CLASS #1: ELECTRIC CIRCUIT VARIABLES

- DORF: CH 1

DCIRCUITS:
- MOVES ENERGY IN FORM OF ELECTRICAL CHARGES
- CONTAINS i) CIRCUIT ELEMENTS (e.g., BATTERY/RESISTORS)
  ii) PATHWAYS (e.g., WIRES)

- FLASH LIGHT:

\[ \text{Switch} \]

\[ \text{Batter} \]

\[ \text{Light Bulb} \]

\[ e^- \]

2 CURRENT
- CONSISTS OF CHARGED PARTICLE (ELECTRON, $e^-$)
  \[ q_e = -1.602 \times 10^{-19} \text{ C} \]

- CURRENT:
  \[ i = \frac{dq}{dt} \quad [i = \frac{\Delta q}{\Delta t} = \frac{C}{S} = \text{A}] \]

- CONVENTION: OPPOSITE THAN DIRECTION OF ELECTRONS (FROM BENJAMIN FRANKLIN)

- DC & AC

- ACCUMULATION:
  \[ q = \int_{t_1}^{t_2} i \, dt \]
**VOLTAGE**

- Energy needed to "move" Charge

\[ V = \frac{dW}{dq} \]

\( W = \text{work (J)} \)

\( q = \text{charge (C)} \)

\[ V = \frac{F}{e} = V \text{ (Volts)} \]

**POWER**

- \[ P = \frac{dW}{dt} \]

- For circuit:

\[ P = \frac{dW}{dq} \cdot \frac{dq}{dt} = V \cdot i \]

\[ P = V \cdot i \]

- Convention:

"Power Supplied"

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"Power Absorbed"
PROBLEM #1:

You are given a circuit and you measure current across an element as follows:

\[ I(t) = \begin{cases} 
720 & \text{for } 0 \leq t < 1 \mu s \\
0 & \text{for } t \geq 1 \mu s 
\end{cases} \]

How much current has flowed from 300 to 1000 ns?

\[ q = \int_{300}^{1000} I(t) \, dt = \int_{300}^{400} I(t) \, dt + \int_{400}^{1000} I(t) \, dt \]

\[ = \left( 360 + 720 \times 10^{-9} A \right) \left( 100 \times 10^{-6} s \right) \frac{1}{2} + \left( 600 \times 10^{-6} \right) \left( 720 \times 10^{-9} \right) \]

\[ = 5.4 \times 10^{-7} C + 4.32 \times 10^{-10} C \]

\[ = 486 \times 10^{-9} C \]

\[ = 486 \text{ pC} \]
### Problem 2

Your cell phone battery is charged for 5 hours with 2 A. As phone charges, its voltage is:

\[ V = 11 + 0.5t \text{ V} \quad t > 0 \text{ in hours} \]

If DTE charges $15 \text{ c/kWh}$, find cost of charging your cell phone.

\[ W = \int_{0}^{5} V(t) \cdot i(t) \, dt \]

\[ = \int_{0}^{5} 2A \left( 11 + 0.5 \left( \frac{t}{60 \cdot 60} \right) \right) \, dt \]

\[ = 2.77 \times 10^{-7} \text{ kWh} \]

\[ = 441000 \text{ J} \]

**Cost**

\[ W = 441000 \text{ J} = 0.1225 \text{kWh} \]

\[ 1 \text{ J} = 1 \text{ W} \cdot \text{s} \left( \frac{1 \text{ kW}}{1000 \text{W}} \right) \left( \frac{1 \text{ h}}{3600 \text{s}} \right) \]

\[ = 2.77 \times 10^{-7} \text{ kWh} \]

\[ \text{Cost} = 0.15 \times 0.1225 \text{kWh} \]

\[ = 0.018 \text{ dollar} \]
**Problem #3:**

*Your Given:*

\[ i(t) \]

\[
\begin{array}{c}
12V \\
\text{SENSOR}
\end{array}
\]

**How much current & power is absorbed by the sensor if the charge entering the sensor is:***

\[ i(t) \text{ (mc)} \]

\[
\begin{array}{ccccccc}
1 & 2 & 3 & 4 & 5 & 6 & t \text{ (ms)}
\end{array}
\]

**Ans.**

\[ i = \frac{dq}{dt} \text{ (slope of } q) \]

**P = V \cdot i = 12 \cdot i**