Electric Potential Name ______________________________

Physics II Date ____________ Period ___________

Electric potential is as important as any concept when it comes to understanding static electricity and electric circuits. It is measured in volts, which you have already heard of. It is something that is easy to measure and extremely useful for all electrical circuits and devices.

In order to get a basic understanding of electric potential we will first look at the idea of potential in a field that we already know something about, namely, the gravitational field. Gravitational potential is a lot like electric potential. Once we get the basic idea of gravitational potential, we will then deal with electric potential.

Gravitational Potential

Gravitational potential is related to gravitational potential energy. As you may remember, gravitational potential energy is energy stored in the gravitational field. When you lift something up, it costs you some energy. The gravitational field gains energy from you when you lift something up, and it loses energy when something descends. We calculate gravitational energy using $GPE = mgy$ where m is the mass of the object of interest, g is the strength of the gravitational field, and y is the vertical position of the object relative to the level we decide on to be $y = 0$.

If we put a 1 kg object at a height $y = 1$ m, the gravitational energy associated with this object is $GPE =$ (1 kg)(10 N/kg)(1 m). This is just 10 Nm, which is 10 Joules. If we put a 2 kg object at the same place, 1 m above $y = 0$, there will be 20 J of GPE. If we put 5 kg at that same location, then I hope you know that there will be 50 J. You may notice that there are 10 J of GPE for each 1 kilogram of mass *at* $y = 0$. The number of Joules of GPE per kilogram is what we call *gravitational potential*. And this gravitational potential is a property of a place in a gravitational field. For example, wherever $y = 2$ m, the gravitational potential will be 20 J/kg. Wherever $y = 5$ m, the gravitational potential will be 50 J/kg. Does this make sense?

Gravitational potential is the *potential energy load factor* for each kilogram at a location in a gravitational field.

The only difference between gravitational potential and electric potential is that electric potential is a property of a place in an electric field, not a place in a gravitational field. A gravitational field is created by the mass of one object, and it will exert a force on any other mass that is placed within it. Gravitational fields are made by and felt by objects that have mass. Therefore, we can think of mass as *gravitational charge*.

Electrical Potential

Electric fields are made by objects that have electric charge, and they exert forces on other objects that also have electric charge. Electric fields are made by and felt by objects that possess electric charge. That means with electric potential, instead of mass, which is gravitational charge, we will be concerned with electric charge, which we measure in Coulombs. One Coulomb is a big charge. One nanocoulomb is an ordinary, run-of-the-mill amount of charge that you might encounter in everyday life.

Electric potential tells us how many joules of electric potential energy there are for each *Coulomb* at a particular place in an electric field. **Electric potential is therefore the *potential energy load factor* for each Coulomb of charge at a location in an electric field.**

Example

For example, a particular location in an electric field might have a potential of 120 Joules per Coulomb. **A volt is defined to be a Joule/Coulomb.** Therefore, 120 J/C is 120 Volts. That means for every Coulomb of electric charge that is placed at this location there are 120 J of electric potential energy. So if you put 3 C at that location, there will be 3 C $\times$ 120 J/C=360 J of electric potential energy associated with that 3 C of charge. This can be written mathematically, too:

$$EPE = qV = 3\ \text{C} \times 120 \frac{\text{J}}{\text{C}} = 360\ \text{J} \tag{1}$$

Problems

1. Calculate the electrical potential energy associated with an object that has a charge of 2 C that is at a position that has a potential of 15 V.
2. Calculate the electrical potential energy associated with an object that has a charge of 0.06 C that is at a position that has a potential of 1000 V.
3. Calculate the electrical potential energy associated with an object that has a charge of 4 μC that is at a position that has a potential of 3×10^4 V.