Lecture 10

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10/10/2024

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Capacitors and Conductors

Capacitors

- **Capacitors** are devices that store energy in the form of an electric field.
  - At equilibrium, the electric field is zero and voltage and constant
  - Capacitance is the ability of a system to store charge.
- The capacitance of a capacitor is given by the formula:

$$C = \frac{Q}{V}$$

  - Where
    - C is the capacitance in farads (F),
    - Q is the charge
    - V is the voltage.
- The energy stored in a capacitor is given by the formula:

$$U = \frac{1}{2}CV^2$$

  - Where
    - U is the energy stored in the capacitor.

- See section Schematic Symbols for common capacitor symbols.

Conductors

- **Conductors** are materials that allow the flow of electric current.
  - Conductors have a low resistance to the flow of electric current.

Batteries

- **Batteries** are devices that store energy in the form of chemical energy.
  - They are used as a voltage source in electric circuits.
  - Most batteries are lithium-ion batteries.
    - They have LiCoO2 cathodes (+) and graphite anodes (-).
    - They have an electrolyte that allows the flow of ions.
  - The voltage of a battery is the potential difference between the positive and negative terminals of the battery.
    - Thus measuring the voltage across terminals and then switching the terminals will give the negative of the original voltage.
- The energy stored in a battery is given by the formula:

$$E = VQ$$

  - Where
    - E is the energy stored in the battery.
    - V is the voltage of the battery.
    - Q is the charge.

Current

- **Current** is the flow of electric charge.
  - The SI unit of current is the ampere A where $A = \frac{C}{s}$.

Ohm's Law

- **Ohm's Law** states that the current flowing through a conductor is directly proportional to the voltage across the conductor and inversely proportional to the resistance of the conductor.
  - The formula for Ohm's Law is:

$$I = \frac{V}{R}$$

    - Where
      - I is the current in amperes (A).
      - V is the voltage in volts (V).
      - R is the resistance in ohms (Ω).

Resistance

- **Resistance** is the opposition to the flow of electric current.
  - The SI unit of resistance is the ohm (Ω).
- The resistance of a conductor is given by the formula:

$$R = \frac{V}{I}$$

  - Where
    - R is the resistance in ohms (Ω).
    - V is the voltage in volts (V).
    - I is the current in amperes (A).
- *Resistors* are devices that are used to control the flow of electric current in a circuit.
  - See section Schematic Symbols for common resistor symbols.

Electric Power

- **Electric Power** is the rate at which electric energy is transferred by an electric circuit.
  - The formula for electric power is:

$$P = IV$$

    - Where
      - P is the power in watts (W).
      - I is the current in amperes (A).
      - V is the voltage in volts (V).
- The energy consumed by an electric circuit is given by the formula:

$$E = Pt$$

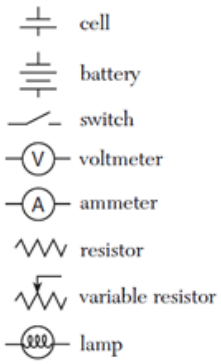
  - Where
    - E is the energy consumed in joules (J).
    - P is the power in watts (W).
    - t is the time in seconds (s).

Electric Circuits

- **Electric Circuits** are systems that allow the flow of electric current.
  - Electric circuits are made up of components such as resistors, capacitors, and batteries.

Schematic Symbols

Circuit Symbols



Types of Electric Circuits

- There are two types of electric circuits:
  - **Series Circuits**: Components are connected in a single path.
    - Resistors in series add up to the total resistance.
    - $R_{\text{total}} = R_1 + R_2 + \ldots + R_n$
  - **Parallel Circuits**: Components are connected in multiple paths.
    - Resistors in parallel add up to the reciprocal of the total resistance.
    - $\frac{1}{R_{\text{total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}$
- Larger circuits can be made up of series and parallel circuits.

Series and Parallel Circuit Diagrams