Electric Potential Difference Notes

- Potential is the key word. Here is some review from Gravitational Potential Energy.
  - Gravitational Potential Energy (PE) - energy stored due to its position (height) above the Earth.
  - Formula: PE = mgh
    - PE = Potential Energy
      - Unit: J
    - m = mass
      - Unit: kg
    - g = 9.8
      - Unit: m/s^2
    - h = height
      - Unit: m
  - Formula: W=Fd
    - W = work
      - Unit: J
    - F = force
      - Unit: N
    - d = displacement
      - Unit: m
  - Formula: $W = \Delta PE$
    - Work is equal to the change in Potential Energy
  - Question: If a weightlifter lifts a 275 kg mass 0.22 meters above his head, how much PE does the mass have?
    - Given: m = 275 kg
      H = 0.22 m
      G = 9.8 m/s^2
    - Unknown: PE = ?
    - Equation: PE = mgh
    - Substitute: PE = (275 kg)(9.8 m/s^2)(0.22 m)
    - Solve: PE = 593 J

- Here are some helpful symbols to keep in mind.

Symbol	Description	Symbol	Description	Symbol	Description
d	distance	g	acceleration due to gravity	PE_g	gravitational potential energy
E	electric field strength	h	height	q	charge
F_e	electromagnetic force	k	Coulomb's constant	U	electric potential energy
F_g	gravitational force	m	mass	µ	micro or 10^{-6}

- Electric Potential Energy - potential energy an electric charge has due to its location in an electric field
  - Equation: $$U = qEd$$
    - U = electric potential energy
      - Unit: Joule (J)
    - Q = electric charge
      - Unit: C
    - E = electric field
      - Unit: N/C
    - D = distance from electric charge to source of electric field
      - Unit: m

- The further away the electric charge is from the source of the field, the more Electric Potential Energy it has
- Question: A point charge of 5.0 µC is placed at a distance of 0.08 m from a hard rubber rod with an electric field of 1.0 x 10^3 . What is the electric potential energy of the point charge?
  - Given: q = 5.0 µC = 5.0 x 10^{-6} C
    d = 0.08 m
    E = 1.0 x 10^3 N/C
  - Unknown: U = ?
  - Equation: U = qEd
  - Substitute: U = (5.0 x 10^{-6} C)(1.0 x 10^3 N/C)(d = 0.08 m)
  - Solve: U = 4.0 x 10^{-4} J

- Question: What is the electric potential energy of the point charge at 1.3 m?
    - Given: q = 5.0 μC = 5.0 x 10^{-6} C
      d = 0.08 m
      E = 1.0 x 10^{3} N/C
    - Unknown: U = ?
    - Equation: U = qEd
    - Substitute: U = (5.0 x 10^{-6} C)(1.0 x 10^{3} N/C)(d = 0.08 m)
    - Solve: U = 4.0 x 10^{-4} J
- Electric potential - electric potential energy of a charged particle divided by its charge
    - Electric potential tells you how strong an electric field is at a given spot
    - Equation: $$V = \frac{U}{q}$$
        - V = electric potential
            - Unit: Volt (V)
        - U = electric potential energy
            - Unit: J
        - q = electric charge
            - Unit: C
- Question: A hard rubber rod with an electric potential energy of 4.9 × 10^{-3} J has a charge of 3.0 μC at the tip. What is the electric potential at the tip? Round your answer to one decimal place.
    - Given: U = 4.9 × 10^{-3} J
      q = 3.0 μC = 3.0 × 10^{-6} C
    - Unknown: V = ?
    - Equation: V = $\frac{U}{q}$
    - Substitute: V = $\frac{4.9 \times 10^{-3} J}{3.0 \times 10^{-6} C}$
    - Solve: V = 1.6 x 10^{3} V
- Question: What is the electric potential if the charge at the tip changes to 2.0 μC? Round your answer to one decimal place.
    - Given: U = 4.9 × 10^{-3} J
      q = 2.0 μC = 2.0 × 10^{-6} C
    - Unknown: V = ?
    - Equation: V = $\frac{U}{q}$
    - Substitute: V = $\frac{4.9 \times 10^{-3} J}{2.0 \times 10^{-6} C}$
    - Solve: V = 2.5 x 10^{3} V

- Equation: $V = k\frac{q}{d}$
    - V = electric potential
        - Unit: V
    - k = 8.99 x 10^9
    - q = electric charge
        - Unit: C
    - d = distance between electric charge and source of electric field
        - Unit: m
- Question: What is the electric potential of a 2.2 μC charge at a distance of 6.3 m from the charge? Recall that Coulomb's constant is k = 8.99 × 10^9 .
    - Given: q = 2.2 μC = 2.2 x 10^{-6} C
      d = 6.3 m
      k = 8.99 × 10^9
    - Unknown: V = ?
    - Equation: V = k $\frac{q}{d}$
    - Substitute: V = (8.99 × 10^9)($\frac{2.2\ x\ 10^{-6} C}{6.3\ m}$)
    - Solve: V = 3140 V
- Question: What is the electric potential at a distance of 99 m from the charge?
    - Given: q = 2.2 μC = 2.2 x 10^{-6} C
      d = 99 m
      k = 8.99 × 10^9
    - Unknown: V = ?
    - Equation: V = k $\frac{q}{d}$
    - Substitute: V = (8.99 × 10^9)($\frac{2.2\ x\ 10^{-6} C}{99\ m}$)
    - Solve: V = 200 V
- Electric potential difference - the difference in electric potential between two spots
    - A.k.a. Voltage
- Question: The magnitude of the electric field between two parallel charged plates is 800.0 N/C. An electron moves to the negative plate 2.5 cm away. Find the electric potential difference and the work. Recall that the charge of an electron is 1.602 × 10^{-19} C.
    - Given: E = 800.0 N/C
      d = 2.5 cm = 0.025 m
      q = 1.602 × 10^{-19} C
    - Unknown: ΔV and W
    - Equations: ΔV = Ed and W = qΔV

- Substitute: ΔV = (800.0 N/C)(0.025 m) and W = (1.602 × 10^{-19} C)ΔV
- Solve: ΔV = 20 V and W = (1.602 × 10^{-19} C)(20 V) = 3.2 x 10^{-19} J