

17-1 Electromagnetic Waves

- transfers energy called electromagnetic radiation
- no medium needed
- transverse
- some electrical, some magnetic properties
- speed is 300,000,000 m/s; nothing is faster; at this speed sunlight reaches Earth, a distance of 150 million kilometers, in 8 minutes

17-2

- Electromagnetic waves travel at same speed but can have different frequencies and wavelengths (speed = frequency x wavelength).
- Electromagnetic Spectrum is the range of electromagnetic waves in order of increasing frequencies and therefore decreasing wavelengths. It ranges from radio waves including microwaves and radar, infrared rays, visible light, ultraviolet rays, X-rays to gamma rays.

Radio waves

- Antennas pick up the waves from the air; wires send them to the radio; the radio converts them to sound. Each station in an area broadcasts at a different frequency. To change the station you adjust the dial/press a button. The # tells you the frequency used.
- Microwaves are the shortest wavelength radio waves used in
 - microwave ovens: waves bounce off penetrating the food where water molecules absorb the energy and warm the food. The waves pass through glass/plastic but will be reflected off metals. So, metals should never be used in microwave ovens.
 - cellular phone calls: microwaves are not easily blocked by trees, mountains, or buildings
- **RADAR (Radio Detection and Ranging)** are short wavelength microwaves used to
 - monitor airplane landing and take off
 - track weather systems
 - find the speed of cars using the Doppler Effect
 - measure the speed of balls at sporting events
- **MRI (Magnetic Resonance Imaging)** is used in medicine to produce pictures of soft tissues in human body that do not show up on X-rays.

Infrared Rays: energy felt as heat used in

- heat lamps
- infrared cameras; the picture, called thermogram, shows different parts of the human body or a house according to different temperatures to check for abnormalities such as energy leaks in a house
- detecting people/animals in the dark
- satellites to study plant growth and cloud motion

Visible Light: the light we see

- The colors are red, orange, yellow, green, blue, indigo, violet in order of increasing frequency.
- Rainbow: when light waves pass through a new medium, they bend/refract, different wavelengths by different amounts. This way, light separates into different colors.

Ultraviolet Rays: beyond violet rays

- some insects, unlike humans, can see them
- some UV rays are good for the skin to make vitamin D needed by bones and teeth; but too much exposure causes skin cancer and eye damage
- used in UV lamps to kill bacteria in hospitals/food processing plants and also to treat jaundice in newborn babies

X-rays

- can penetrate most matter, especially dense ones like bone and lead
- too much can cause cancer
- used in small amounts to
 - take pictures inside the human body
 - check for tiny cracks in pipelines or steel structures

Gamma rays

- are produced by some nuclear reactions
- some objects in space give them off which will later be blocked by the atmosphere; so telescopes that detect gamma rays must be placed above the atmosphere
- too much can cause serious illness
- in controlled conditions, they can be used to kill cancer cells in radiation therapy and examine internal structures in the body

17-3

- Illuminated object: object seen because it reflects light, ex. desk
- Luminous object: object gives off its own light, ex. light bulb, burning match, sun
- Spectroscope: instrument to view the different colors of light produced by different light bulbs
- Different types of lighting:
 - a. incandescent light
 - glows when tungsten filament gets hot and continuously gives off all colors of visible light appearing white
 - not very efficient; less than 10% of the energy given out as light, rest as infrared rays felt as heat
 - b. fluorescent light
 - glass tube with a gas and a powder coating; the gas emits UV as heated making the coating emit visible light
 - more efficient than incandescent since most of the energy is given off as light; so they last longer, use less electricity, and are less expensive
 - c. Neon light
 - sealed glass tube filled with a noble gas which releases the energy it absorbs as light
 - commonly used for bright, flashy signs, each gas giving out a different color
 - d. Sodium Vapor light
 - Sodium changes into gas as heated giving off energy in the form of yellow light
 - commonly used for street lighting since it uses less electricity and is economical
 - e. Tungsten-Halogen light
 - has Tungsten filament and a Halogen gas which gives off a bright light when heated
 - uses less electricity so is used in overhead projectors, floor lamps
 - gets very hot and must be placed away from flammable objects like curtains and paper
- Bioluminescence: process by which organisms like fireflies, jellyfish, deep-sea fish produce own light as a result of chemical reactions among proteins and oxygen. They use this to search for food, attract mates, and protect themselves.

17-4

- AM (Amplitude Modulation)
 - long wavelengths
 - easily reflected by Earth's ionosphere and therefore broadcast over long distances, especially at night when the absorption of radio waves by the ionosphere is less
 - reception not very clear; so they are used for talk shows rather than music
- FM (Frequency Modulation)
 - higher frequencies and energy
 - therefore they penetrate the atmosphere rather than being reflected back to Earth; so they don't travel as far as AM
 - clear reception, better sound quality; so they are used to broadcast music
- TV
 - electromagnetic waves carry picture and sound signals
 - weather can affect the reception; cable reception is better
- Cellular Phones
 - use microwaves
 - can't travel great distances
- Cordless Phones
 - information transmitted from handset to the base by radio waves
 - no wires between base and handset
- Pagers
 - your message is first sent to a receiving station, where it is coded and sent as electromagnetic waves to the correct pager
- Communication Satellites
 - long-distance communication is faster and cheaper
 - radio waves are sent from Earth to the satellite, which then relays them to Earth receivers after strengthening the signals
 - used for phone, TV, and GPS (**G**lobal **P**ositioning **S**ystem)

