# SPH4U
# UNIVERSITY PHYSICS

GRAVITATIONAL, ELECTRIC, & ... FIELDS

☞ Electric Potential
(P.350-354)

## Electric Potential

*As discussed earlier, the electric potential energy is not the property of a single charge alone – it depends on the value of the charge(s) and the electric field involved. This leads to a new quantity called **electric potential**, V, which is a measure of how much electric potential energy is associated with a specific quantity of charge at a particular location in an electric field. Based on this definition:*

$$V = \frac{E_E}{q}$$

***NOTE!***
*The SI unit of electric potential is the volt (V). The volt relates to other SI units as follows:*

1 V = 1 J/C = 1 N·m/C



## Electric Potential

**ELECTRIC POTENTIAL (V)**

- the value of potential energy per unit positive charge for a given point in an electric field (1 V = 1 J/C = 1 N·m/C)

***NOTE!***
*Electric potential, or just potential, is a convenient measure because it is **independent** of the amount of charge at a particular location in the field. It depends only on the electric field strength at that location. For example, if you had 1 C of electrons at a particular location in a uniform electric field, you would possess X J of electric potential energy. If you doubled the amount of electrons to 2 C at the same location in the electric field, you would have 2X J of electric potential energy. In both situations, however, you would have the same electric potential (V = XJ/1C = 2XJ/2C = XJ/C).*

## Electric Potential Difference

*Another convenient definition relating to electric potential energy is* ***electric potential difference****, ΔV. We can define the change in the potential, or the potential difference, for a charge q that moves between two points as:*

$$\Delta V = V_B - V_A = \frac{\Delta E_E}{q}$$

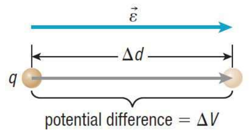
***NOTE!***

*This is the same potential difference we spoke of in the electricity unit in grade 9 and then again in grade 11. This is just a more formal definition. Recall that the electric potential difference between two points in a circuit is measured with a device called a* ***voltmeter****. It is connected across the path of the moving charges.*



## Electric Potential Difference

*The electric potential difference (ΔV) is the amount of work required per unit charge to move a positive charge from one point to another in the presence of an electric field.*






## Electric Potential Difference

*For the case of a uniform electric field, the equation for electric potential difference becomes:*

$$\Delta V = \frac{\Delta E_E}{q} = \frac{-W}{q} = \frac{-q\varepsilon\Delta d}{q}$$

$$\Delta V = -\varepsilon\Delta d$$

## Electric Potential Difference

**ELECTRIC POTENTIAL DIFFERENCE (ΔV)**

- the amount of work required per unit charge to move a positive charge from one point to another in the presence of an electric field

$$\Delta V = \frac{\Delta E_E}{q} = -\varepsilon \Delta d$$

where
- $\Delta V$ is the change in the electric potential of the field (V)
- $\Delta E_E$ is the change in the electric potential energy of the field (J)
- $q$ is the charge on the object (C)
- $\varepsilon$ is the electric field intensity (N/C)
- $\Delta d$ is the displacement of the charge (m)

**RECALL** ☞ 1 V = 1 J/C = 1 N·m/C

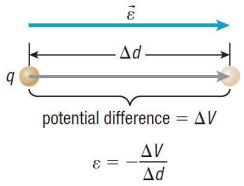


## Electric Potential Difference

*Now, rearranging for $\varepsilon$ (the electric field intensity) we get the following relationship:*

$$\varepsilon = \frac{\Delta V}{\Delta d}$$

*Notice that this relationship shows how a non-uniform electric field varies with the change in electric potential (that is, electric potential difference) and the change in position in the field.*

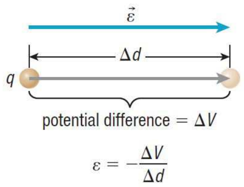





## Electric Potential Difference

*According to the equation, the electric field ($\varepsilon$):*

- *is largest in regions where V is large*
- *changes rapidly with small changes in displacement*
- *is zero in regions where V is constant*
- *points from regions of high potential to regions of low potential*



## Electric Potential Difference

***NOTE!***

*If we consider a circuit in which a battery is the source of electrical energy, a positive test charge will naturally move in the same direction as the electric field from the positive terminal where a high potential exists to the negative terminal where a low potential exists – **conventional current**. Conversely, electrons will naturally travel from a region of low potential to a region of high potential, in a direction opposite to the direction of the electric field – **electron flow**.*

November 18, 2012 4U3 - Electric Potential 9

## Electric Potential Difference

**PRACTICE**

1. The electrons in an old TV picture tube are accelerated through a potential difference of +2.5 x $10^4$ V.
   (a) Do electrons move from a region of high potential (+) to a region of low potential (–), or vice versa?

   (a) low to high (i.e. – to +)

November 18, 2012 4U3 - Electric Potential 10

## Electric Potential Difference

**PRACTICE**

1. The electrons in an old TV picture tube are accelerated through a potential difference of +2.5 x $10^4$ V.
   (b) Calculate the change in the electric potential energy of the field. ($q_e$ = -1.6 x $10^{-19}$ C)

   (b) $\Delta E_E$ = -4.0 x $10^{-15}$ J

November 18, 2012 4U3 - Electric Potential 11

## Electric Potential Difference

**PRACTICE**

1. The electrons in an old TV picture tube are accelerated through a potential difference of +2.5 x $10^4$ V.
   (c) Calculate the change in the kinetic energy of one of the electrons.

   (c) $\Delta E_k = -\Delta E_E =$ +4.0 x $10^{-15}$ J (electron speeds up)



## Electric Potential Difference

**PRACTICE**

1. The electrons in an old TV picture tube are accelerated through a potential difference of +2.5 x $10^4$ V.
   (d) Calculate the final speed of an electron if the initial speed is zero. ($m_{electron}$ = 9.11 x $10^{-31}$ kg)

   (d) $v_f$ = 9.4 x $10^7$ m/s



## ✔ Check Your Learning

**TEXTBOOK**

P.354 Q.2,3