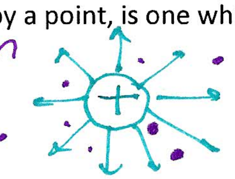
Electrostatics: Electric Potential, Electric Potential Difference and Electric Potential Energy

Name: ____________ Period: 3rd Date: ______

1. Electric Potential Energy (U_E)

If a charged object is in an electric field it has electric potential energy - that is it has the potential to move in that field. Note that the potential energy it has could be used to attract or repel depending on the charges.

A non-uniform field, such as that provided by a point, is one which has a different strength and direction (depending on position)



In this case we can derive a formula for the electric potential energy (U_E) in a NON-UNIFORM FIELD:

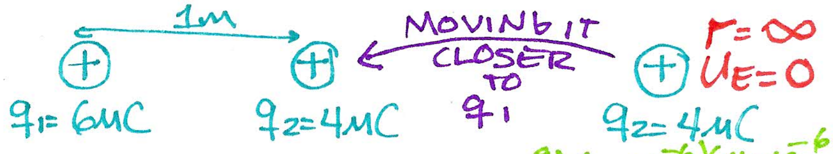
$$W = U_E = F_E \cdot d$$

$$= \left[\frac{Kq_1q_2}{r^{\cancel{2}}}\right] \cdot \cancel{d} = \frac{Kq_1q_2}{r}$$

$$\boxed{U_E = \frac{Kq_1q_2}{r}}$$

Example:

How much work must be done to bring a 4.0 μC charged object to within 1.0 m of a 6.0 μC charged object from a long way away?



$$W = U_E = \frac{Kq_1q_2}{r} = \frac{(9\times10^9)(6\times10^{-6})(4\times10^{-6})}{1}$$

$$W = U_E = 0.216J$$

NOTE:

1. Potential energy is a …

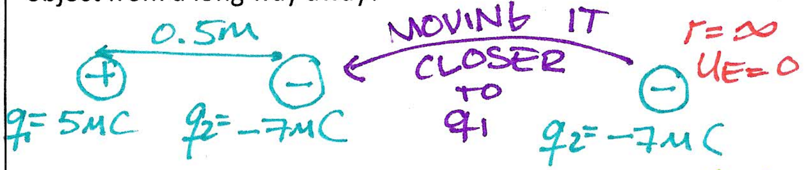
SCALAR

2. We WILL …

use + & − signs for charges

In this case, bringing a positive charge near another positive charge requires input therefore the work is positive.

Example: How much work must be done to bring a -7.0 uC charged object to within 0.5 m of a 5.0 uC charged object from a long way away?



include signs!

$$W = U_E = \frac{Kq_1q_2}{r} = \frac{(9\times10^9)(5\times10^{-6})(-7\times10^{-6})}{.5} = -0.63J$$

In this case, by bringing a negative charge near a positive charge, it releases energy therefore work is negative.

2. Electric Potential (V): is defined as the electric potential energy per unit charge

~~In this case, bringing a negative charge near a positive charge~~ ______________________ ~~energy therefore work is~~ ______________________.

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

V: Electric Potential [Volts]

U_E: Electric Potential Energy (J)

q: Charge (C)

UNIT: Volts (V)

$$V=\frac{\frac{Kq_1\cancel{q_2}}{r}}{\cancel{q}}=\frac{Kq}{r}$$

Which becomes...

$$V=\frac{Kq}{r}\Rightarrow K\sum_i\frac{q_i}{r_i}$$

Σ = SUM

i = # of charges

NOTE:

(1) The electric potential is defined in terms of the moving of a positive charge. Therefore:

+ charges move towards __low__ potential

- charges move towards __high__ potential

(2) The unit for potential is __Volts (V)__

Example: Calculate the electric potential at point P as shown in the diagram.

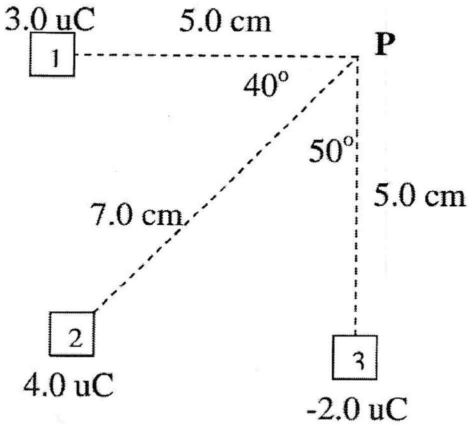
3 charges

$$V_p=K\left[\frac{q_1}{r_1}+\frac{q_2}{r_2}+\frac{q_3}{r_3}\right]$$

Include negatives!

$$V_p=9\times10^9\left[\frac{3\times10^{-6}}{.05}+\frac{4\times10^{-6}}{.07}+\frac{-2\times10^{-6}}{.05}\right]$$

$$V_p=6.94\times10^5\ V$$



NOTE:

(1) Potentials are __scalar__ quantities, which means that they only include __magnitude__ (numerical value)

(2) We WILL use __positive__ and __negative__ signs of charges

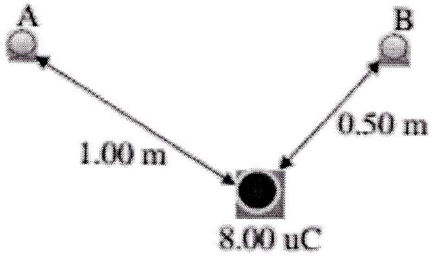
3. Potential Difference

We sometimes want to determine the electric potential between two points. This is known as the potential difference. For example, given two points A and B, the potential difference between A and B is:

$$V_{AB} = V_B - V_A$$

NOTE: When we talk about potential at a point we are talking about the potential difference between that point and infinity, where the potential at infinity is ZERO.

Example: What is the potential difference between points A and B due to the charge shown?



$$V_{AB} = V_B - V_A$$

$$V_A = \frac{Kq}{r} = \frac{(9\times10^{9})(8\times10^{-6})}{1}$$

$$V_A = 72{,}000V$$

$$V_B = \frac{Kq}{r} = \frac{(9\times10^{9})(8\times10^{-6})}{.5}$$

$$V_B = 144{,}000V$$

To find potential difference

$$V_{AB} = V_B - V_A$$

$$V_{AB} = 144{,}000 - 72000$$

$$\boxed{V_{AB} = 72{,}000V}$$