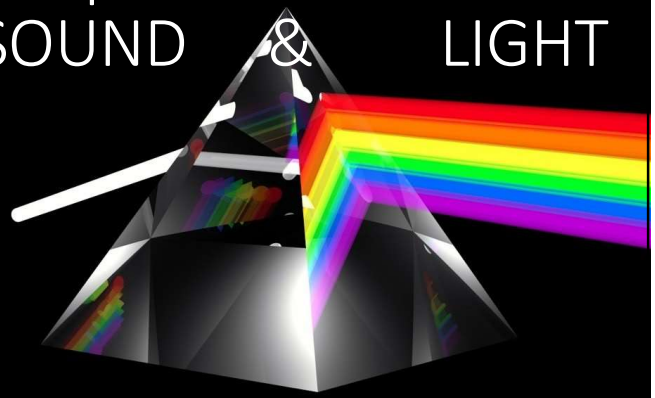
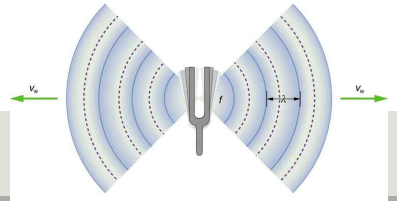
Chapter 16
SOUND & LIGHT



Properties of Sound

- Sounds waves
  - Type of mechanical wave
  - longitudinal waves
  - In air moves in directions away from the source.
- Speed of sound depends on the medium



Properties of Sound

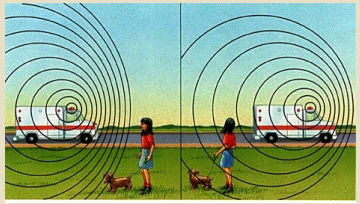
- The density and stiffness of the medium affects the speed at which sound travels through the medium.
- Mediums that are more dense allow sound to travel faster because the particles are close together and do not have to travel a great distance when colliding with neighboring particles.
- Temperature also affects the speed of sounds
  - Hot temperature allow sounds to move faster than cold temperatures.

Speed of sound in Various Mediums

Medium	Speed of sound (m/s)	Medium	Speed of sound (m/s)
Gases		**Liquids at 25 °C**	
Air (0 °C)	331	Water	1,490
Air (25 °C)	346	Sea water	1,530
Air (100 °C)	386	**Solids**	
Helium (0 °C)	972	Copper	3,813
Hydrogen (0 °C)	1,290	Iron	5,000
Oxygen (0 °C)	317	Rubber	54

Doppler Effect

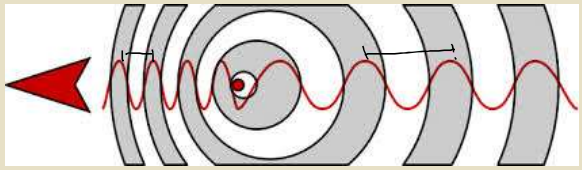
- Frequency changes when the source of waves is moving
- Ex. Siren moving toward you sounds different than a siren moving away from you



Video Clip

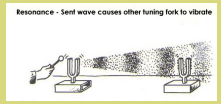
Doppler Effect

- Doppler effect-an observed change in the frequency of a wave when the source or observer is moving
- A sound wave frequency change is noticed as a change in pitch.
- The Doppler effect occurs for many types of waves, including sound waves and light waves.

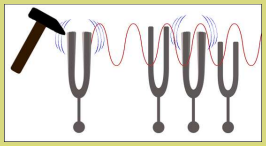


Musical Instruments

- *Resonance* is an effect in which the vibration of one object causes the vibration of another object at a natural frequency
- Instruments use resonance to amplify sound (guitar)



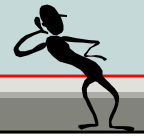
Tuning Forks Clip



Hearing and the Ear

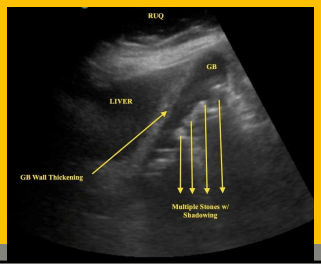
- The human ear is a very sensitive organ that senses vibrations in the air, amplifies them, and transmits signals to the brain
  - Sound waves cause membranes in the ear to vibrate (eardrum)
  - Vibrations pass through three regions in the ear: outer, middle, inner
  - Resonance occurs in the inner ear
  - The brain interprets impulses from the nerve fibers as a sound with a specific frequency

Hearing Test Hearing test 2



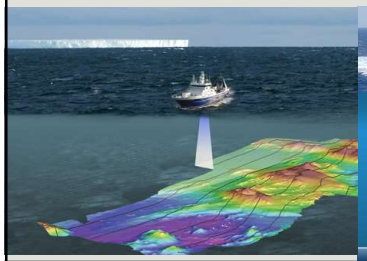
Ultrasound and Sonar

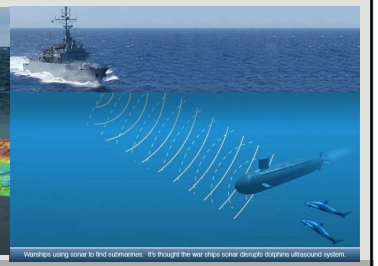
- Like all waves, sound waves reflect
- The reflection of sound waves can be used to determine distance and to create maps and images
  - Sonogram made by different boundary surfaces by a computer. **Ultrasound** is used to create sonogram (1,000,000,000 Hz and 15,000,000 Hz). Not damaging to human cells



Ultrasound and Sonar

- *Sonar* is a system that uses reflected sound waves to determine the distance to and location of objects
- Sonar is used for underwater location
- Distance can be determined by the formula $d=vt$



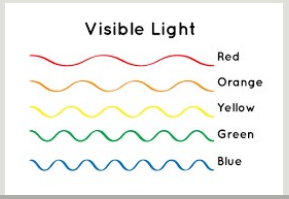


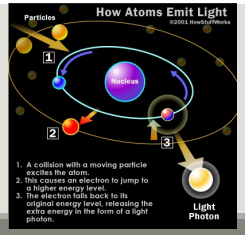
Video

Light

- Type of electromagnetic wave
- Light can behave as waves and as particles.
  - Wave model- interference of light
  - Particle model-light knocking electrons off a metal plate or light traveling through space photon

Both models are accepted by scientists





Light

The energy of light is proportional to frequency

- Each photon of light carries a small amount of energy.
- The amount of this energy is proportional to the frequency of the corresponding electromagnetic wave.

Type of wave	Wavelength	Wave frequency	Photon energy
Infrared	1.33×10^{-6} m	2.25×10^{14} Hz	1.5×10^{-19} J
Visible light	6.67×10^{-7} m	4.5×10^{14} Hz	3.0×10^{-19} J
Ultraviolet	3.33×10^{-7} m	9.0×10^{14} Hz	6.0×10^{-19} J

Light

The speed of light depends on the medium

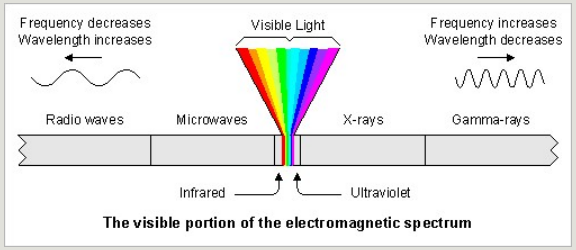
- In a vacuum, light travels at the same speed,
  $c = 3 \times 10^8$ m/s.
  - Nothing travels faster than the speed light.
  - Light is the fastest signal in the electromagnetic spectrum.
  - Light slows down when passing through a medium
    - Transparent mediums like air, water, glass

Medium	Speed of light ($\times 10^8$ m/s)
Vacuum	2.997925
Air	2.997047
Ice	2.29
Water	2.25
Quartz	2.05
Glass	1.97
Diamond	1.24

Light

Electromagnetic Spectrum- Types of light

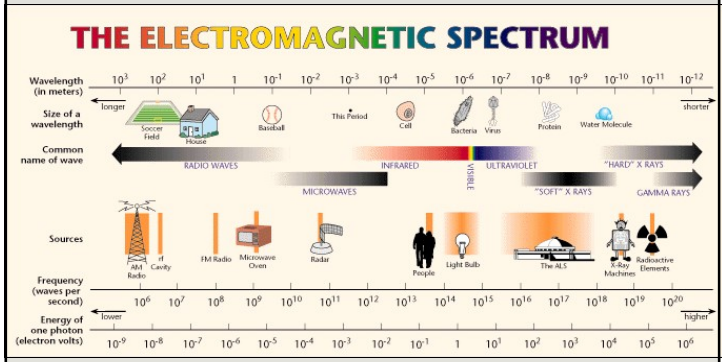
- EM Spectrum- consists of waves at all possible energies, frequencies, and wavelengths



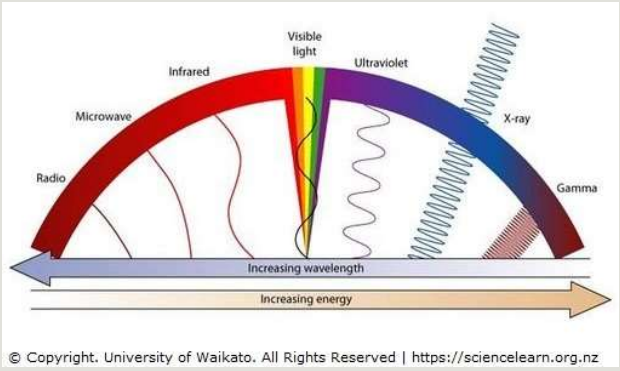
The visible portion of the electromagnetic spectrum

EM clip

Electromagnetic Spectrum



Electromagnetic Spectrum

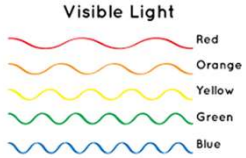


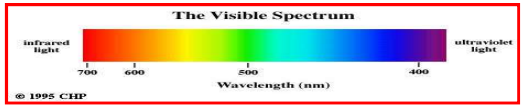
Electromagnetic Spectrum- Types of light

- Radio waves are used in communication and radar
  - Lowest frequency
  - FM, AM, and TV signals
- Microwaves used in cooking and communication
  - Telecommunication over a long distance. (Space to Earth)
- Infrared light can be felt as warmth
  - Sun or a heat lamp warm you.
  - Weather satellites read (temperature changes) for the tracking of cloud movement

Visible Spectrum – Light we can see

- Roy G. Biv – Acronym for remembering the colors of visible light
  - Largest to Smallest Wavelength.
    - R- Red
    - O- Orange
    - Y- Yellow
    - G- Green
    - B- Blue
    - I- Indigo
    - V-Violet

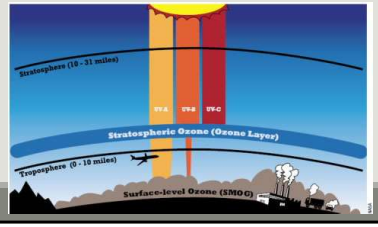




How are the visible light spectrums above and below different?

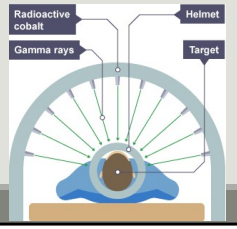
Electromagnetic Spectrum- Types of light

- Ultraviolet light has higher energy and shorter wavelengths than visible light.
  - Sunlight contains ultraviolet light (UV rays) (9%)
  - UV rays can pass through thin layers of clouds, causing sunburn.



Electromagnetic Spectrum- Types of light

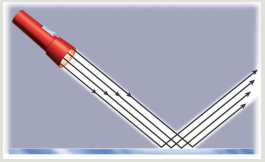
- X rays and gamma rays are used in medicine.
  - Both have higher energy and shorter wavelengths than UV rays
  - Gamma rays have the highest energy and the shortest wavelengths.
  - Both rays can kill living cells, or turn them into cancer cells.
  - Gamma rays can be used to treat cancer, by killing diseased cells



Reflection

Rough surfaces reflect light rays in many directions.

Smooth surfaces reflect light rays in one direction.

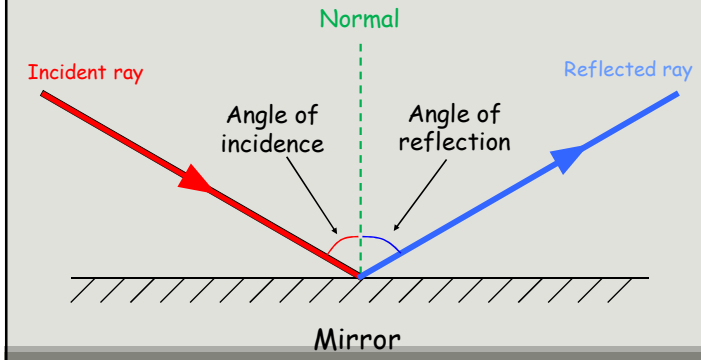


The *angle of reflection* is the light rays reflecting off the surface.

The *angle of incidence* is the light rays striking the surface

Reflection

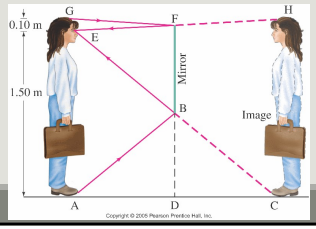
Reflection from a mirror



Mirrors

1. Flat mirrors

- Form virtual images by reflection.
- A virtual image is an image that forms at a point from which light rays appear to come but do not actually come.
- Some of the light rays are reflected off the mirror into your eyes.
  - Perceive an image of yourself behind the mirror



Mirrors

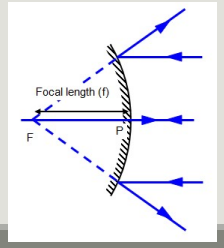
2. Curved mirrors

- Can distort images
- The normal line points in different directions for different parts of a curved mirror.
- Two types:
  - Convex mirrors
  - Concave mirrors

Mirrors

Curved Type 1: Convex mirrors

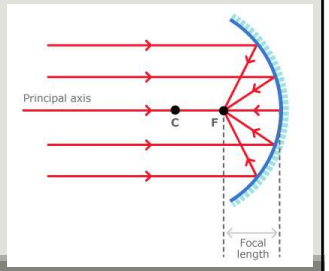
- Curve or bulge out
- Produce a stretched out image
- Light rays that start out parallel are reflected in different directions
- Make objects appear ***smaller*** than they actually are
  - Ex. Mirrors on the passenger side of vehicles



Mirrors

Curved Type 2: Concave mirrors

- Caved in shape
- Create real images AND virtual images
- A real image results when light rays are focused onto a single point or small area
- Ex. Used by telescope
- Ex. Radio telescopes gather radio waves from extremely distant objects.



Seeing Color

White light

- contains all visible colors - ROY G. BIV
  - **an object…**
    - reflects the color you see
    - absorbs all other colors

Black is the absence of color; all light is absorbed

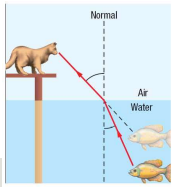
- No light gets to your eyes

REFLECTS ALL COLORS

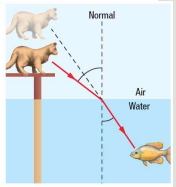
ABSORBS ALL COLORS

Refraction of light

- Refraction- Light waves bend, or refract, when they pass from one transparent medium to another
  - Objects appear to be in different positions
  - Refraction of light in the atmosphere creates *mirages*.



A To the cat on the pier, the fish appears to be closer than it actually is.



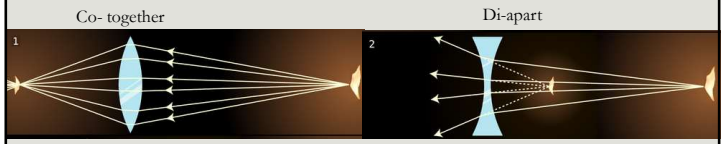
B To the fish, the cat seems to be farther from the surface than it actually is.

Lenses

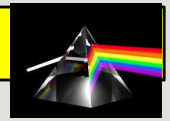
Lenses

- A lens is a transparent object that refracts light rays, causing light rays to change direction
- Rely on refraction

- A *converging lens* bends light inward (virtual or real image)
- A *diverging lens* bends light outward (virtual image only)



Dispersion and Prisms



- A *prism* is a transparent block with a triangular cross section.
  - Different colors of light are refracted differently.
  - Light waves with different wavelengths travel at different speeds.
  - In the visible spectrum:
    - violet –slowest bend more than red-fastest
- The slower light refracts more when passing between media