Lectures 1/2, Jan 14/17, 2022

Electric Variables

- An electric circuit is an interconnection of conductors, nonconductors and semiconductors
- The flow of electricity always involves the movement of charge
- Fundamental electric variables:
  1. Electric current
     - If we take a cross section of a conductor with moving charges, we get charge $q(t)$ as a function of time
     - Define *current* as the rate of change charge with respect to time, $i \equiv \dfrac{\mathrm{d}q}{\mathrm{d}t}$ with units of C/s = A (Coulombs per second, or Amperes)
     - Current also has a direction (i.e. the direction of charge flow); the convention is the direction of movement of the *positive* charge (even though negative charges is what's actually moving physically)
     - Direction shown with arrows
  2. Voltage
     - Movement of charge is associated with energy
     - Define *voltage* between two points as the energy required to move 1 Coulomb of charge between two points in a circuit
     - $v \equiv \dfrac{\mathrm{d}w}{\mathrm{d}q}$ where w is energy, q, is charge; units of J/C = V (Joules per Coulomb, or Volts)
     - Voltage also has a *polarity* (positive or negative); the positive side is where the movement starts, and the negative side is where the movement ends
       * When we say "the voltage between point A and point B", point A is the positive side and point B is the negative side
     - Polarity shown with positive and negative signs
  3. Power
     - Rate of absorbing or delivering energy with respect to time
     - $\dfrac{\mathrm{d}w}{\mathrm{d}t} = \dfrac{\mathrm{d}w}{\mathrm{d}q}\dfrac{\mathrm{d}q}{\mathrm{d}t} \implies P \equiv \dfrac{\mathrm{d}w}{\mathrm{d}t} = vi$ with units of J/s = W (Joules per second or Watts)
     - To differentiate whether power is consumed or generated, we need another sign convention
     - Passive sign convention (PSC): for a pair of v and i, PSC holds if current enters the positive side of the voltage polarity first
       * If PSC holds, then $P = +vi$; $P > 0 \implies P$ is absorbed; $P < 0 \implies P$ is delivered
       * Otherwise, $P = -vi$; same holds for the meaning of sign of P