Chapter 20

Electric Circuits

Electromotive Force

- **emf**
- **Maximum potential difference provided by a power source**

Current

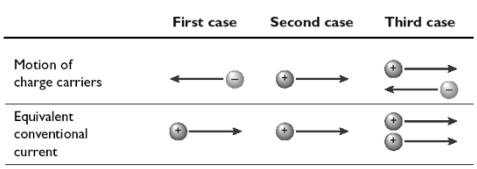
- **Rate at which electrical charges move through a given area**
- Units => C/s = Ampere (A)

Example

- **If the current through a light is 230 mA, how much charge passes a specific point in 12 seconds?**

Conventional Current

- **Charge carriers are presumed to be positive**



Types of current

- **Direct Current**
  - **Charges move in only one direction**
- **Alternating Current**
  - **Motion of charges changes continuously from forward to reverse**

Resistance

- The opposition to the flow of current in a conductor
- Units => V/A = Ohms (Ω)

Ohm's Law

- Resistance is constant over a wide range of potential differences
  - Most metals
  - Does not include all materials
    - diodes

Resistors

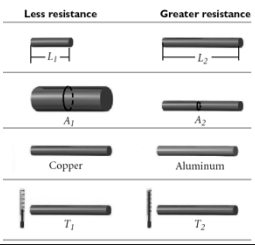
- Electrical component that provides a specific resistance
- Used to control the current

Example

- A 9.0 V battery is connected to a flashlight with a resistance of 200.0 ohms. What is the current running through the flashlight?

Resistance

- More collisions will mean more resistance
  - $R \propto L$
  - $R \propto 1/A$
  - R depends on material
  - $R \propto T$



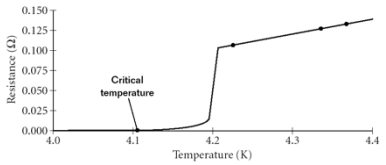
Resistivity

- Describes how much resistance a substance provides
  - ohm•meter
  - Conductors have low resistivity
  - Insulators have high resistivity
  - P. 591

Resistivity

- Temperature also affects the resistivity of a substance
  - Metals-Resistivity increases with T
  - Semiconductors-decreases with T
  - Temperature coefficient of resistivity - α

Superconductors



- Materials that have a resistance of zero at or below a critical temperature

Drift Velocity

- Electric Field sets charges in motion
- Electric field is established at almost the speed of light
- Charges travel more slowly

Drift Velocity

- Electrons do not travel in a straight line
  - Repeated collisions with vibrating atoms cause zigzagging
- Despite collisions electrons still move at a net velocity
  - Drift velocity
    - very slow

Questions

- What is Work?
- What is Work measured in?
- What is Power?
- What is Power measured in?

Energy Transfer

- Circuit with a battery and light
  - Battery provides electrical potential energy
  - Light changes it to light and heat

Electric Power

- Rate of conversion of electrical energy

Example Problem

- A 100.0 W light bulb is connected to 120 V potential difference.
  - What is the resistance of the light bulb?
  - What is the current flowing through the light bulb?

Example Problem

Kilo-watt hours

- Power companies charge for energy, not power
- Energy delivered in 1 hour at a constant rate of 1 kW

$$1kW \cdot h = 3.6 \times 10^6 J$$

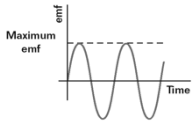
Example

- How much does it cost to operate a 60 W light bulb for 1 week if the cost of electricity is \$0.08/kW·h?

Example

Alternating Current-V

- Potential difference would oscillate between + and – peak or maximum values



  - 60 Hertz or 60 cycles per second
    - US, Canada, & Central America
  - 50 Hertz or 50 cycles per second
    - Most of the rest of the world

Alternating Current-I

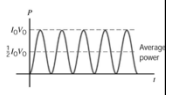
- Current would also oscillate between + and – peak or maximum values

Alternating Current-P

- Power would also oscillate between zero and a positive maximum

Alternating Current-P

- Since power fluctuates, it is customary to consider the average power



Cutnell & Johnson
Wiley Publishing
Physics 5th Ed.
Figure 20.12 (W757)
C M K

Root Mean Square Current

- Average magnitude of Alternating current
- Amount of direct current that dissipates as much energy as alternating current during a complete cycle

Root Mean Square Potential Difference

- Average magnitude of alternating potential difference
- Amount of direct potential difference that dissipates as much energy as alternating potential difference during a complete cycle

Alternating Current

- Calculations for AC use the same formulas as for DC, but
  - Resistance doesn't change
  - Replace I and V with I_{rms} and V_{rms}

Series Wiring

- Circuit that contains only one possible path
- No components will function if one element is broken

Series - Current

- Current will be the same in each Resistor

Series - Voltage

- Total potential difference will be the sum of the potential difference of all resistors

Series - Resistance

Series - Resistance

- Equivalent resistance increases as more components are added

Parallel

- Circuit that contains more than one possible path
- One path can be broken and the others still operate

Parallel - Voltage

- Each path operates independently
- Each path uses the entire potential difference

Parallel - Current

- Each path will carry a portion of the current

Parallel - Resistance

Parallel - Resistance

- Equivalent resistance decreases as more components are added

Power in ***Parallel & Series***

- All components use some energy
- Total energy converted will include all components

Complex Resistor Combinations

- Most Circuits contain combination of series & parallel

20-3 Complex Resistor Combinations

How to solve

1. Find equivalent resistance for entire circuit
   1. Combine Parallel resistors
   2. Combine series resistors
   3. Repeat until single resistance
2. Find all totals (I, ΔV, P)
3. Work backward to find each individual value