Electromagnetic Spectrum

Objectives

- Recognize characteristics of EM waves.
- Determine the type of EM wave based on its characteristics.

Electromagnetic Waves

- Electromagnetic (EM) waves do not require a medium in which to travel.
  - Electric field component
  - Magnetic field component
  - Caused by vibrating charges

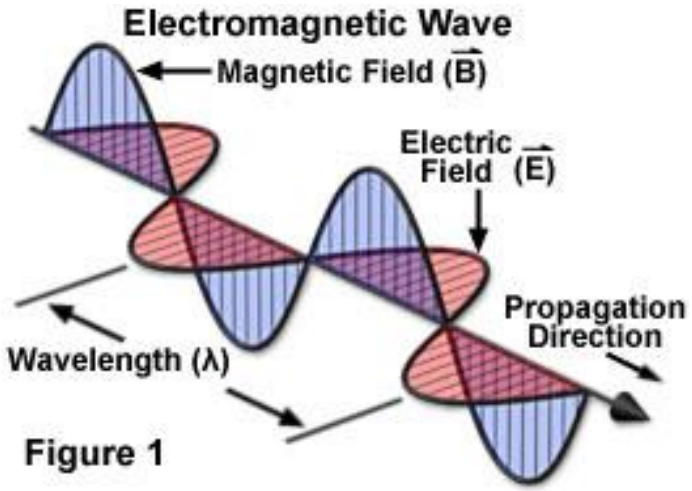


Figure 1

Characteristics of EM Waves

- Speed in a vacuum is c ($c=3.0 \times 10^8$ m/s)
- Higher frequencies -> Smaller wavelengths
- Frequency of EM wave determines its characteristics
  - Higher frequency -> more energetic
  - Lower frequency -> less energetic

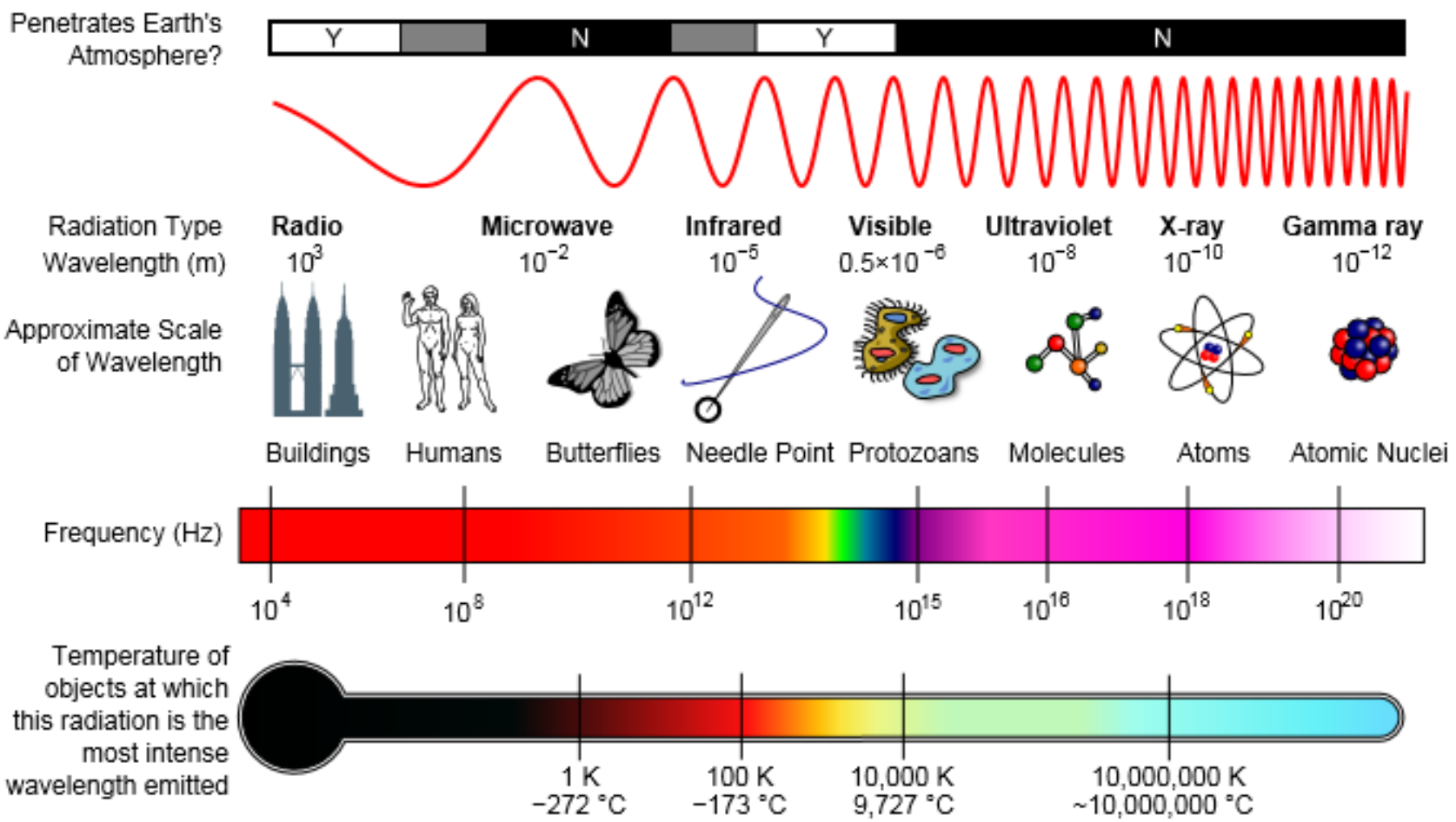
What is light?

- Light is a special type of wave.
- What we know as Visible Light is actually a type of something called ELECTROMAGNETIC RADIATION.

EM Spectrum

Electromagnetic waves are everywhere.
Light is only a small part of them.

- Radios
- TVs
- Microwaves
- Light (visible/UV/Infrared)
- Radiation
- Lasers
- Tanning Huts
- X-Rays


Penetrates Earth's Atmosphere?
Y
N
Y
N
Radiation Type
Wavelength (m)
Radio
10^{3}
Microwave
10^{-2}
Infrared
10^{-5}
Visible
0.5×10^{-6}
Ultraviolet
10^{-8}
X-ray
10^{-10}
Gamma ray
10^{-12}
Approximate Scale of Wavelength
Buildings
Humans
Butterflies
Needle Point
Protozoans
Molecules
Atoms
Atomic Nuclei
Frequency (Hz)
10^{4}
10^{8}
10^{12}
10^{15}
10^{16}
10^{18}
10^{20}
Temperature of objects at which this radiation is the most intense wavelength emitted
1 K
−272 °C
100 K
−173 °C
10,000 K
9,727 °C
10,000,000 K
~10,000,000 °C

EM Radiation

- Where do these waves come from?
- When something releases energy it also emits radiation. Depending on the amount of energy, the object will emit different types of electromagnetic radiation.
- But what is creating the disturbance? What is emitting this energy?
- ELECTRONS, oscillating electrons!

Electromagnetic Waves

- When we studied mechanical waves, they were all transferred through a medium. What medium is light transferred through?
- LIGHT DOES NOT NEED ONE!
- EM waves are special in the fact that they do not need a medium to propagate through.

Wave Speed Equation

We know how to calculate the speed of a wave using

$$V = f * \lambda$$

but for an EM wave you use

$$c = f * \lambda$$

C= $3x10^8$ m/s

Energy in EM Waves

- Which waves do you think have more energy?
- Radio waves or gamma waves?
- Because waves don't really have a mass, we cant really talk about their energy like mechanical waves.
- The greater the frequency of an EM wave, the more crests pass a point in a certain amount of time, therefore the more photons pass that point.
- This means that more energy moves past that point in a certain amount of time or the wave is more energetic.

Sample Problem 1

- Gamma-ray bursters are objects in the universe that emit pulses of gamma rays with high energies. The frequency of the most energetic bursts has been measured at around 3.0×10^{21} Hz. What is the wavelength of the gamma rays?

Sample Problem 2

- What is the wavelength range for the FM radio band (88MHz – 108 MHz)? M = 10^6

Sample Problem 3

- A television remote control is used to direct pulses of electromagnetic radiation to a receiver on a television. This communication from the remote control to the television illustrates that electromagnetic radiation
- A) is a longitudinal wave
- B) possesses energy inversely proportional to its frequency
- C) diffracts and accelerations in air
- D) transfers energy without transferring mass