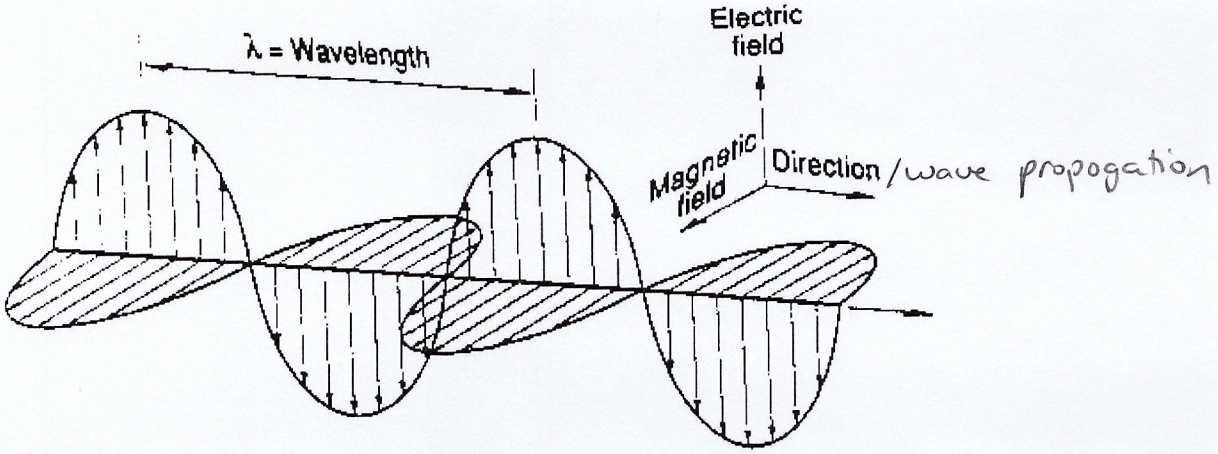
Electromagnetic Radiation (EMR)

- Oersted discovered an electric current will produce a magnetic field and Faraday discovered a magnetic field can be used to produce an electric current
- *Maxwell* put the two ideas together to develop the theory on **electromagnetic radiation (EMR)**
- Important! * An electromagnetic wave is produced either by an *accelerating charged particle* or a *changing magnetic or electric field*
- * Electromagnetic waves are made up of vibrating electric and magnetic fields that regenerate each other
  - At any point on the wave, the electric field is perpendicular to the magnetic field
- EMR is said to be a **transverse waves** because direction of wave travel is perpendicular to oscillation
- * All EMR waves travel at the speed of light (c = 3.0x10^8 m/s) in a *vacuum* (we also assume this for air as well) ↑ on data sheet
  - The speed of EMR waves vary as they travel through different mediums



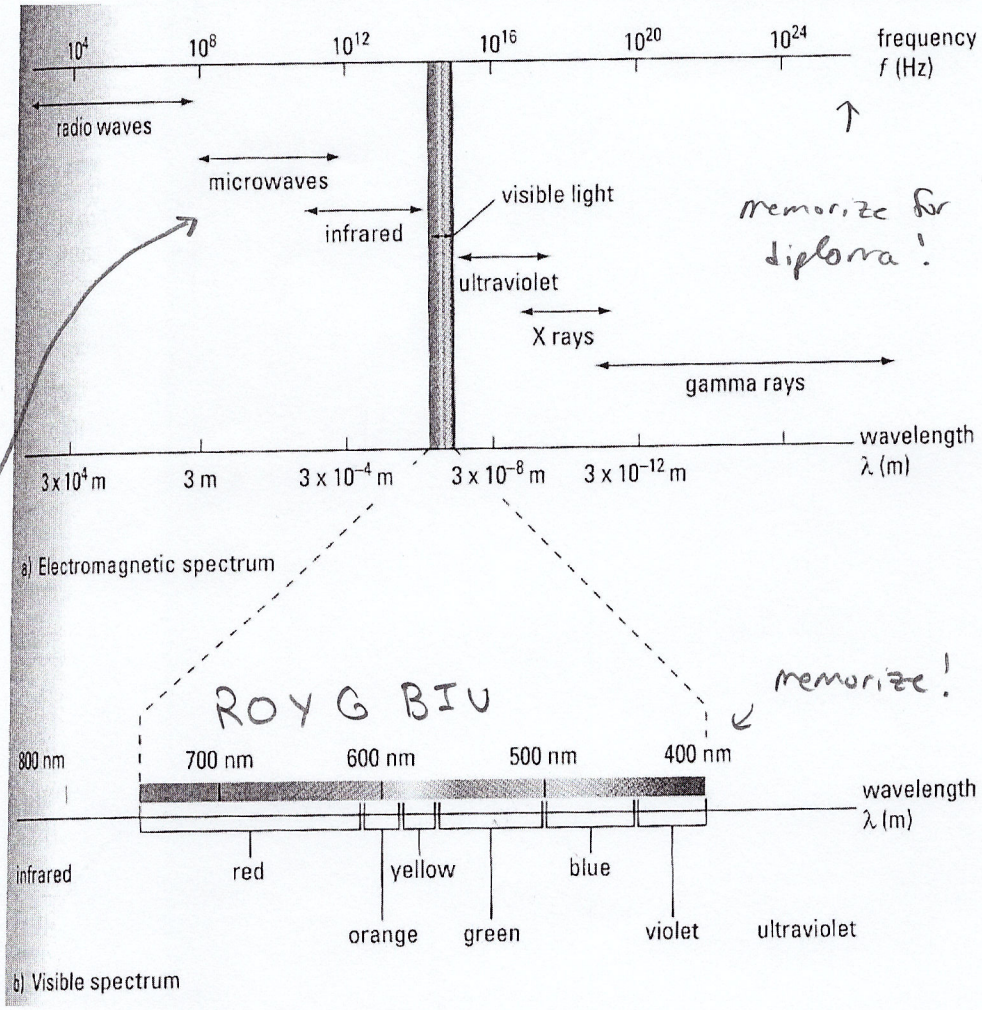
THE WAVE

- **Wavelength (λ):** measured distance between successive crests (peak) or troughs
- * **Source:** Vibrating/accelerating charges or changing electric/magnetic fields create an EMR wave
- **Medium:** the substance a wave travels through
- **Wave propagation:** the movement/direction of a wave through a medium
- **Frequency:** the number of waves that pass a certain point in a given time; measured in hertz (Hz)
- **Period:** the time it takes for one complete wavelength to pass a certain point

THE EMR SPECTRUM

- The shorter the wavelength, the higher the frequency, the higher in energy of the EMR
- The longer the wavelength, the lower the frequency, the lower in energy of the EMR

* need to know general ranking of EMR Spectrum!



- **Monochromic light** is light consisting of a single frequency (or wavelength) White light is not monochromic because it consists of a bunch of colors/frequencies/wavelengths

THE FORMULAS (FOR WAVE THEORY)

- Light (a type of EMR) is explained in two different theories; wave theory (classical physics) and particle theory (quantum physics or modern physics)
  - Called the wave-particle duality
  - Generally, EMR having a frequency less than visible light is treated as a wave and EMR having a frequency greater than visible light is treated as a particle
- The first part of the unit, we will investigate the wave theory to explain EMR. The second part of the unit will consist of looking at the particle theory to explain EMR

- Wave equations (for wave theory)

$$v = f\lambda$$

which is 3.0×10^8 m/s for all EMR in a vacuum or air

where v is the velocity of the EMR wave (m/s)
f is the frequency of the wave (hertz – Hz or s^{-1})
λ is wavelength (m)

$$T = \frac{1}{f}$$

where T is period (s) = the time it takes to travel one complete wavelength
f is the frequency of the wave (hertz – Hz or s^{-1})

- Since EMR travels at a constant speed as long as it remains in the same medium, we can also use the constant motion/velocity equation

$$v = \frac{d}{t}$$

where v is the speed of light *and* all EMR ($c = 3.00 \times 10^8$ m/s in air or a vacuum)
d is the distance the EMR travels (m)
t is the time interval (s)

EXAMPLES:

1. If a star explodes 9.85×10^{26} m from earth, how many days would it take the light from this explosion to reach earth?

↳ EMR ∴ $v = 3.00 \times 10^8$ m/s

$v = 3.00 \times 10^8$ m/s
$d = 9.85 \times 10^{26}$ m
$t = ?$

$v = \frac{d}{t} \Rightarrow t = \frac{d}{v}$

$$t = \frac{9.85 \times 10^{26}\ m}{3.00 \times 10^8\ m/s} = 3.28\overline{3} \times 10^{18}\ s$$

$$t = 3.28\overline{3} \times 10^8\ s \times \left(\frac{1\ hr}{3600\ s}\right) \times \left(\frac{1\ day}{24\ hr}\right) = \boxed{3.80 \times 10^{13}\ days}$$

2. Blue light has a wavelength about 460nm and red light has a wavelength about 720nm.
   a. Which color has more energy?
   b. Calculate the period of blue light.

a.) blue light b/c shorter λ = more energy

b.) $\lambda = 460\ nm \times \left(\frac{10^{-9}\ m}{1\ nm}\right) = 4.60 \times 10^{-7}\ m$

$T = \frac{1}{f} \rightarrow v = \lambda f \Rightarrow f = \frac{v}{\lambda}$

$\therefore\ T = \frac{1}{\left(\frac{v}{\lambda}\right)} = \frac{\lambda}{v}$ where $v = c = 3.00 \times 10^{8}\ m/s$

$T = \frac{4.60 \times 10^{-7}\ m}{3.00 \times 10^{8}\ m/s}$

$\boxed{T = 1.53 \times 10^{-15}\ s}$

*****Now try pg. 189 #1-5, 9-11, 14-19*****