Chapter 18: Electric Circuits - Notes

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October 19, 2024

Magnetic Field of a Current Loop

- Produces a **magnetic dipole moment**.
- Similar principles apply to **atomic magnetic moments** in permanent magnets.

Permanent Magnets

- Result from alignment of **atomic dipole moments**.
- **Ferromagnetic materials** (e.g., iron, cobalt, nickel) exhibit permanent magnetism.
- **Domains** form within ferromagnetic materials, aligning in the presence of an external magnetic field.
- **Paramagnetic** materials have weak attractions; **diamagnetic** materials experience repulsion.
- Heating a ferromagnet can demagnetize it by disrupting domain alignment.

Key Concepts in Electric Circuits (Chapter 18)

- **Surface Charges** on wires create the **electric field (E-field)** that drives current in a circuit.
- **Steady State** follows initial **transient effects**.
- A **battery** maintains charge separation and potential difference.
- Circuit analysis involves two primary laws:
  1. **Current Node Rule** (Kirchhoff's Law): Current into a node equals current out.

2. **Voltage Loop Rule**: Total potential difference around a loop is zero.

- **Conventional Current**:
  - Electrons move opposite to conventional current flow.
  - **Electron current** exits the negative terminal and enters the positive terminal.

- **Drift Speed Formula**:

  $$I = qnAv$$

  where:
  - I: current
  - n: electron density
  - A: cross-sectional area
  - v: drift speed

- **Equilibrium vs. Steady State**:
  - **Equilibrium**: No current; electron drift velocity is zero.
  - **Steady State**: Constant current; steady drift velocity.

- **Energy Conversion in Circuits**:
  - Current is not "used up" in a circuit.
  - The **bulb** converts **chemical energy** from the battery into **thermal** and **light energy**.

Electric Potential (Voltage) Analogy

- **Electric Potential** is similar to height on a contour map:
  - **Electric field** is analogous to the slope of a hill.
  - **Voltage** drives current, similar to how gravitational potential drives water flow.

Kirchhoff's Current Law (Current Node Rule)

- **Current Node Rule**: Current entering a node equals current exiting.
- Example: In a parallel circuit, current splits among branches but remains conserved.

Electric Field in Wires

- **Electric field (E-field)** is generated by **surface charges** on the wires.
- Constant current implies a constant E-field throughout the wire.
- **Drude's Model** explains that electrons lose energy through collisions with lattice defects but continue moving due to the E-field.
- **Mobility** (u) is a material property controlling drift velocity.

Surface Charges and Circuit Behavior

- The **surface charge** distribution along the wire creates the E-field.
- **Transient State** occurs when a circuit is first connected, leading to a disturbance in the E-field before reaching steady state.
- Surface charges adjust rapidly, restoring equilibrium and maintaining a steady E-field throughout the circuit.