Topic 2

DC Circuits and Kirchoff's Laws

Material discussed 1/17/19.

2.1 DC Circuits

Terminology: node/junction, branch, open circuits & short circuits, circuit elements in series, circuit elements in parallel.

2.2 Equivalent Resistances

- For resistors in series:
$$R_{\text{eq}} = R_1 + R_2$$

- For resistors in parallel:
$$\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} \quad \text{or} \quad R_{\text{eq}} = \frac{R_1 R_2}{R_1 + R_2}$$

2.3 DC Circuits Analysis

2.3.1 Kirchoff's Current Law (KCL)

Conservation of charge implies that the sum of the currents flowing into a junction equals the sum of the currents flowing out of the junction: If currents coming into a junction are given the opposite sign of those flowing out, we have

$$\sum_i I_i = 0.$$

2.3.2 Kirchoff's Voltage Law (KVL)

Conservation of energy implies that the sum of the voltage differences around any closed loop in a circuit must equal zero:

$$\sum_i \Delta V_i = 0.$$

Signs are important!

2.3.3 Analysis

If n currents in a circuit are unknown, use KCL and KVL to write n linearly independent equations in terms of the n unknown currents, and then solve the equations. (Examples in class.)

2.4 Power

- The work done on the charges by electric fields in a circuit element, $W_E = q\Delta V$ does not lead to an increase in the kinetic energy of the the charge carriers because of the drag forces on the charge carriers. Instead, energy increase due to the work is dissipated in the form of thermal energy.
- The power (work per unit time) dissipated in a circuit element is given by

  $$\text{power} = \frac{\text{work}}{\text{time}} = \frac{\text{work}}{\text{charge}} \times \frac{\text{charge}}{\text{time}},$$

  or

  $$P = I\,\Delta V.$$

- For those circuit elements that have a linear relationship between I and ΔV, Ohm's law can used to write the dissipated power in two other ways:

  $$P = I^2 R = \frac{(\Delta V)^2}{R}.$$

- The SI unit of power is Joules/second (J/s) or Watts (W).