 90%

We see that

A	positive	probe	speeds up	when	moving	down V
"	"	"	slows down	"	"	up V
A	negative	"	speeds up	"	"	up V
A	"	"	slows down	"	"	down V

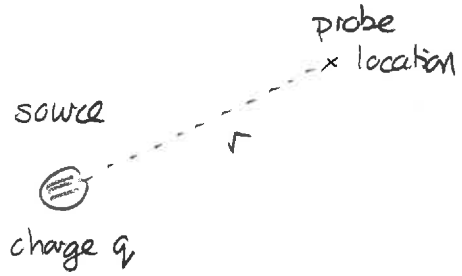
Quiz3

Note that the sign of the potential is important.

Potential produced by a point charge

So far we have not described how to determine the potential produced by sources. The simplest case involves a point charge. The way to determine the potential involves using calculus to determine the work done on a probe as it moves from one location to another. This gives ΔU_{elec} and eventually ΔV. The result is:

The electric potential produced at a point a distance r from a source charge is

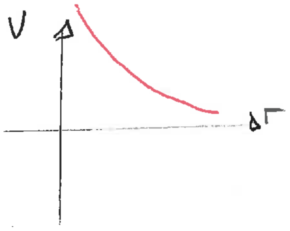


$$V = k\frac{q}{r}$$

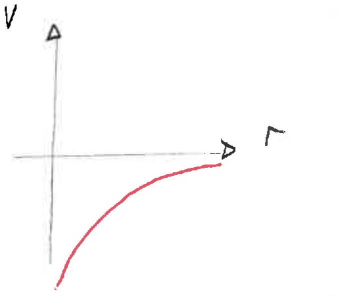
where q is the charge of the source charge

Quiz 4 30% → 90%

Graphing gives the following:

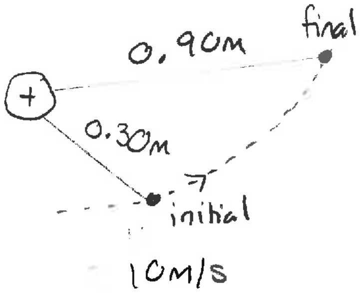


positive source



negative source

Example: A point particle with charge $+4.0\times10^{-6}C$ is held fixed. A probe charge with mass 0.0060kg and charge $8.0\times10^{-6}C$ moves as illustrated. Determine its speed at the final location.



Answer: Energy conservation

$$\Delta K + \Delta U_{elec} \Rightarrow \Delta K + q_{probe}\Delta V = 0$$

$$\Delta K = -q_{probe}\Delta V$$

$$\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = -q\left(V_f - V_i\right)$$

We need initial and final potentials.

$$V_i = k\frac{q_{source}}{r_i} = \frac{8.99\times10^9 Nm^2/C^2 \times 4.0\times10^{-6}C}{0.30m} = 120000V$$

$$V_f = k\frac{q_{source}}{r_f} = \frac{8.99\times10^9 Nm^2/C^2 \times 4.0\times10^{-6}C}{0.90m} = 40000V$$

So

$$\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = -8.0\times10^{-6}C\left[40000V - 120000V\right]$$

$$= +0.64J$$

$$\frac{1}{2}(0.0060kg)\ V_f^2 - \frac{1}{2}(0.0060kg)(10m/s)^2 = +0.64J$$

$$0.0030kg\ V_f^2 - 0.30J = 0.64J$$

$$\Rightarrow \quad 0.0030kg\ V_f^2 = 0.94J$$

$$\Rightarrow \quad V_f^2 = 313m^2/s^2$$

$$\Rightarrow \quad V_f = \sqrt{313m^2/s^2} = 18m/s$$