Preview of Period 2: Electromagnetic Waves – Radiant Energy I

2.1 Energy Transmitted by Waves

How can waves transmit energy?

2.2 Refraction of Radiant Energy

What happens when a light beam travels through water?

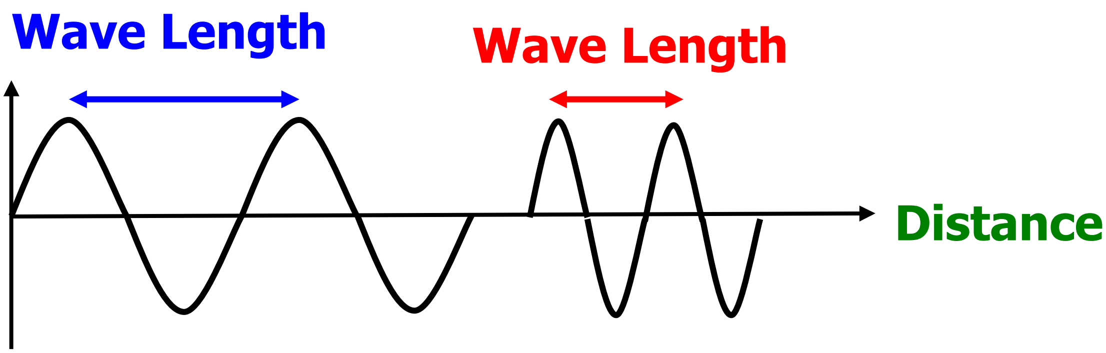
2.3 Focusing Radiant Energy

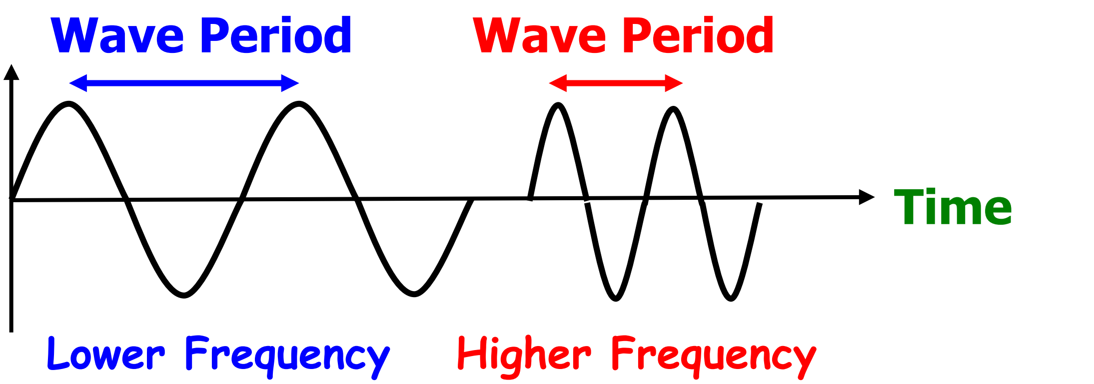
What happens when a light beam strikes a lens?

2.4 The Quantum Model of Electromagnetic Radiation

How can the quantum model explain the electric current produced by solar cells and fluorescence?

Wavelength, Period, and Frequency





The **period** of a wave is the time it takes the wave to complete one cycle.

The **frequency** of a wave is the inverse of its period.

frequency* = *1/period

Frequency is measured in Hertz (Hz).

1 Hz = 1 cycle/second

Wave Speed

The frequency of a wave is the inverse of its period. Frequency is measured in Hertz (Hz).

frequency = 1/period

The relationship between wavelength and frequency gives the speed of a wave:

$$s = f\,L$$

s = speed at which radiant energy travels (meters/sec or mi/sec)

f = frequency (cycles/sec, or Hertz)

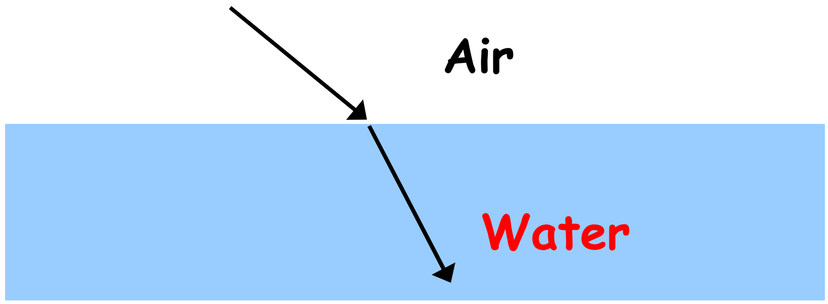
L = wavelength (in meters or feet)

Compare Electromagnetic and Sound Waves

- Which type of waves can travel through air?
- Which type of waves can travel through a vacuum?
- How do the speeds of sound waves and electromagnetic waves compare?

Refraction of Light

When light enters a transparent material, the speed of the wave changes and the light beam is *refracted,* or bent.



The *index of refraction* (n) is a measure of the amount that a light beam is bent as it passes from one medium to another medium.

$$n = \frac{\text{speed of light in a vacuum}}{\text{speed of light in material}}$$

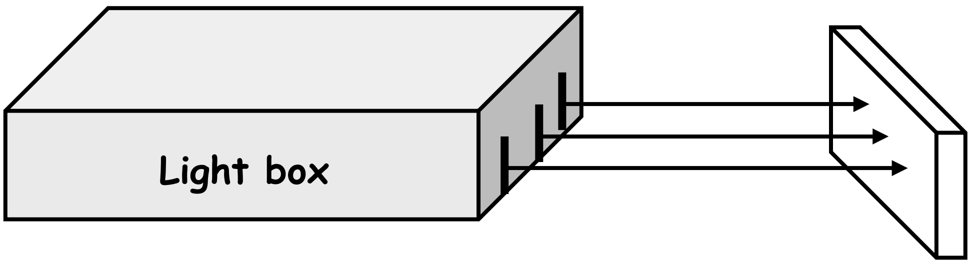
The speed of light in a vacuum is 3×10^8 m/s.

Light Refracted by a Prism

The amount that light is refracted depends on the frequency of the light wave.

When light passes through a prism, this difference in refraction separates the light into a rainbow of colors.

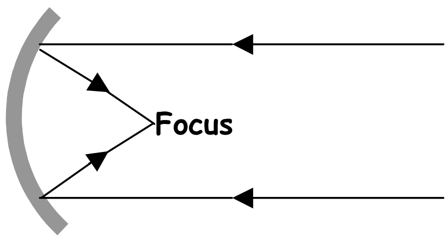
Light Reflecting from a Plane Mirror



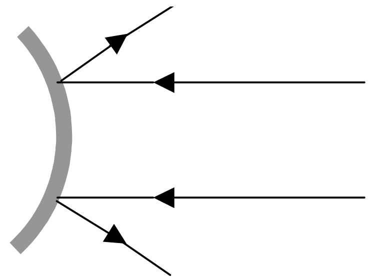
- Place a sheet of white paper under the mirror.
- Mark the position of the mirror on the paper with a straight line.
- Draw lines on the paper showing the path of the light beams as they strike the mirror and reflect off the mirror.
- Use a protractor to compare the angle of incidence and the angle of reflection of light striking a mirror.
- How are these angles related?

Mirrors and Lenses

Light from concave and convex mirrors

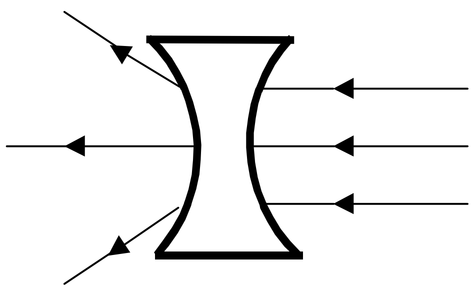


A Concave Mirror Focuses Radiant Energy

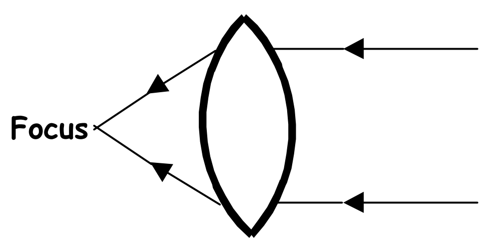


A Convex Mirror Spreads Radiant Energy

Light through concave and convex lenses



A Concave Lens Spreads Radiant Energy



A Convex Lens Focuses Radiant Energy

Quantum Model of Electromagnetic Radiation

The quantum model treats radiant energy as many small packets of energy called photons.

The energy of a photon is related to the frequency and wavelength.

$$E = h\,f = (h\,c)/L$$

E = energy of a photon (joules)

h = is a proportionality constant
= 6.63×10^{-34} joule sec

f = frequency (Hertz)

c = speed of the radiant energy
= 3×10^{8} meters/sec

L = wavelength (meters).

When radiant energy interacts with matter, it absorbs or deposits energy in amounts that are integer multiples of this photon energy

Solar Cells and the Quantum Model

The quantum model treats radiant energy as many small packets of energy called photons.

Solar cells use the photoelectric effect to produce electricity.

- When electrons absorb photons of electromagnetic radiation, some electrons have enough energy to escape from their atom and form an electric current.

- Only photons with wavelengths equal to or shorter than visible light have enough energy per photon to produce a current.

Period 2 Summary

2.1 The period of a wave is the time it takes to complete one cycle. The frequency of a wave is the inverse of its period: **frequency = 1 / period**

Radiant energy can be thought of as a wave with a wavelength and a frequency. The speed of a wave is

$$s = f\ L$$

2.2 As light passes from one medium to another it is refracted, or bent. Light travels at 3.0×10^8 m/s in a vacuum, but travels at different speeds in materials such as in water or glass. The index of refraction is

$$n = \frac{\text{speed of light in a vacuum}}{\text{speed of light in a material}}$$

2.3 A concave mirror focuses beams of radiant energy, but a convex mirror spreads the beams.

A convex lens focuses radiant energy and a concave lens spreads the energy.

2.4 The quantum model treats radiant energy as consisting of small packets of energy called photons. Photon energy is related to wave frequency or wavelength.

$$E = h\,f = (h\,c)/L$$

2.5 In solar cells (photoelectric cells), electrons can absorb photons of radiant energy. A photon of sufficient energy can cause an electron to escape from its atom and generate an electric current.

Period 2 Review Questions

R.1 What is the difference between wavelength, wave amplitude, and wave frequency? Which of these variables can be used to determine the speed of a wave?

R.2 Compare the speed of sound to the speed of light in air. What is the ratio of the speed of sound to the speed of light?

R.3 What is refraction of light? Why is white light that travels through a prism split into its constituent colors?

R.4 Why is it unsafe to leave glass soft drink bottles in a forest?

R.5 Photons striking a particular solar cell do not produce an electric current in the cell. Why is this? Would more photons of the same energy produce a current?