Chapter 4

Basic Physics of Radiography

Learning Objectives

- Define matter and list its three forms
- Name the fundamental particles of the atom and list characteristics of each
- Draw or describe a conceptual model of atomic structure
- List and describe six forms of energy
- Draw a sine wave and measure its amplitude and its wavelength

Learning Objectives (Cont'd)

- Relate the wavelength of a sine wave to its velocity and frequency
- State the characteristics of x-rays
- Explain the relationship between potential difference (kVp) and current (mA) in an electric circuit

Learning Objectives (Cont'd)

- State the frequency of A-C current in the United States and Canada using the correct units
- Describe the process of electromagnetic induction

Matter

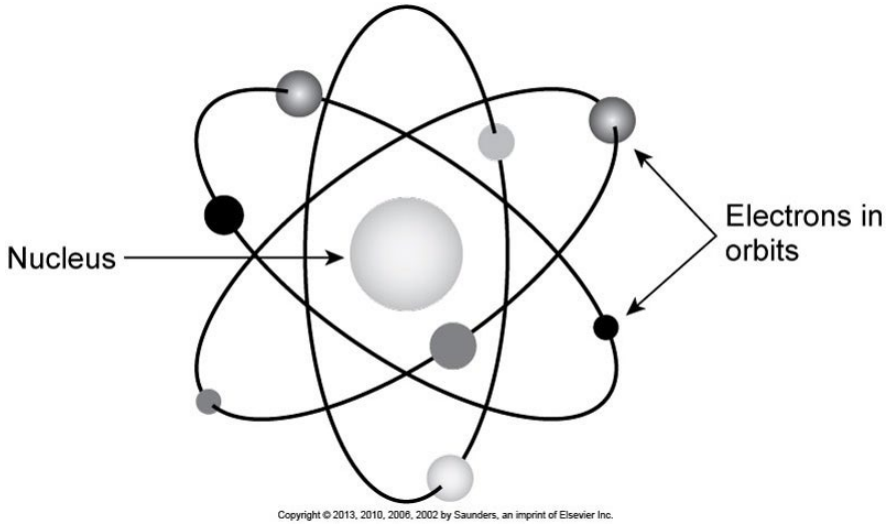
- Can take the forms of:
  - Solid
  - Liquid
  - Gas
- Mass = the amount of matter in an object

Atoms

- Compose all matter
- Consist of:
  - Protons
  - Neutrons
    - Protons and neutrons together form the nucleus or center of an atom
  - Electrons (important in radiology production)

Atoms (Cont'd)

- Protons
  - Positively charged
  - Reside in nucleus
- Neutrons
  - No charge
  - Reside in nucleus
- Electrons
  - Negative charge
  - Orbit the nucleus in shells or energy levels
  - Shells contain a specific number of electrons



Atoms (Cont'd)

- May be:
  - Neutral
    - Contain the same number of protons and electrons
  - Ionized
    - Contain a greater or lesser number of electrons than protons

*When a neutral atom gains or loses an electron it is said to be ionized, this process is called ionization.

Atoms (Cont’d)

- K-shell:

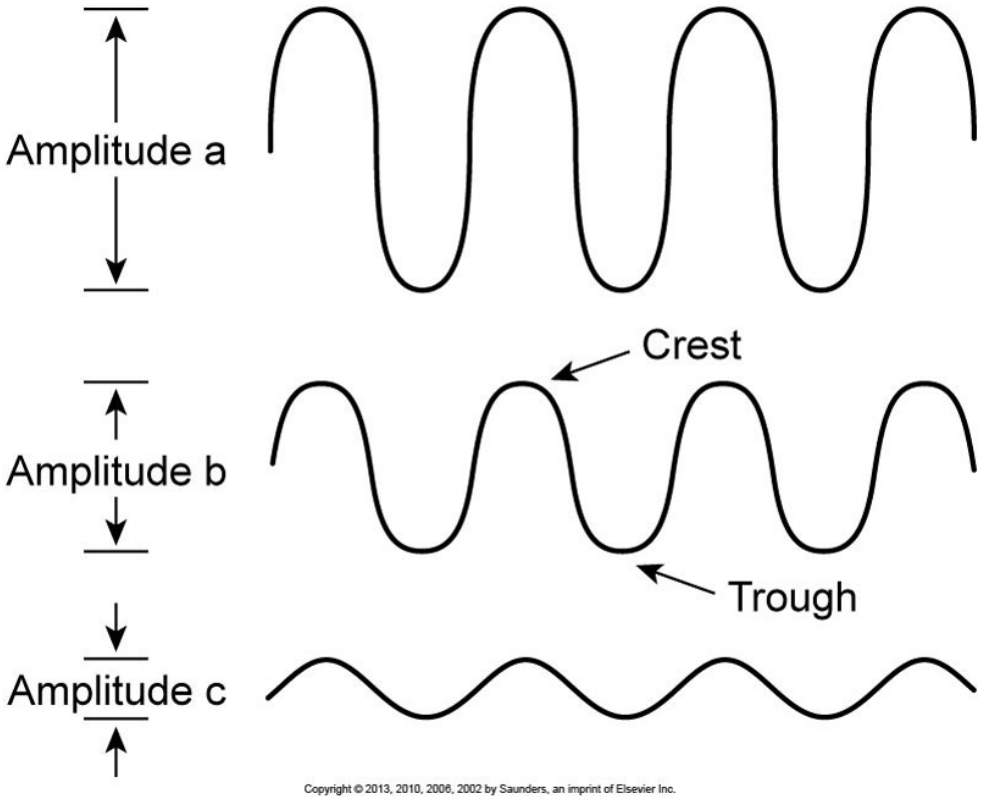
  Important because removal of an electron in this shell is one way in which x-rays are created

Energy

- Ability to do work
- Classifications include:
  - Mechanical – kinetic (energy of motion) & potential (stored energy)
  - Chemical – released through chemical changes
  - Thermal - heat
  - Nuclear – energy used to produce electricity in a nuclear power plant
  - Electric – electricity; the ability of electric charges to do work
  - Electromagnetic – have both electric and magnetic properties; occurs in a pattern called a sine wave

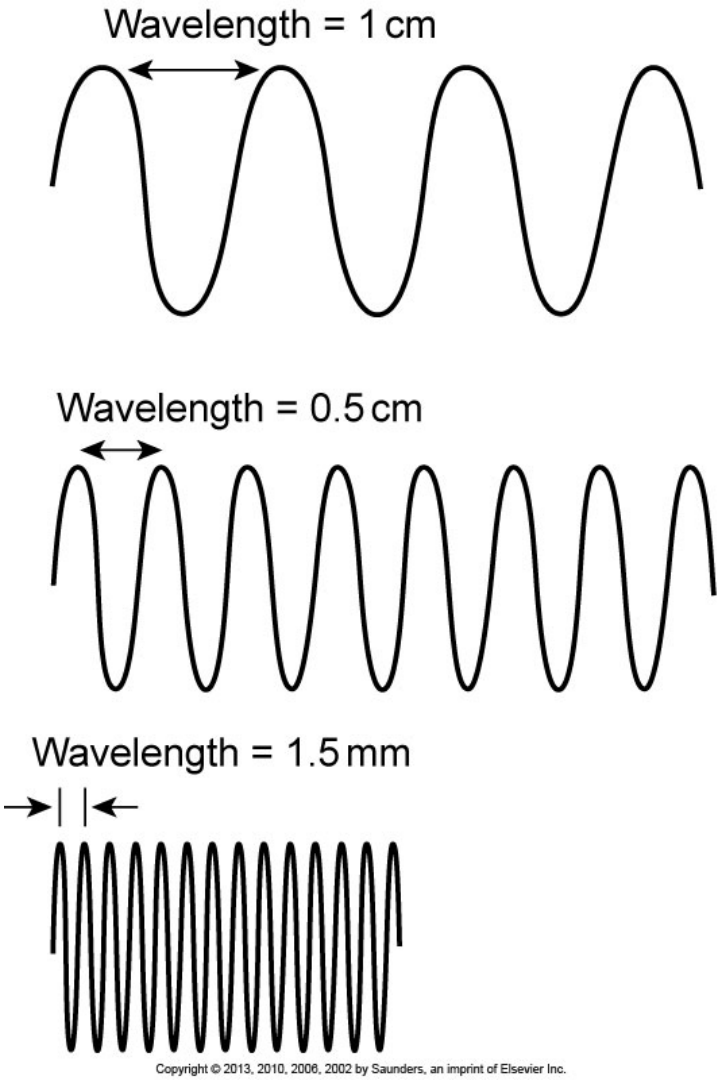
Electromagnetic Energy

- Includes light, x-rays, radio waves, and microwaves
- Travel in sine waves characterized by:
  - Amplitude (height) or distance between the wave crest and trough
  - Wavelength or distance from crest to crest
  - Frequency or number of crests per second passing a given point



Electromagnetic Energy (Cont'd)

- Velocity is constant (186,000 miles/sec)
- Wavelength and frequency vary
- Short wavelength = high frequency and high energy
- Long wavelength = low frequency and low energy



Characteristics of X-rays

- X-rays
  - Travel in straight lines at 186,000 miles/sec
  - Have no mass
  - Are highly penetrating and invisible
  - Are electrically neutral
  - Can cause harmful biologic effects
  - Cannot be detected by human senses
  - Can cause ionization
  - Produce secondary and scatter radiation

Characteristics of X-rays (Cont’d)

X-rays are unique because they have very *high frequency* and very *short wavelengths*

Electricity

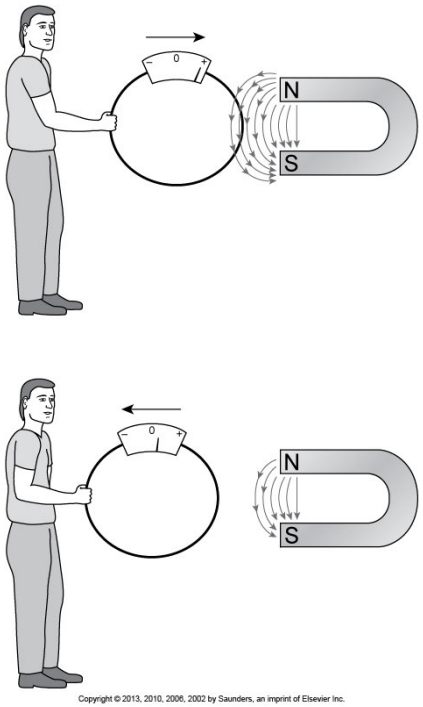
- Used to produce x-rays
- Three electrical factors of an electric circuit
  - Electric Current
    - Number of negative electrons flowing toward a positive charge
    - Circuit is the path over which electrons move
    - Measurement unit = ampere (A)
  - Electrical Resistance
    - Anything that hinders the electron flow or current
    - Amount depends on conductor material, length, diameter, and temperature
    - Measurement unit = ohm (Ω)
  - Potential Difference
    - Power and speed of electron flow or current
    - Measurement unit = volt (V) *1000 volts = kilovolt (used to measure the potential difference across an x-ray tube)

Types of Electric Currents

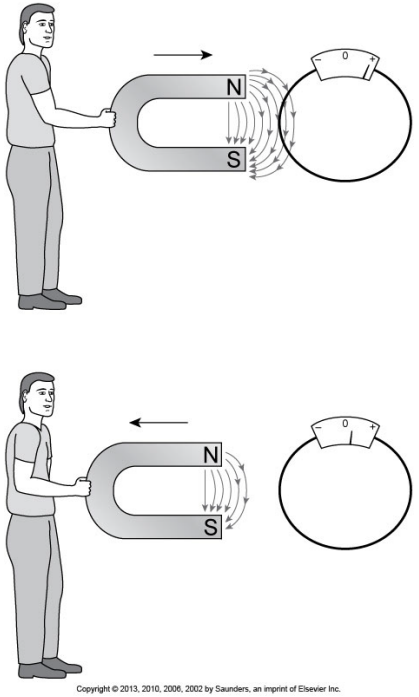
- Direct (D-C)
  - Current flows at a constant rate in one direction from the positive pole (anode) to the negative pole (cathode)
- Alternating (A-C)
  - Current flow changes or alternates directions at a rate of 60 cycles per second or 60 hertz (Hz) in the United States and Canada
  - Process of *rectification* changes A-C to D-C

Electromagnetic Induction

- Moving a conductor within a magnetic field will produce an A-C

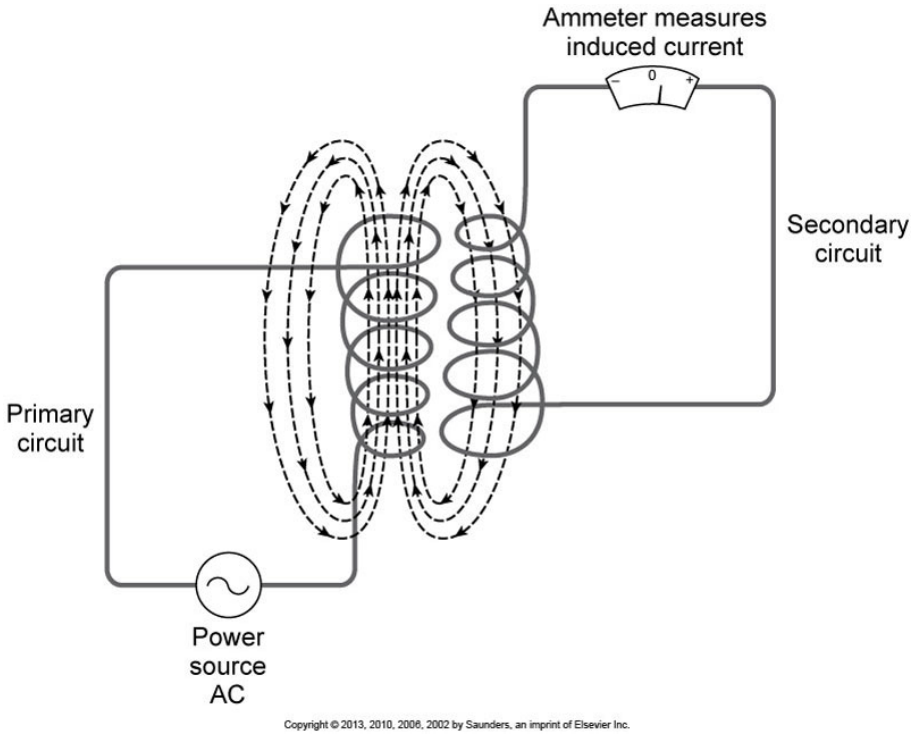


- Moving a magnetic field across a conductor also produces A-C



Electromagnetic Induction and Transformers

- Transformer coils use electromagnetic induction to vary the amount of voltage
- Voltage changes affect the amount of current or amperage
- Step-up transformers increase voltage and decrease amperage
- Step-down transformers decrease voltage and increase amperage



Summary

- Matter takes the form of a solid, liquid, or gas
- All matter is made up of atoms that contain protons, neutrons, and electrons
- When an atom has more or fewer electrons than protons, it is an ion or charged atom

Summary (Cont'd)

- X-rays are a form of electromagnetic energy
- X-ray strength depends on its wavelength and frequency
- Even though human senses cannot detect x-rays, they are capable of producing biologic effects
- X-rays cause ionization in the atoms of tissues

Summary (Cont'd)

- Electricity is used to produce x-rays
- Characteristics of electricity include current, resistance, and potential difference
- Circuit elements may be arranged in series or parallel
- Current is direct or alternating
- Alternating current in the United States and Canada is 60 Hz

Summary (Cont'd)

- Electromagnetic induction uses movement between the conductor and magnetic field to produce A-C
- Transformer coils employ electromagnetic induction to increase or decrease the voltage in the x-ray circuit