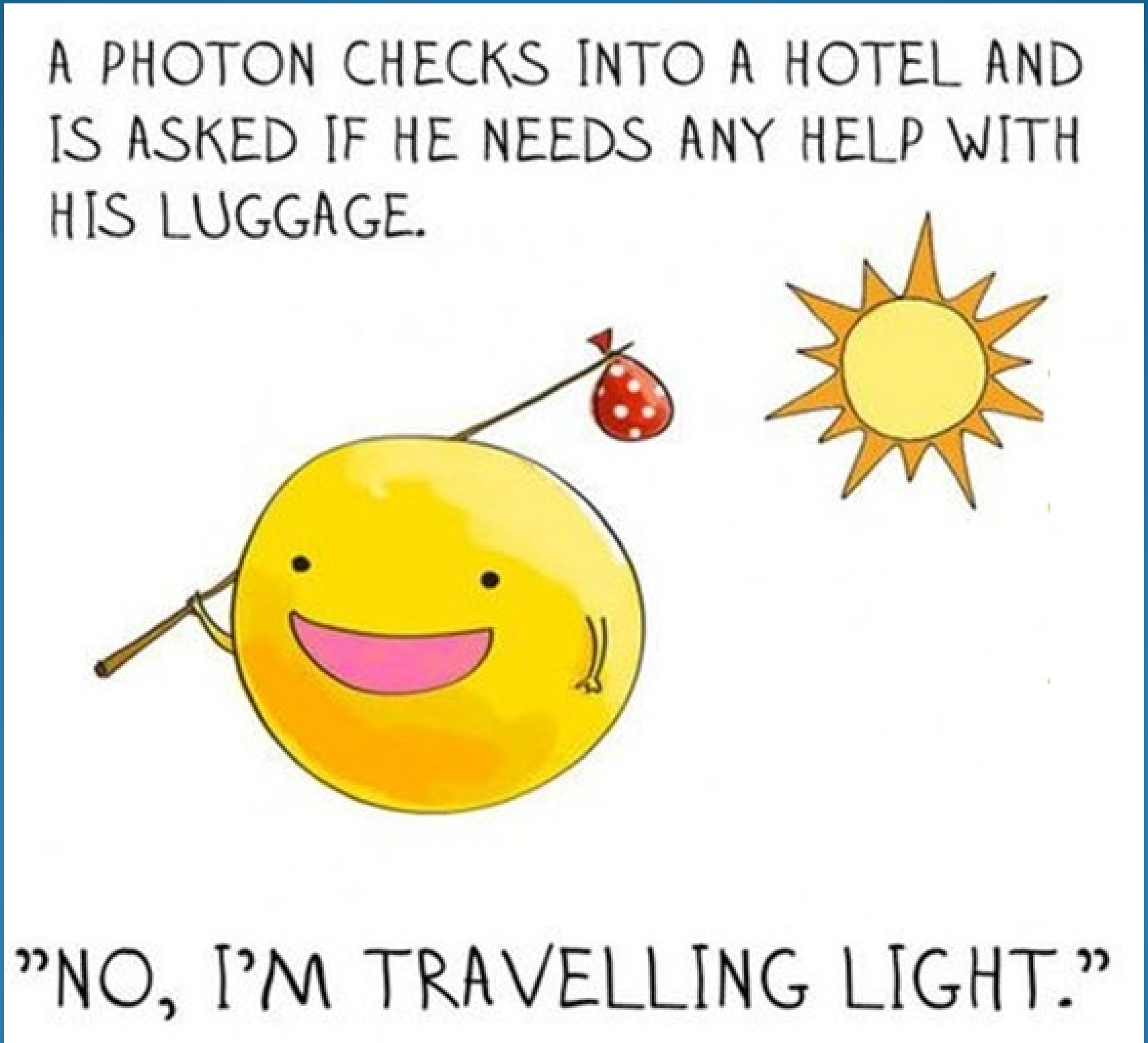
Electromagnetic Radiation

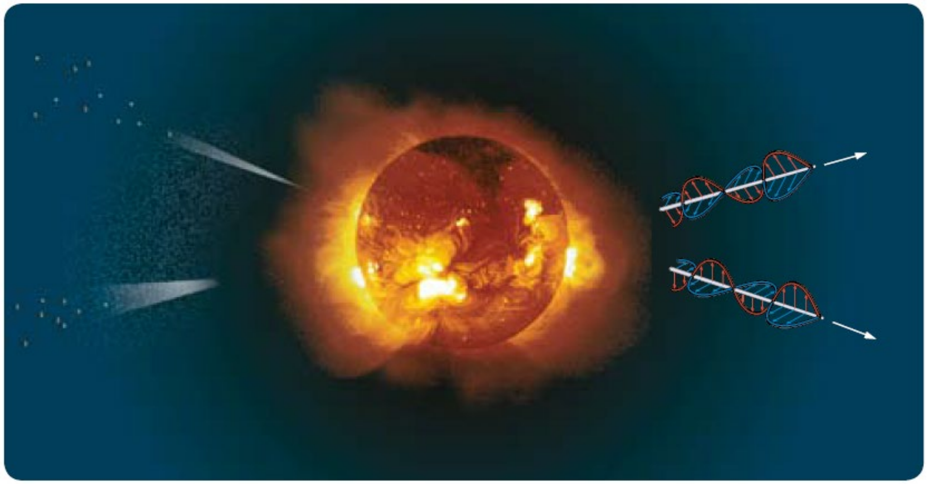


Curriculum

- compare and contrast, to each other, the various constituents of the electromagnetic spectrum, on the basis of source, frequency, wavelength
- investigate and describe the relationships of the variables in the universal wave equation $v = \lambda f$
- explain that nuclear fusion in the sun, represented by the equation $^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + ^{1}_{0}n$, produces a wide spectrum of EMR
- calculate values for any of the variables in the universal wave equation

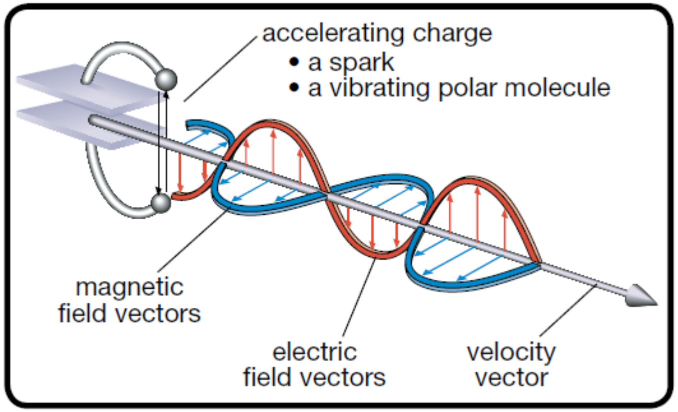
The Sun

- Almost all of the Earth's energy comes from radiation originated from the sun
- The sun spits off two types of radiation:
  - Solar wind particles (fast moving electrons, protons)
  - Electromagnetic radiation (light & heat)



Electromagnetic Radiation

- Electromagnetic radiation (EMR) is the light we see with our eyes
- It is the heat we feel on our skin
- EMR is created by accelerating charged particles
- This creates a changing electric field, which induces a changing magnetic field, which induces a changing electric field…



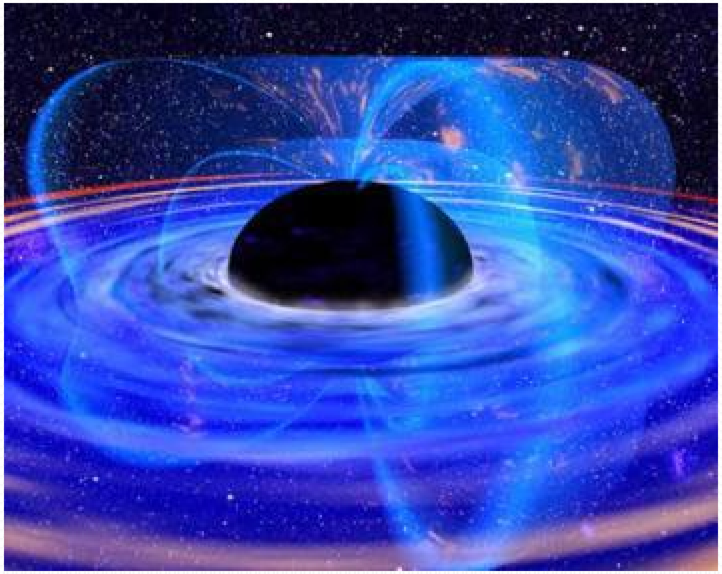
Mediums

- Mechanical waves require a medium, which is a substance they travel through
  - Ex. Water waves, sound waves
- Spaces is a vacuum and has no mediums for waves to travel through

Video (4 min)

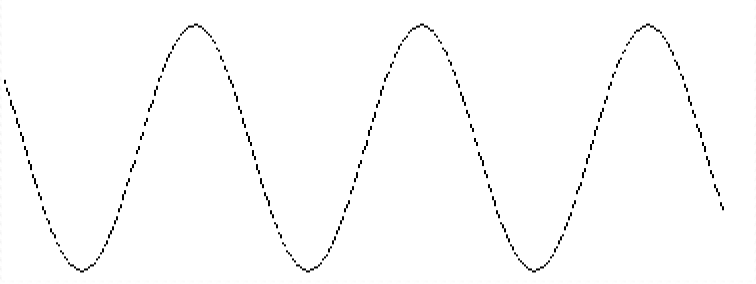
Mediums

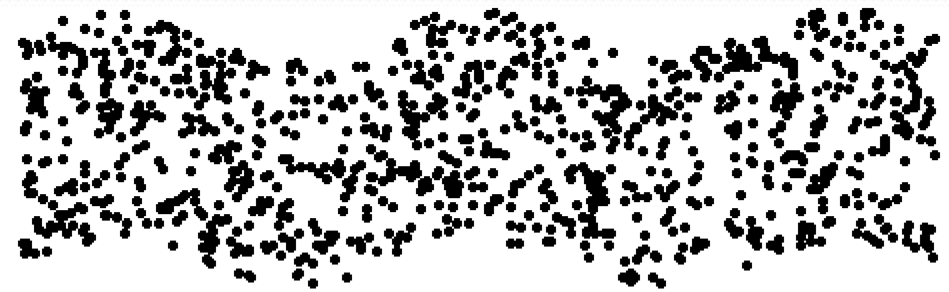
- Scientists used to think that space was filled with a dense, invisible, undetectable gas called **ether**
- This was the medium they thought electromagnetic waves traveled through



Mediums

- Scientists proved that light was a **transverse wave**
- Transverse waves are only able to travel through solid mediums

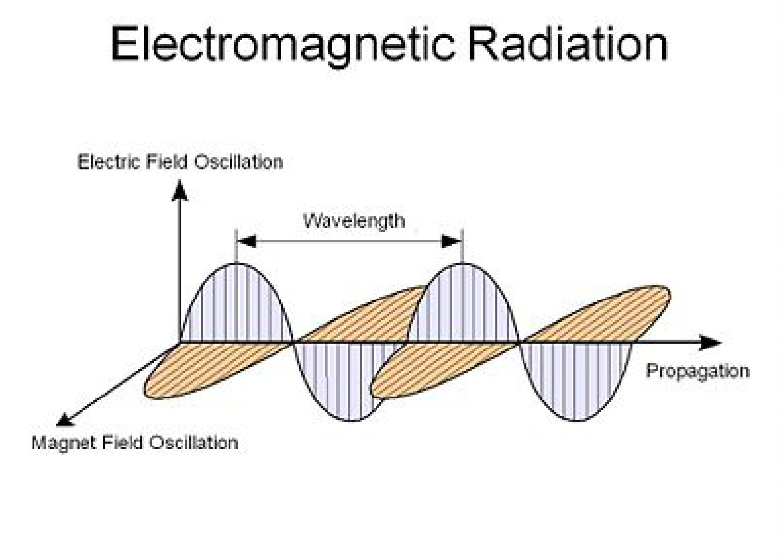




- This meant that the ether in space was a dense solid… which doesn't really make sense

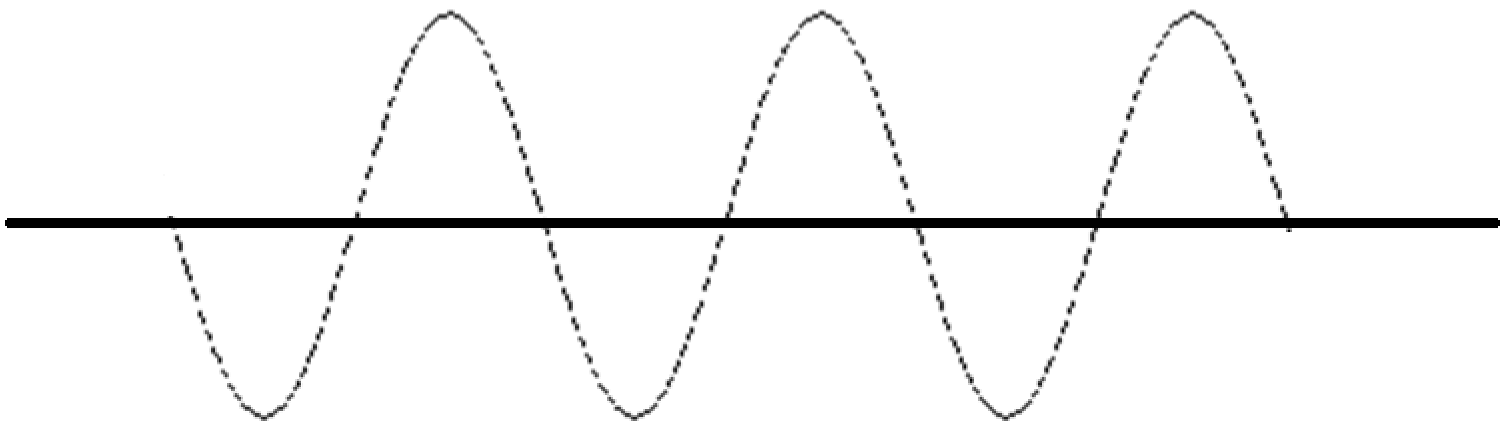
Mediums

- Today we know EMR to be caused by vibrating electric and magnetic fields
- Electric and magnetic fields do not need a medium to exist and that is why EMR can travel through the vacuum of space and do not require a medium



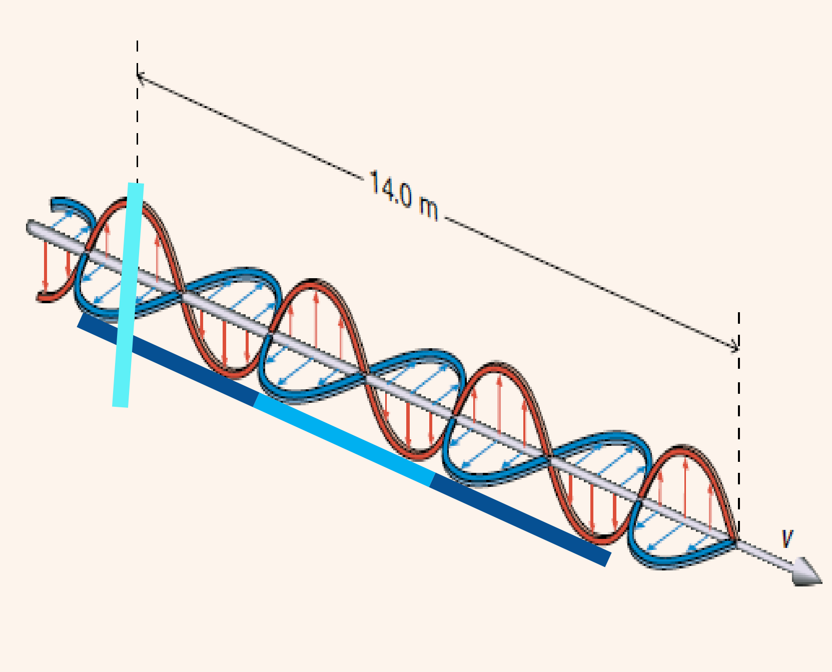
Wavelength λ

- A wavelength is the distance a wave travels before it starts to repeat itself



Example

- Determine the wavelength of this electromagnetic radiation



Step 1: determine the number of wavelengths in this space

=3.25

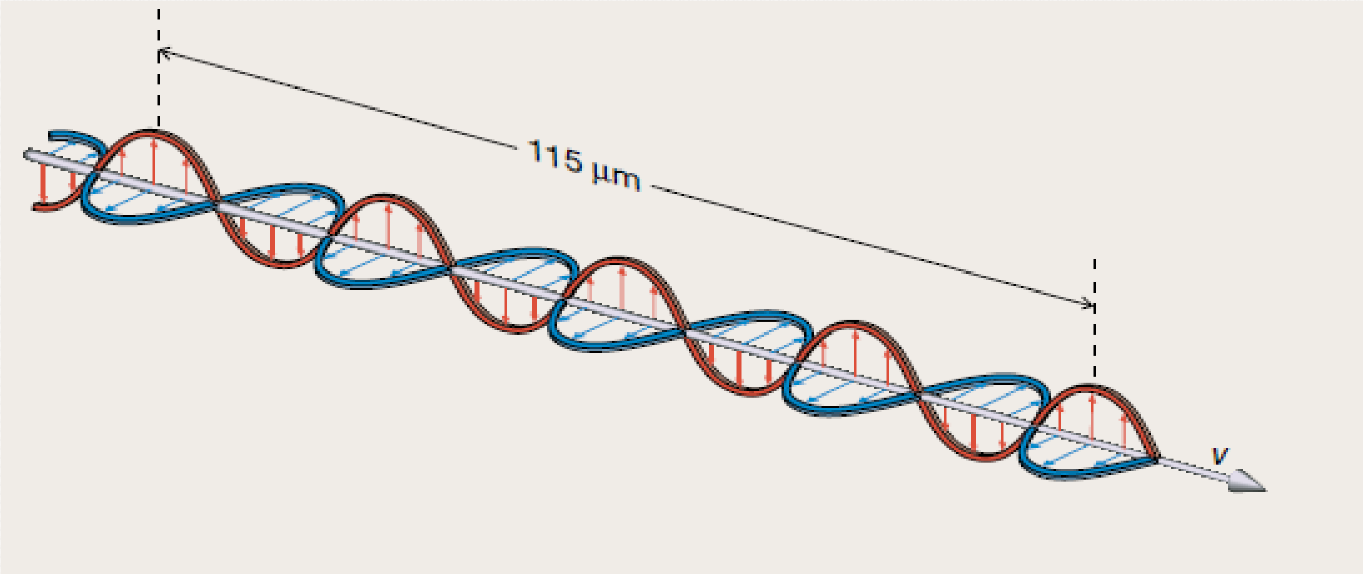
Step 2: calculate the wavelength of the EMR

$3.25\lambda = 14.0$ m   isolate to find λ

$\lambda = 4.31$ m

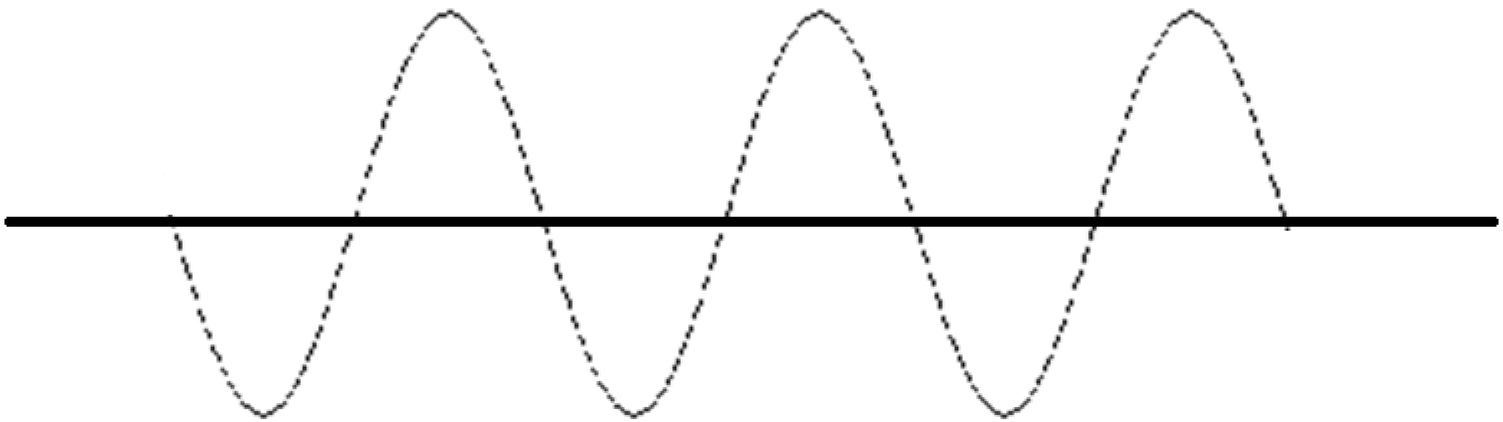
Board Question

- Determine the wavelength of this electromagnetic radiation
  - Step 1: determine the number of wavelengths
    - 4 wavelengths
  - Step 2: calculate the wavelength
    - $4\lambda = 115\ \mu m$ (isolate for λ)



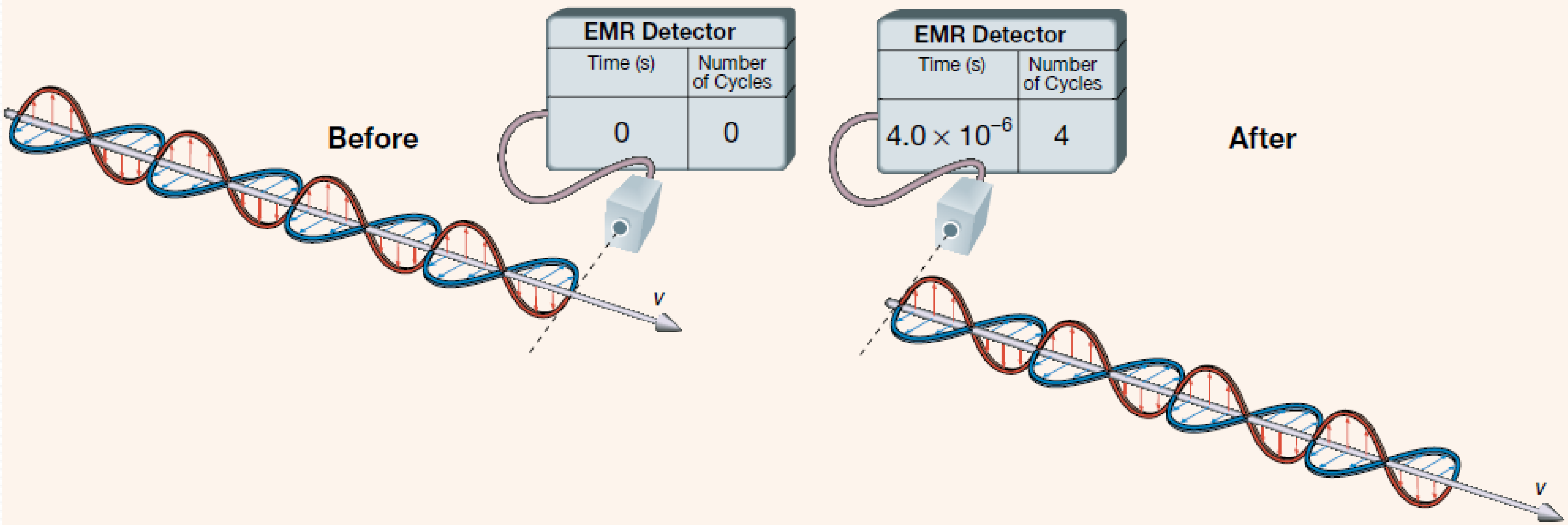
Frequency f

- **Frequency** is the number of waves that pass a point every second
- Frequency is in the units Hz which is the same thing as waves per second



Example

The following diagram shows an illustration of an electromagnetic radiation passing a detector. Use this information to determine the frequency of the EMR.



$$f = \frac{number\ of\ cycles\ passing\ deterctor}{time\ for\ the\ cycles\ to\ pass}$$

$$f = \frac{4}{4.0\ x\ 10{-}6\ s} \qquad = 1.0 \text{ x } 10^{6} \text{ HZ}$$

Board Question

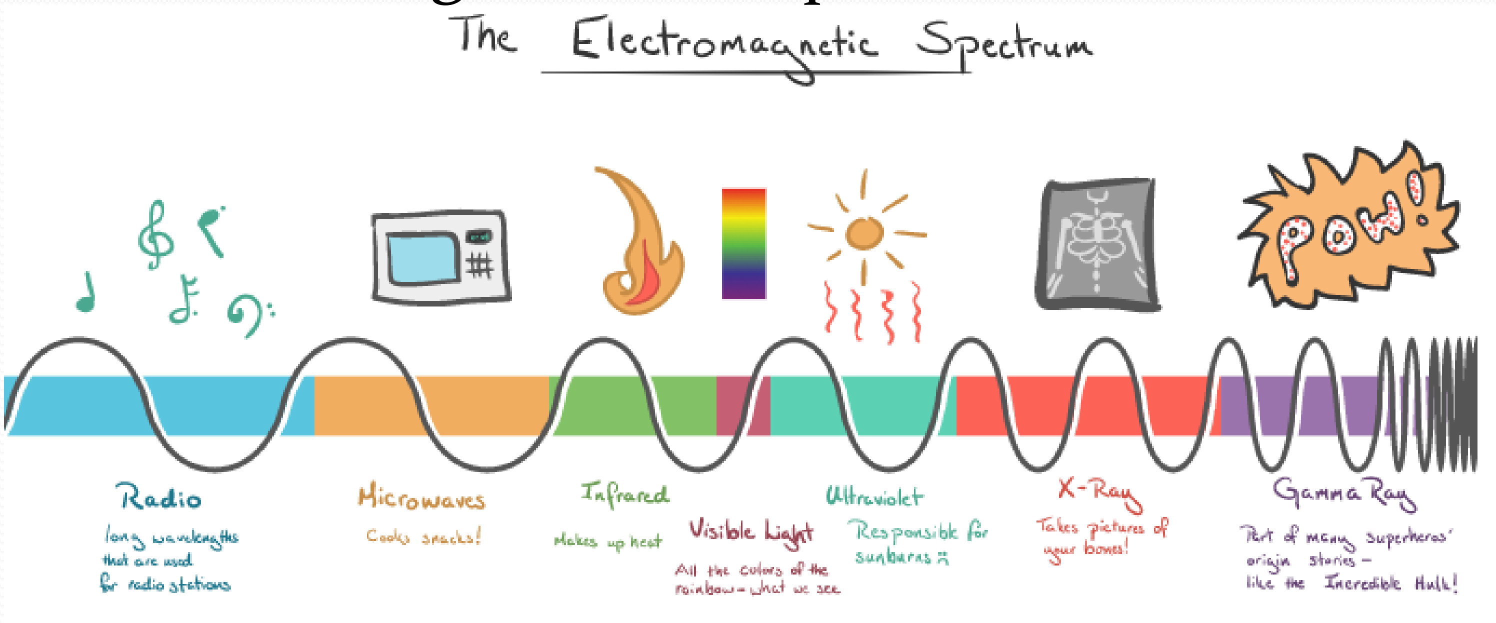
- In 1.00 ms, 740 radio waves pass an antenna. Determine the frequency of those radio waves
- ** hint: change ms to s

$$f = \frac{number\ of\ cycles\ passing\ deterctor}{time\ for\ the\ cycles\ to\ pass}$$

$$\frac{740}{1.0\ x\ 10{-}3\ s} = 7.4 \text{ x } 10^5 \text{ Hz}$$

Electromagnetic Spectrum

- All EMR is part of a larger spectrum of light
- What we can see is just a small section of the large electromagnetic spectrum
- Different parts of the spectrum are categorized by their wavelengths and frequencies



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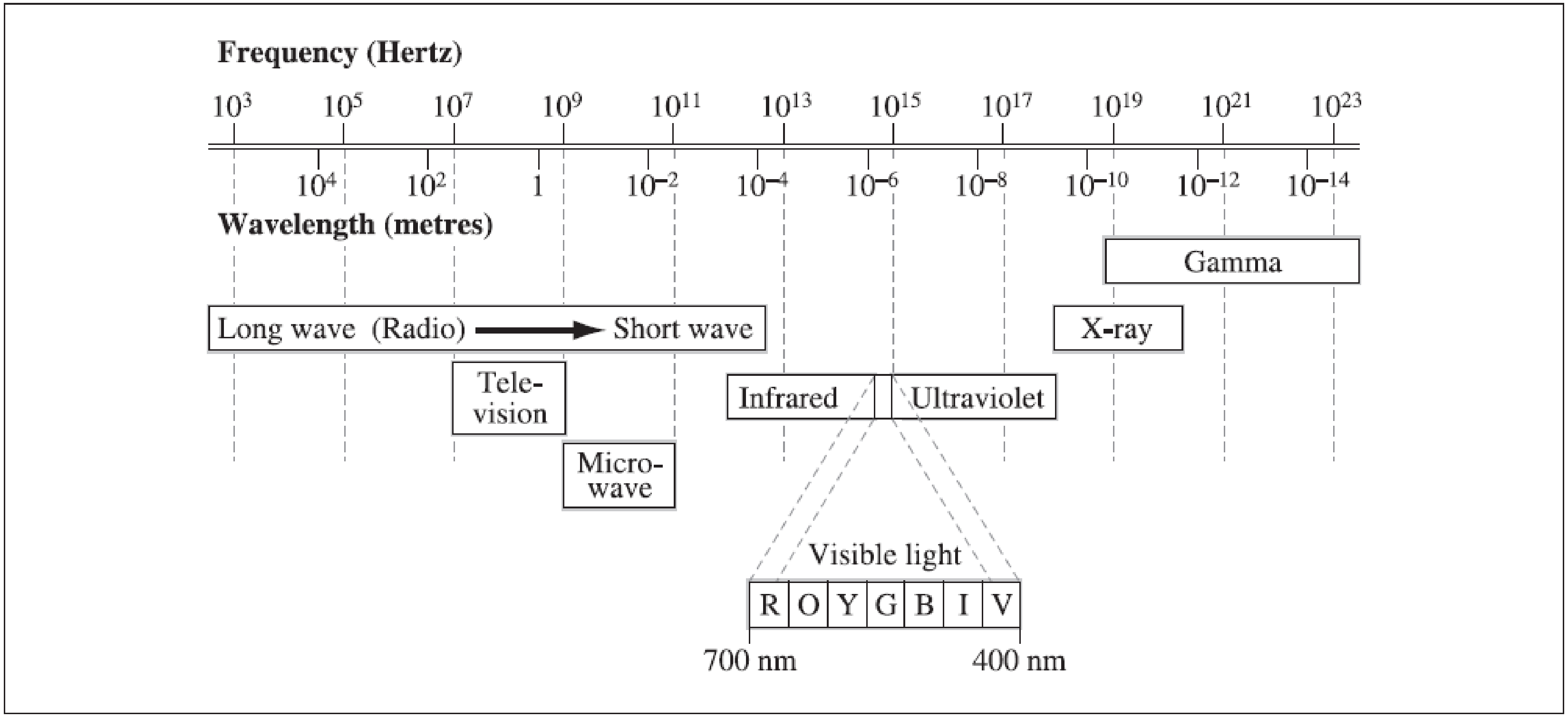
Electromagnetic Spectrum



Common Factor

- What all EMR has in common is they all travel at the same speed, the **speed of light**
- The speed of light is 3.00×10^8 m/s
- We can use this common factor to find wavelength or frequency when the other one is given

Universal Wave Equation

$$c = f\lambda \qquad v = f\lambda$$

- c= speed of light (m/s)
- v= speed of other wave (m/s)
- f = frequency (Hz)
- λ = wavelength (m)

Example

$$c = f\lambda$$

- An excited atom in a neon sign emits electromagnetic radiation with a wavelength of 6.4×10^{-7} m.
- Calculate the frequency of the electromagnetic radiation.
- $f = \frac{c}{\lambda}$
- $\frac{3.00 \; x \; 108}{6.4 \; x \; 10^{-} \, 7} = 4.6875 \times 10^{14}$ Hz

Example

$$v = f\lambda$$

- Sound waves travel 1250 m/s underwater. A sound wave has a frequency of 650 kHz, determine the wavelength.
- ** change kHz to Hz

Notice: its NOT traveling through AIR but water

$$\frac{1250\ m/s}{650\ x\ 103\ Hz} = 0.001923 \text{ m}$$

Board Question

$$c = f\lambda$$

- The antenna of a FM radio station broadcasts electromagnetic radiation with a frequency of 104.5 MHz.
- A driver in a car is receiving these FM radio waves while travelling down a highway at 90.0 km/h, or 25.0 m/s.
- Calculate the wavelength of the electromagnetic radiation.

$$\frac{3.00\ x\ 10\ 8}{104.5\ x\ 106} = 2.87\ \text{m}$$