Electric Potential & Electric Potential Energy

Remember

Force of Gravity $F_g = \dfrac{Gm_1m_2}{r^2}$

Electric Force $F_e = \dfrac{K|q_1||Q_2|}{r^2}$

$\vec{F}_e = q\vec{E}$

Electric Field $\vec{E} = \dfrac{K|Q|}{r^2}$

Electric Potential

- ***Electric Potential*** is the energy ***per*** charge measured in J/C (= Volt)
- Also known as Voltage, Volts, Potential Difference, and Potential

$$V = \frac{KQ}{r}$$

V = voltage (J/c)
K = electric constant 9 E 9 Nm²/C²
Q = charge creating the voltage
r = distance from the charge

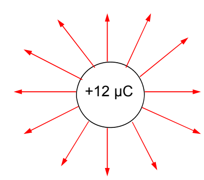
Example

- A +12 μC charge is held at the origin.
- What is the electric potential at a distance of 5 mm from this charge? Draw the E-Field.

$$V = \frac{KQ}{r}$$

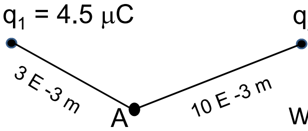
$$V = \frac{(9x10^9 \frac{Nm^2}{C^2})(12x10^{-6}C)}{5x10^{-3}m}$$

$$V = 2.16x10^7 \text{ Volts}$$



Practice

q₁ = 4.5 μC q₂ = -8.5 μC



What is the potential at point A due to q_1?

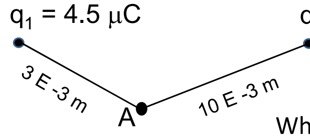
$$V = \frac{KQ}{r}$$

$$V = \frac{(9x10^9 \frac{Nm^2}{C^2})(4.5x10^{-6}C)}{3x10^{-3}m}$$

$$V = 1.35x10^7 \text{ Volts}$$

Practice

q_1 = 4.5 μC q_2 = -8.5 μC



What is the potential at point A due to q_1 and q_2?

$$V = \frac{KQ_1}{r_1} + \frac{KQ_2}{r_2}$$

$$V = 1.35x10^7 + \frac{(9x10^9 \frac{Nm^2}{C^2})(-8.5x10^{-6}C)}{10x10^{-3}m}$$

$$V = 1.35x10^7 + (-7.65x10^{-6})$$

$$V = 5.85x10^6 \text{ Volts}$$

Electric Potential Energy

- ***Electric Potential Energy*** is the ***total*** energy a charge has. It is measured in Joules.

$$PE_e = q\Delta V = W$$

W = work; measured in Joules (J)
PE_e = electric potential energy; measured in Joules (J)
q = charge that is moved; measured in Coulombs (C)
ΔV = potential difference (final Voltage – initial Voltage); measured in Volts (J/C)

It is important that you notice the difference between *electric potential (voltage)* and *electric potential energy!!!!*

Example

- How much work would need to be done to move a proton from Round Rock to a point 5 mm from a 12 µC charge?

$$PE_e = q\Delta V = W$$

$$W = (1.6E-19C)\frac{(9E9\frac{Nm^2}{C^2})(12E-6C)}{5E-3m}$$

$$W = 3.46E-12J$$

Example, cont.

- If the proton were released and allowed to move back to Round Rock, how fast would it be going?

$$PE_e = q\Delta V = W$$

$$PE_e = KE = 1/2mv^2$$

$$3.45x10^{-12}J = \frac{1}{2}(1.67x10^{-27}kg)v^2$$

$$4.13x10^{15} = v^2$$

$$6.43x10^7 m/s = v$$

Practice

- How much energy does an electron gain when it moves through a potential difference of -7 V?

$$PE_e = q\Delta V = W$$

$$PE_e = (-1.6E-19C)(-7V)$$

$$PE_e = 1.12E-18J$$