Chapter 20 Summary

Essential Concepts and Formulas

Electromotive Force and Current

- The maximum potential difference *V* is called the electromotive force ***emf*** (not not a force as the name implies)
- Flow of charge is called electric current, I
- Measured in C/s = Ampere
- 2 Types of currents: Direct (DC) and Alternating (AC)

$$I = \frac{\mathrm{V}q}{\mathrm{V}t}$$

$$A = \frac{C}{s}$$

$$\xi = emf$$

Ohm's Law

- Analagous to water flowing in a hose.
- In water, great pressure means larger water flow
- In electricity, greater voltage means larger current
- R=resistance
- Resistor: device that offers resistance
- Used to control current and voltage levels

$$V = IR$$

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

$$\frac{volt}{ampere} = ohm(\Omega)$$

Resistance and Resistivity

- Like in a hose, resistance relates to length and area
- Rho is proportionality constant known as resistivity of material
- Rho is inherent property of material, like density
- Like density, changes with temperature

$$R = \rho \frac{L}{A}$$

Electric Power

- Definition: When charge flows from A to B in a circuit, leading to current I and voltage V, the electric power is P=IV
- Unit: Watt (W)
- Substituting other expressions for I and V, we obtain equivalent expressions for power

$$P = \frac{\mathrm{V}Work}{\mathrm{V}Time}$$

$$P = \frac{(\mathrm{V}q)V}{\mathrm{V}t} = \frac{\mathrm{V}q}{\mathrm{V}t}V = IV$$

$$P = IV$$

$$P = I(IR) = I^2 R$$

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

Alternating Current

- Similar to DC current, but voltage and current oscillate
- Equations are basically analogous to dc equations
- rms=root mean square. Obtained by dividing peak value by sqrt(2)
- Eqns aren't as important as concept of oscillation

$$V = V_0 \sin 2\pi ft$$

$$I = \frac{V_0}{R} \sin 2\pi ft = I_0 \sin 2\pi ft$$

$$P = I_0 V_0 \sin^2 2\pi ft$$

$$\overline{P} = \frac{1}{2} I_0 V = \left(\frac{I_0}{\sqrt{2}}\right)\left(\frac{V_0}{\sqrt{2}}\right) = I_{rms} V_{rms}$$

$$\overline{P} = I_{rms} V_{rms}$$

$$\overline{P} = I^2{}_{rms} R$$

$$\overline{P} = \frac{V^2{}_{rms}}{R}$$

Series Wiring

- If devices are in series, the **current** is the same everywhere in the circuit
- Equivalent resistance is sum of individual resistors ($R_s > R_n$)
- You can still find power delivered to the resistors.
- In general, total power delivered is equal to power delivered to equivalent resistance

$$R_s = \sum R_n$$

$$V = IR_s$$

Parallel Wiring

- If devices are in parallel, the **voltage** is the same across each branch
- Equivalent Resistance $R_p < R_n$
- In general, total power is equal to power delivered to equivalent resistor
- Smallest resistance has largest impact (if one equals 0, short out occurs)

$$\frac{1}{R_p} = \sum \frac{1}{R_n}$$

$$I = V \frac{1}{R_p}$$

Circuits Wired Partially in Both

- Strategy: Break it up into series/parallel parts
- Deal with isolated resistors, find equivalent resistance
- Slowly, keep adding one more part at a time, so slowly eliminating resistors
- Once again, easiest way is to break the circuit into manageable parts

Internal Resistance and Kirchhoff's Rule

- Internal resistance: resistance of the battery depends on the current; the terminal voltage (delivered to the circuit) is the emf of the battery minus the internal resistance
- Junction rule: Current into a junction equals current out of a junction (conservation of charge)
- Loop Rule: For a closed-circuit loop, the total of all the potential drops is the same as the total of all the potential rises (conservation of energy)

Measurement of Current and Voltage

- Ammeter: Measures current at some point in the circuit. Probes must be inserted in **series** with the circuit. Meter should have a negligible resistance.
- Voltmeter: Measures the voltage between two points. Probes must be inserted in **parallel** with the circuit. Meter should have a negligible resistance.

Capacitors in Series and in Parallel

- As with resistors, there are equivalent capacitance when multiple capacitors in series
- Capacitors in series all have the same amount of charge on each plate of the capacitor
- Capacitors in parallel are charged to the same voltage

$$C_p = \sum C_n$$

$$\frac{1}{C_s} = \sum \frac{1}{C_n}$$

Summary of Equations

$$I = \frac{Vq}{Vt}$$

$$V = IR$$

$$R = \rho \frac{L}{A}$$

$$P = IV = I^2 R = \frac{V^2}{R}$$

$$V = V_0 \sin 2\pi ft$$

$$I = I_0 \sin 2\pi ft$$

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

$$\overline{P} = I^2{}_{rms} R = \frac{V^2{}_{rms}}{R}$$

$$R_s = \sum R_n$$

$$\frac{1}{R_p} = \sum \frac{1}{R_n}$$

$$C_p = \sum C_n$$

$$\frac{1}{C_s} = \sum \frac{1}{C_n}$$