

1. Teach for 10-15 minutes to explain:

- a. Analogy between gravitational potential energy and electrostatic potential energy: emphasize that an apple on the table has gravitational potential energy, i.e. the potential to do work, because when it is dropped and falls on your toe and will bruise your toe. When the apple is pushed off the table the gravitational potential energy is converted to kinetic energy of the object.

Similarly a negative ion near a positively charged object has an electrostatic potential energy, because when let it go the negative ion will accelerate towards the positive object. So its electrostatic potential energy is converted into kinetic energy.

- b. In PHYS1430 we learned that gravitational potential energy is:

$$U_{\text{gravitational}} = m * gh$$

Where m is the mass of the apple, h is the height of the apple above the surface of the earth, and g is the acceleration due to gravity at sea level. This little g depends on the total mass of the earth and its radius.

The potential energy of a negative ion near a positively charged sphere is given by a similar expression:

$$U_{\text{electrostatic}} = q * V$$

Where q is the charge of the ion and V is the electric potential near the surface of the charged sphere. This electric potential depends on the total charge of the charged sphere and its radius.

- c. Although we cannot measure the gravitational potential energy directly, we can measure the height as a function of the position and then multiply the height time mg to find the gravitational potential energy of an object. Those of you who like to go hiking in the hill-country might use height contour maps. Those maps show lines that all have the same height and help you in deciding how to move from a point A to a point B. Following a contour line means that you do not go up or down, and means your gravitational potential energy stays the same. Such height contour plot can be made with a GPS system that shows the three coordinates of your position. Moving perpendicular to a contour line, means a drastic change of your potential energy, so means going up or going down.

Similarly one can make a contour plot of the electrostatic potential energy around a charged object. To do this we need to measure the electric potential around the charged sphere. We do this with a voltmeter. Actually a voltmeter does not really give you the electric potential but only the electric potential difference between two points defined by the position of its electrodes. Note that this is very similar to elevation measurements done with a ruler. We are not able to measure the absolute elevation with a ruler either, only the difference in elevation between both ends of the ruler.

- d. Note that in Phys1430 we learned that gravitational potential energy and force are related to each other by¹:

$$F_{gravity} = -\frac{\partial U_{gravity}}{\partial z} \Rightarrow F_{gravity} = -\frac{\partial(m * g * h)}{\partial z} = -\frac{\partial(m * g * z)}{\partial z} = -mg$$

Similarly in electrostatics, the derivative of the potential energy gives the force, i.e.

$$F_{electrostatic} = -\frac{\partial U}{\partial x} \Rightarrow F_{electrostatics} = -\frac{\partial(q * V)}{\partial x}$$

But in chapter 23 we learned that the electrostatic force is given by:

$$F_{electrostatics} = qE$$

Or in other words:

$$qE = -\frac{\partial(qV)}{\partial x} = -q \frac{\partial V}{\partial x} \Leftrightarrow E = -\frac{\partial V}{\partial x}$$

Or in other words, in areas with a large electric field, the electric potential (read the reading on your multimeter) changes fast while moving your measurement electrode.

- e. Note that because of

$$U_{electrostatic} = q * V$$

The electric potential is given by:

$$V = \frac{U_{electrostatic}}{q}$$

This equation shows two important things:

- The unit of electric potential is the Joule/Coulomb, which is often named the volt.
- The electric potential at a certain position is the potential energy of a test charge of one coulomb when placed at that particular position. Note we found a similar equation between electric field and force in chapter 23, i.e.

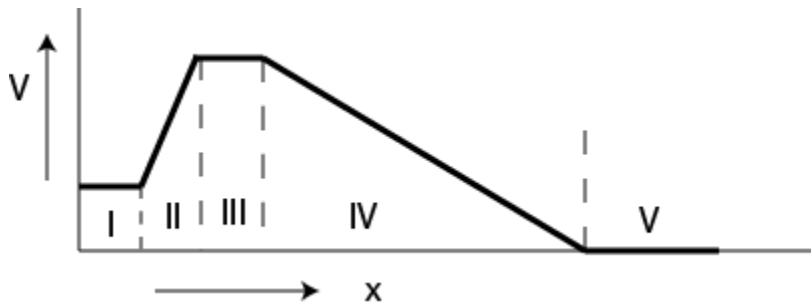
$$E = \frac{F}{q}$$

In this lab you will measure the electric potential around two point charges. These point charges are modeled by two electrodes stuck in a tray filled with water. We will use a multimeter for measuring the electric potential between two points in the water tray. The multimeter will need to be put on DC voltage measurements. One of the electrodes is kept at the same position in the tray during the whole

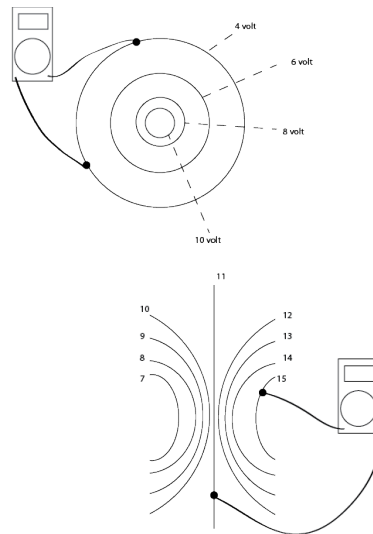
measurement procedure, while the other electrode is moved around. The electric potential between the stationary electrode and the movable electrode is read from the meter and gives us an idea how the electric potential varies for different locations in the tray.

Discuss with your section the following or similar problems:

1. The figure below gives the electric potential as a function of x . In which region(s) is the electric field equal to zero? In which region is the magnitude of the electric field maximum?



2. Consider the Equipotential plot of a positive point charge in the figure below.
 - a. Assume we place the electrodes of the voltmeter at position A and B, do we measure an electric potential difference?
 - b. Draw a field line pattern in the equipotential plot.



Notes:

[1] To make the comparison completely correctly, one should write z as a function of x and y . However this might confuse most of the students, so I encourage you not to do so.