CLASS #1: ELECTRIC CIRCUIT VARIABLES

READ: DORF CHAPTER 1

OBJECTIVES: 1) DEFINE VOLTAGE & CURRENT
2) CALCULATE POWER & ENERGY OF CIRCUITS

1) DEFINE CIRCUITS & ELECTRICITY

- ELECTRICITY IS THE MOVEMENT OF ENERGY
- CIRCUITS ARE A PHYSICAL SYSTEM WITHIN WHICH ENERGY (ELECTRICAL) MOVES
  - CONSISTS OF CIRCUIT ELEMENTS
  - PATHWAYS (WIRES) FOR FLOW OF ELECTRICITY FROM ELEMENT TO ELEMENT

2) EXAMPLE: FLASHLIGHT

- BATTERY HOLDS ENERGY (ELECTRICAL)
- WIRE/TRACE
- LIGHT BULB RADIATES LIGHT ENERGY

BATTERY & LIGHT BULB ARE CIRCUIT ELEMENTS

3) CURRENT:

- CONSISTS OF A CHARGE PARTICULAR MOVING
- TYPICALLY AN ELECTRON (e⁻)

\[ q_{\text{electron}} = -1.602 \times 10^{-19} \text{ C (Coulomb)} \]

- CURRENT IS RATE OF CHANGE OF CHARGE PAST A POINT:

\[ I = \frac{dq}{dt} \]

(COULOMB/SEC = AMPERE OR A)

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PHYSICAL MOTION OF ELECTRONS
\[ e^- \rightarrow e^- \rightarrow e^- \rightarrow \cdots \]

\[ i = \frac{dq}{dt} \] CURRENT

CONVENTION:
- CURRENT IS OPPOSITE FLOW OF ELECTRONS
- CURRENT IS FLOW OF POSITIVE CHARGE
- FROM BENJAMIN FRANKLIN

IF \( i \) IS CONSTANT \( \rightarrow \) DIRECT CURRENT (DC)

\[ i \]

-WIDELY USED IN CIRCUITS

IF \( i \) IS SINUSODAL \( \rightarrow \) ALTERNATING CURRENT (AC)

\[ i \]

-WIDELY USED FOR ELECTRICITY DISTRIBUTION (E.G. TRANSMISSION LINES)

SEE "WAR OF CURRENTS" - EDISON VS. WESTINGHOUSE (AC)

ACUMULATED CHARGE:
\[ q = \int_{t_1}^{t_2} i \, dt \]

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4. **Voltage**:  
- Energy required to induce charge movement  
- Magnitude and direction (polarity)

\[ V_{ab} \]

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

- \( V \) = Voltage (Joules or J)  
- \( q \) = Charge (C)  
- \( V \) = Volts (\( \frac{J}{C} \) or V)

5. **Power**  
- Power is the rate of expending or absorbing energy

\[ p = \frac{dW}{dt} \]

\[ J/s \text{ or Watts, W} \]

- Consider chain rule:

\[ p = \frac{dw}{dt} = \frac{dw}{dq} \cdot \frac{dq}{dt} = V \cdot I \]

\[ p = V \cdot I \]

\[ V_{ab} \]

\[ \text{Power supplied by element is} \]

\[ V_{ab} \cdot I \]

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POWER ABSORBED BY ELEMENT
\[ \frac{1}{V_{ab}} \cdot i \]

\section*{Example: Flash Light}

[Diagram of a flash light circuit]

\section*{Example:}

\begin{equation*}
    i(t) = \begin{cases} 
        4(1 - e^{-5t}) & t \geq 0 \\ 
        0 & t < 0 
    \end{cases}
\end{equation*}

How much charge has flowed in circuit?

\[ q = \int_{0}^{t} i(t) \, dt \]

\[ = \int_{0}^{t} 4(1 - e^{-5t}) \, dt \]

\[ = 4t - \left[ -\frac{4}{5} e^{-5t} \right]_{0}^{t} \]

\[ = 4t + \frac{4}{5} e^{-5t} - 4(0) - \frac{4}{5} e^{0} \]

\[ q(t) = 4t + \frac{4}{5} e^{-5t} - \frac{4}{5} \]

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**Example:** Your calculator uses 4 AA batteries. Each battery provides 1.5V and has 200 W-s of energy.

If calculator draws 10 mA, how long will batteries last?

\[ V = 4(1.5V) = 6V \]

\[ P = V \cdot I = 6V \cdot (10 \times 10^{-3} A) = 0.06 W \]

\[ E_{\text{tot}} = 200 \text{ W-s} \]

\[ \Delta t = \frac{\Delta E}{P} = \frac{200 \text{ W-s}}{0.06} = 3.33 \times 10^3 \text{ s} \]