Chapter 17 :
The Electromagnetic Spectrum

NOTES on 17.2
Waves of the Electromagnetic Spectrum

All electromagnetic waves travel at the same speed in a vacuum but have different wavelengths and frequencies.

The higher the frequency – the higher the energy.

So, if the speed remains the same, that means the wavelengths and frequencies of the different electromagnetic waves must be different.

Speed = Wavelength X Frequency

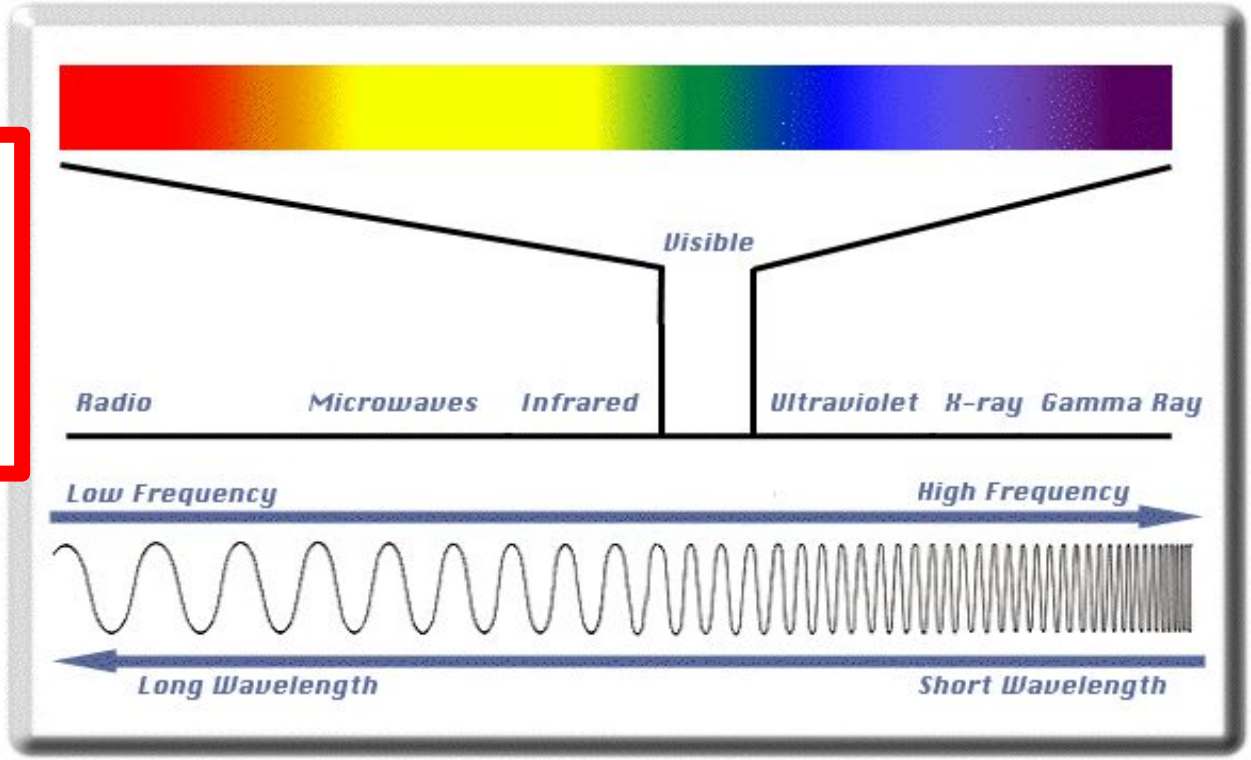
If the wavelength increases, the frequency must decrease.
If the wavelength decreases, the frequency must increase.

Waves with the longest waves have the lowest frequencies.
Waves with the shortest waves have the highest frequencies.

Got all that? Now let's get a visual to go with the facts!

Visible light

Radio:
-long wavelength
-low energy
-low frequency



Gamma rays:
- short wavelength
– high frequency
–high energy

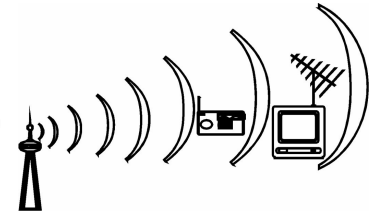
The Electromagnetic Spectrum – arranged

- ❑ in order of increasing frequency and decreasing wavelength
- ❑ in order of increasing energy levels

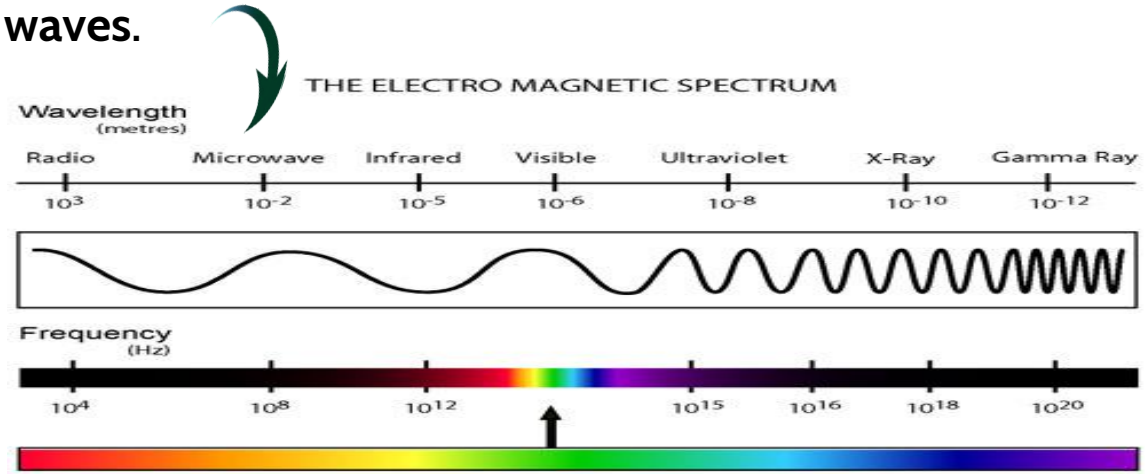
Why are **infrared** and ultraviolet appropriately named?

Radio waves:

- electromagnetic waves with the **longest** wavelengths and the **lowest** frequencies.



- include broadcast waves (for radio and television)
  - these have longer wavelengths
  - a broadcast station sends out radio waves at certain frequencies
  - the TV or radio picks up the waves and converts the radio waves into an electrical signal which is converted to sound. (TV converts into sound and picture.)
- include microwaves
  - these have the shortest wavelengths and highest frequencies of the **radio waves**.



Cellular phones and radar use microwaves!

Radio Detection and Ranging

- radar uses reflected radio waves to detect objects and measure their distance and speed
- To measure speed, police officers use a radar gun, a radar device which makes use of the Doppler effect.

- The frequency of the reflected waves is different from the frequency of the original wave.
- The difference in frequency is used to calculate the car's speed.

Infrared Rays:

- the invisible heat you feel from the sun
- often called **heat rays** because its energy is felt as heat
- electromagnetic waves with wavelengths shorter than those of radio waves, meaning they have a greater frequency and energy level

Heat lamps:

- have bulbs that give off mostly infrared rays and very little visible light.
- used to heat up rooms
- used in restaurants to keep food warm

Infrared Cameras

- most objects give off some infrared waves
- warmer objects give off infrared waves with more energy and higher frequency than cooler ones
- infrared cameras use infrared rays instead of light
- the pictures are called **thermograms**, which create an image that shows regions of different temperatures in different colors
- firefighters and satellites make use of infrared cameras

Visible Light

- electromagnetic waves that you can see
- shorter wavelengths and higher frequencies than infrared rays
- longest wavelengths appear in red; shortest wavelengths of visible light appear as violet
- visible light is a mixture of many colors:
  red, orange, yellow, green, blue, and violet
- prisms will refract different wavelengths of visible light by different amounts and thereby separate the colors.
- Red: refracts the least Violet: refracts the most

Ultraviolet Rays

- wavelengths are shorter than those of visible light
- higher frequencies than visible light – more energy
- their energy is great enough to damage or kill living cells
- ultraviolet lamps are often used to kill bacteria in hospital equipment
- small doses of UV rays are useful
  - cause skin cells to produce vitamin D – needed for healthy bones/teeth
- too much exposure is dangerous
  - can burn your skin
  - cause skin cancer
  - damage your eyes

Mike Pigott, an AccuWeather meteorologist, said that to make any kind of rainbow you need a couple of key ingredients. "The sun needs to be at a low angle. Usually, the magic number is actually 4 so need to be at your b it refracts (or bends) a ts back out of the raindr ght spread out across i rmed when there are tw

"In the case d have that first reflecti n off the back [of the eflect twice. And t ends to be fainter than primary rainbow.

X-Rays

- electromagnetic waves with wavelengths just shorter than those of UV
- higher frequency than UV
- carry more energy and can penetrate most matter
- dense matter, such as bones, absorbs X-rays and does not allow them to pass through – appear as lighter areas on the X-ray film
- skin and soft tissue allow the X-rays to pass through, causing the photographic film to darken
- too much exposure to X-rays can cause cancer
  - lead aprons will prevent the X-rays from reaching your body while having dental X-rays
- sometimes used in industry and engineering to check the quality of pipelines

Gamma Rays

- electromagnetic waves with the shortest wavelengths and highest frequencies
- the most penetrating of all the electromagnetic waves
- some medical uses: kill cancer cells
- some objects in space give off bursts of gamma rays
  - blocked by Earth's atmosphere – gamma-ray detecting telescopes must orbit above Earth's atmosphere
  - astronomers thing that explosions of stars are one way that gamma rays are produced

All **scorpions** fluoresce under **ultraviolet light**, such as an electric black **light** or natural moonlight. The blue-green **glow** comes from a substance found in the hyaline layer, a very thin but super tough coating in a part of the **scorpion's** exoskeleton called the cuticle.