Chapter 4

Basic Physics for 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 five forms of energy
- Draw a sine wave and measure its amplitude and its wavelength

Learning Objectives

- Relate the wavelength of a sine wave to its velocity and frequency
- Compare and contrast the characteristics of x-rays with the characteristics of visible light
- Explain the relationship between potential difference, current, and resistance in an electric circuit and state the units used to measure each

Learning Objectives

- State the frequency of alternating current in the United States and Canada using the correct units
- Describe the process of electromagnetic induction
- Draw simple diagrams of step-up and step-down transformers

Matter

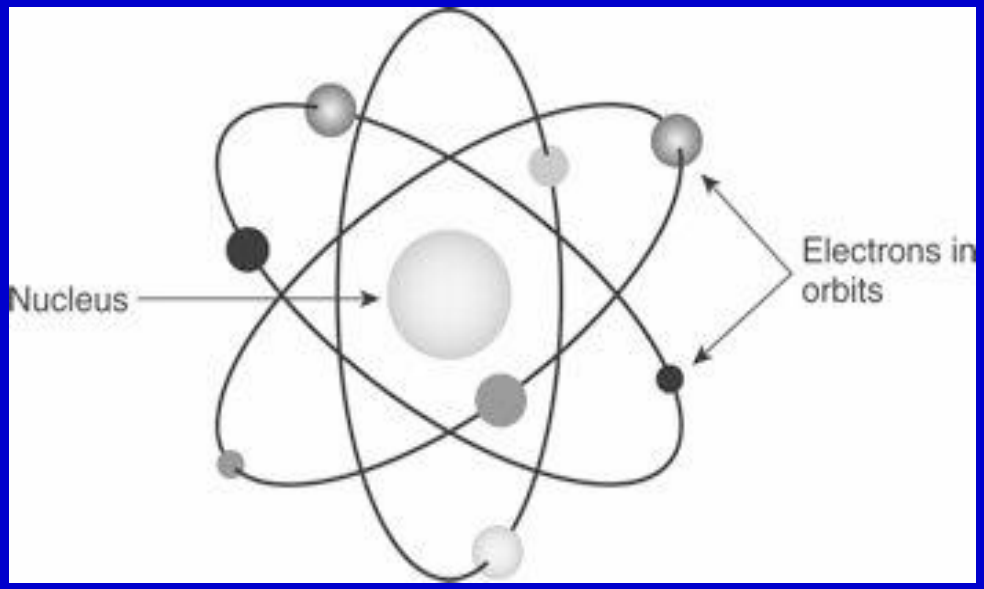
- Can take the forms of:
  - Solid
  - Liquid
  - Gas
- Mass = the amount of matter in an object

Atoms

- Compose all matter
- Consist of
  - Protons
  - Neutrons
  - Electrons

Atoms

- 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



Clicker Question

The negatively charged particles orbiting around the nucleus of an atom are:

a) protons

b) neutrons

c) electrons

Atoms

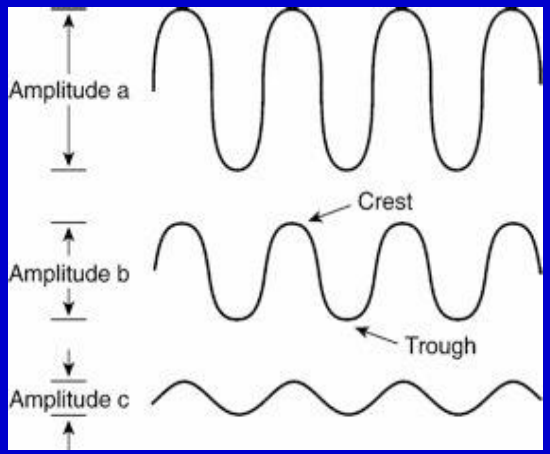
- May be
  - Neutral
    - Contain the same number of protons and electrons
  - Ionized
    - Contain a greater or lesser number of electrons than protons

Energy

- Ability to do work
- Classifications include:
  - Mechanical
  - Chemical
  - Thermal
  - Nuclear
  - Electric
  - Electromagnetic

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



Clicker Question

The distance between the crest and trough of an electromagnetic energy wave is termed:

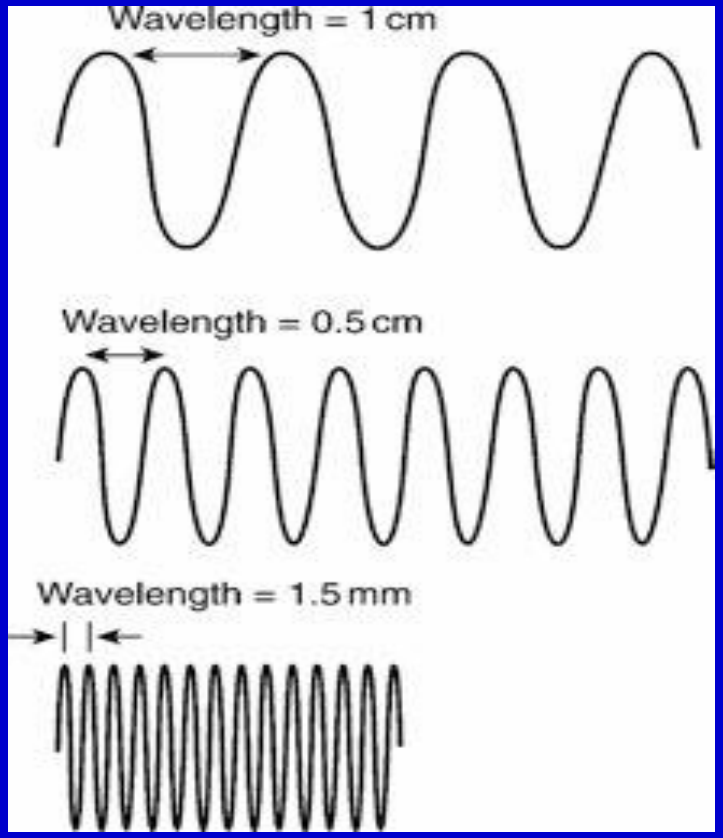
a) wavelength

b) frequency

c) amplitude

Electromagnetic Energy

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



Clicker Question

Short wavelength electromagnetic energy has:

a) low frequency and energy

b) high frequency and energy

c) low frequency and high energy

d) high frequency and low energy

Characteristics of X-rays and Visible Light

- X-rays and Visible Light
  - Travel in straight lines at 186,000 miles/sec
  - Affect photographic emulsions
  - Can cause harmful biologic effects
- X-rays
  - Cannot be detected by human senses
  - Can penetrate matter
  - Can cause certain materials to fluoresce

Electricity

- Used to produce x-rays
- Electric Current
  - Number of negative electrons flowing toward a positive charge
  - Circuit is the path over which electrons move
  - Current is represented by the letter I
  - Measurement unit = ampere (A)

Electricity

- 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
  - Strength of electron flow or current
  - Measurement unit = volt (V)

Clicker Question

The unit of measurement for electric current is the:

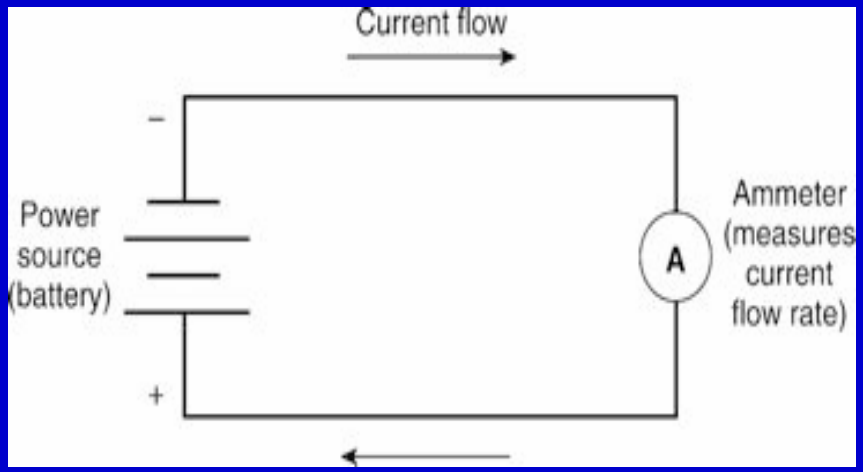
a) ampere

b) ohm

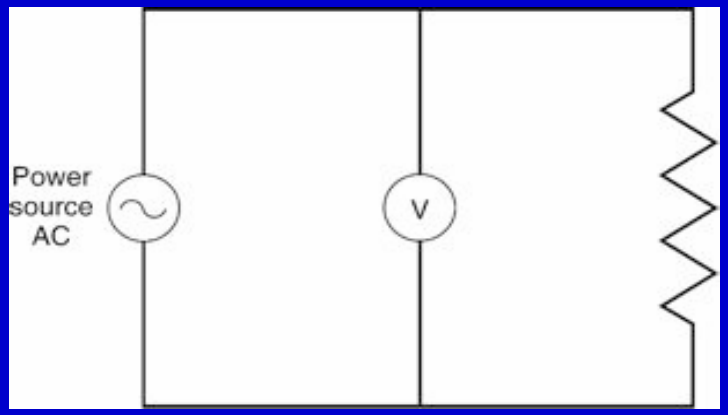
c) volt

Types of Circuits

- Series
  - Devices such as an ammeter are wired directly into the circuit



- Parallel
  - Devices such as the voltmeter are wired across the circuit so that electric potential between two points can be measured



Types of Currents

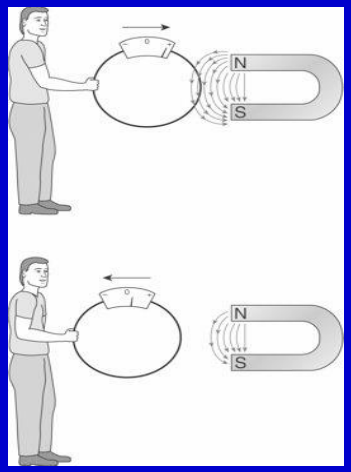
- Direct (DC)
  - Current flows at a constant rate in one direction from the positive pole (anode) to the negative pole (cathode)
- Alternating (AC)
  - Current flow changes or alternates directions at a rate of 60 cycles per second or 60 hertz (Hz) in the USA and Canada
  - Process of rectification changes AC to a pulsating DC

Clicker Question

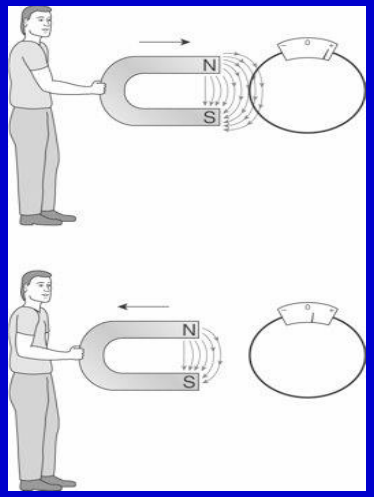
Alternating current operates at:

a) 120 Hz
b) 60 Hz
c) 30 Hz
d) 15 HZ

Electromagnetic Induction



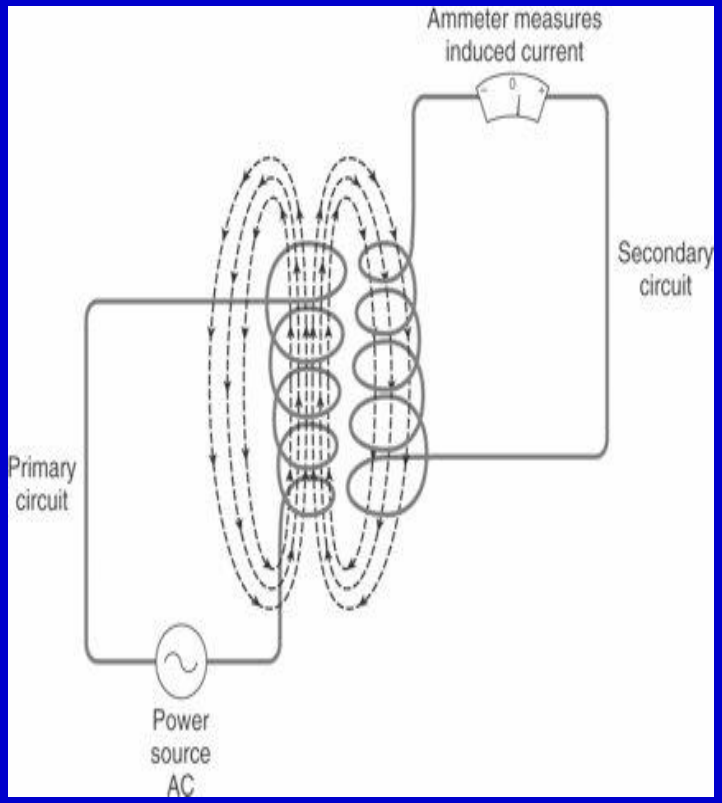
- Moving a conductor within a magnetic field will produce an AC



- Moving a magnetic field across a conductor also produces AC

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

- 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

Summary

- 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 US and Canada is 60 Hz

Summary

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