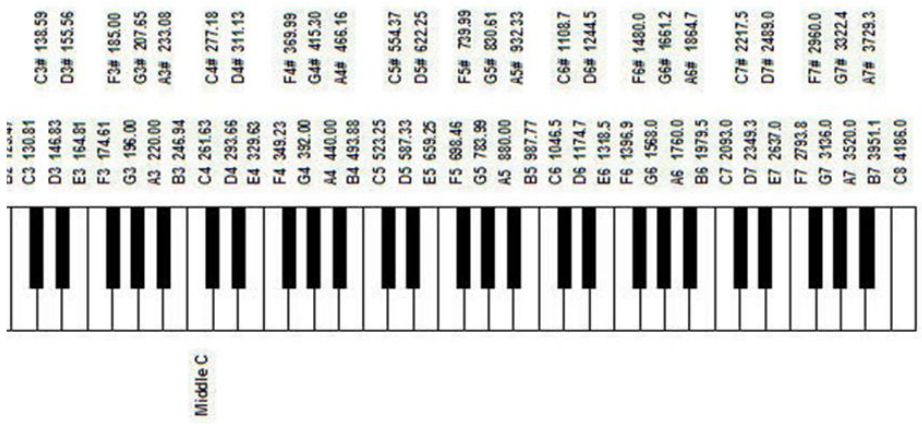
Light and the EM Spectrum

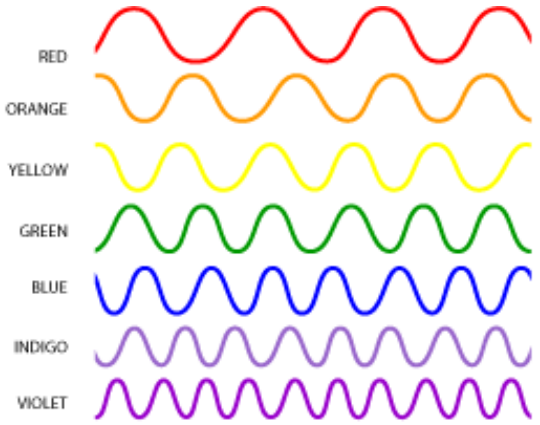
IB PHYSICS | WAVES - LIGHT

Frequency and Light

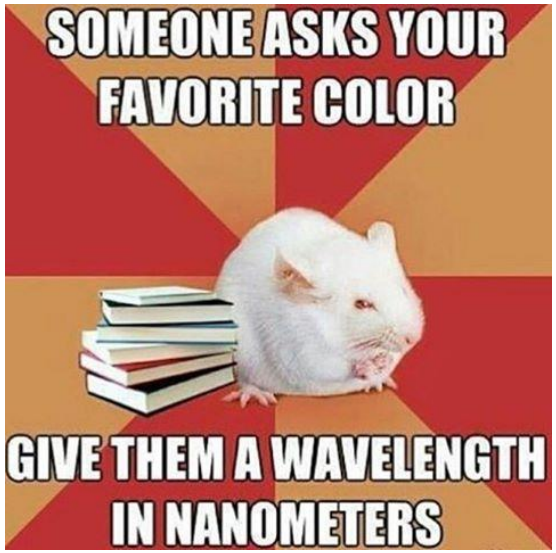
Sound — Change in Frequency →

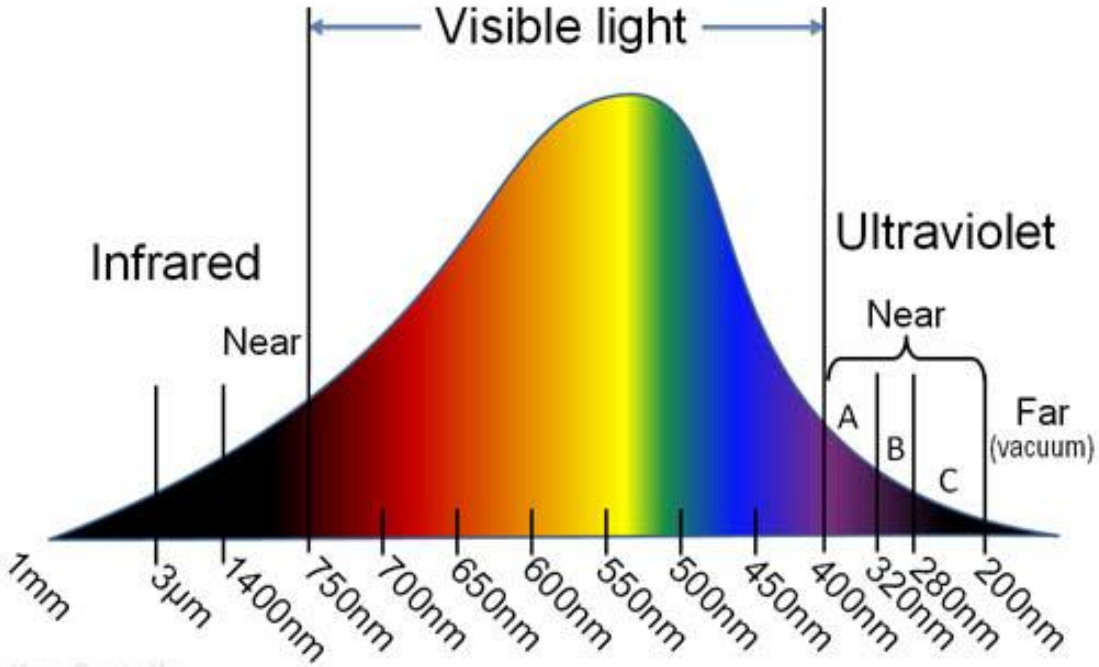
Light — Change in Frequency →





Frequency and Light





Speed of Electromagnetic Waves

In a vacuum All electromagnetic waves travel at:

$$c = 299{,}792{,}458 \text{ m s}^{-1}$$

Speed of Electromagnetic Waves

Fundamental constants

Quantity	Symbol	Approximate value
Acceleration of free fall (Earth's surface)	g	$9.81\ \mathrm{m\,s^{-2}}$
Gravitational constant	G	$6.67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}}$
Avogadro's constant	N_A	$6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
Gas constant	R	$8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
Boltzmann's constant	k_B	$1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
Stefan–Boltzmann constant	σ	$5.67 \times 10^{-8}\ \mathrm{W\,m^{-2}\,K^{-4}}$
Coulomb constant	k	$8.99 \times 10^{9}\ \mathrm{N\,m^2\,C^{-2}}$
Permittivity of free space	ε_0	$8.85 \times 10^{-12}\ \mathrm{C^2\,N^{-1}\,m^{-2}}$
Permeability of free space	μ_0	$4\pi \times 10^{-7}\ \mathrm{T\,m\,A^{-1}}$
Speed of light in vacuum	c	$3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
Planck's constant	h	$6.63 \times 10^{-34}\ \mathrm{J\,s}$

Try this…

The sun is roughly 149,600,000 km from Earth, how long has the light from the sun been traveling before it gets here?

Light Equation

You already know the wave speed equation

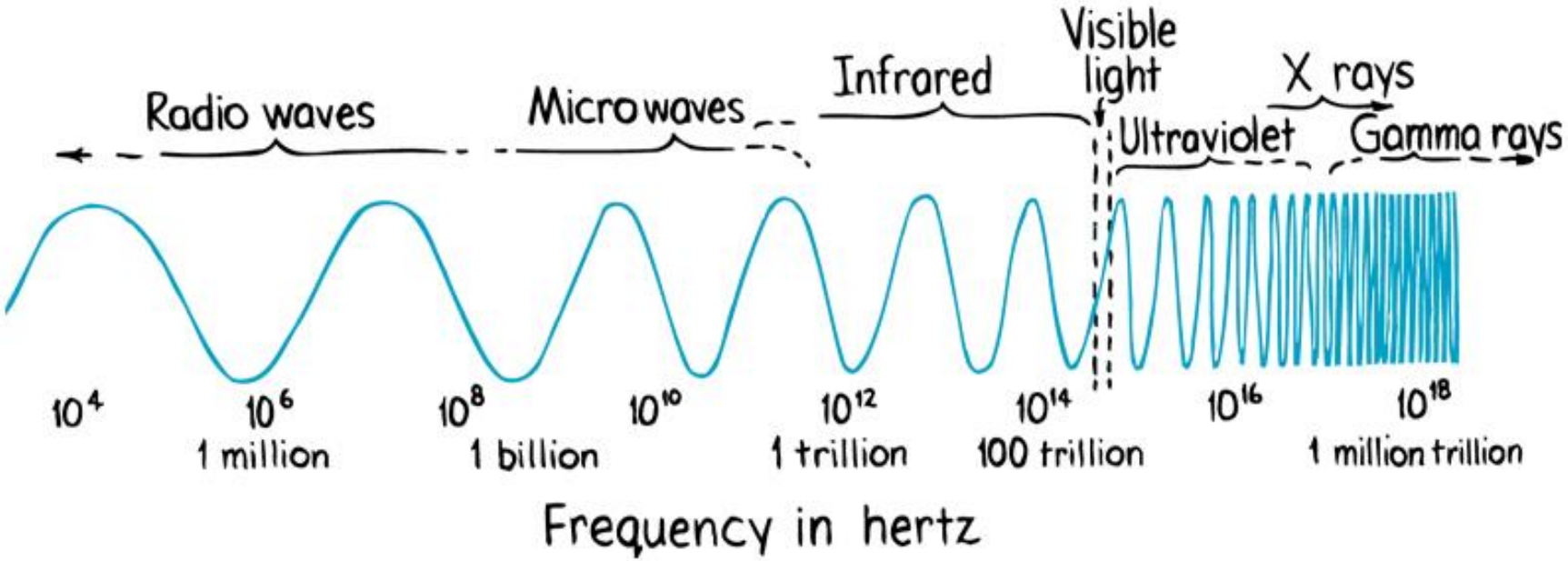
$$v = f\lambda$$

Works the same for electromagnetic waves

$$c = f\lambda$$

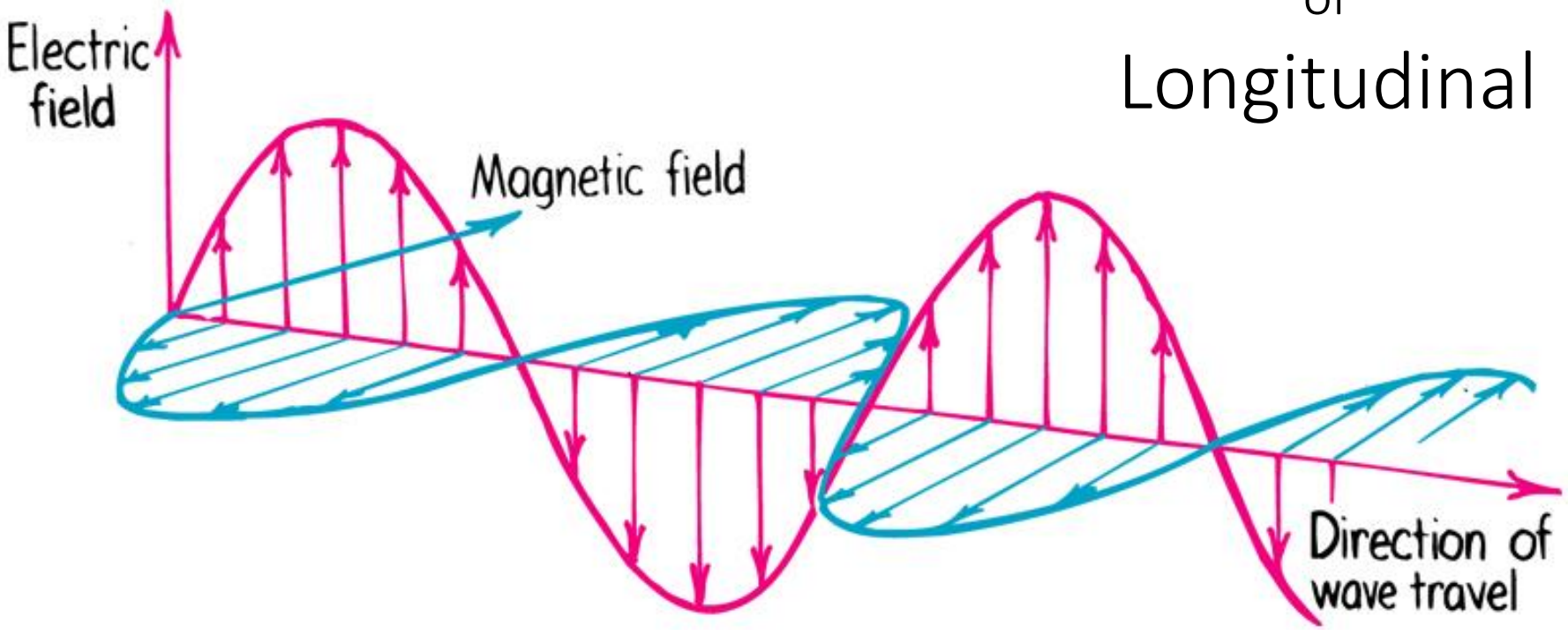
Electromagnetic Spectrum

Visible light is just part of the picture…



Electromagnetic Waves

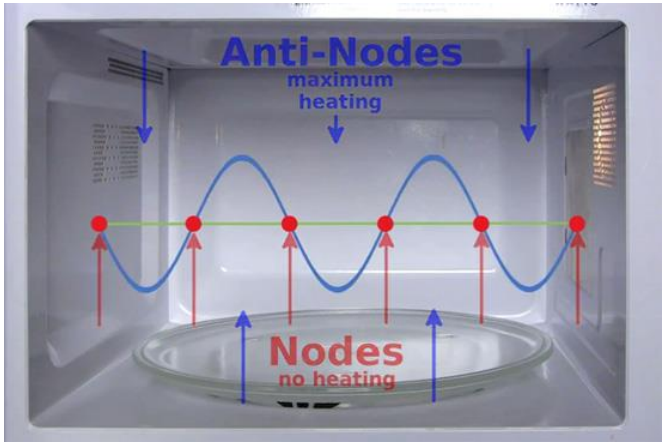
? Transverse or Longitudinal ?

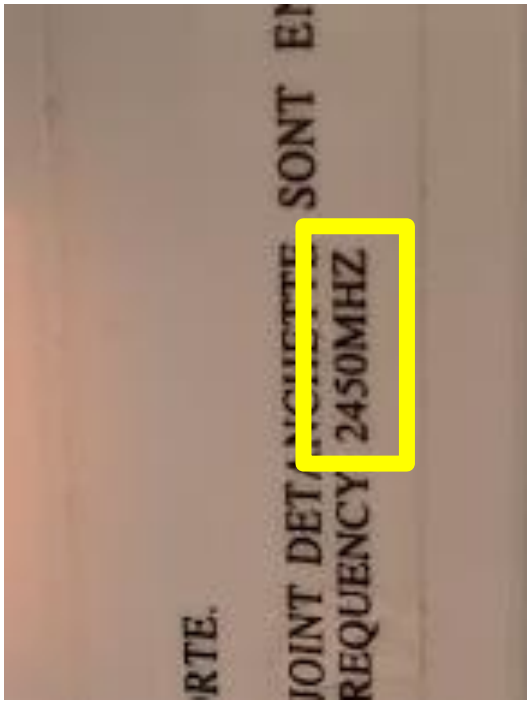


Standing Waves in a Microwave

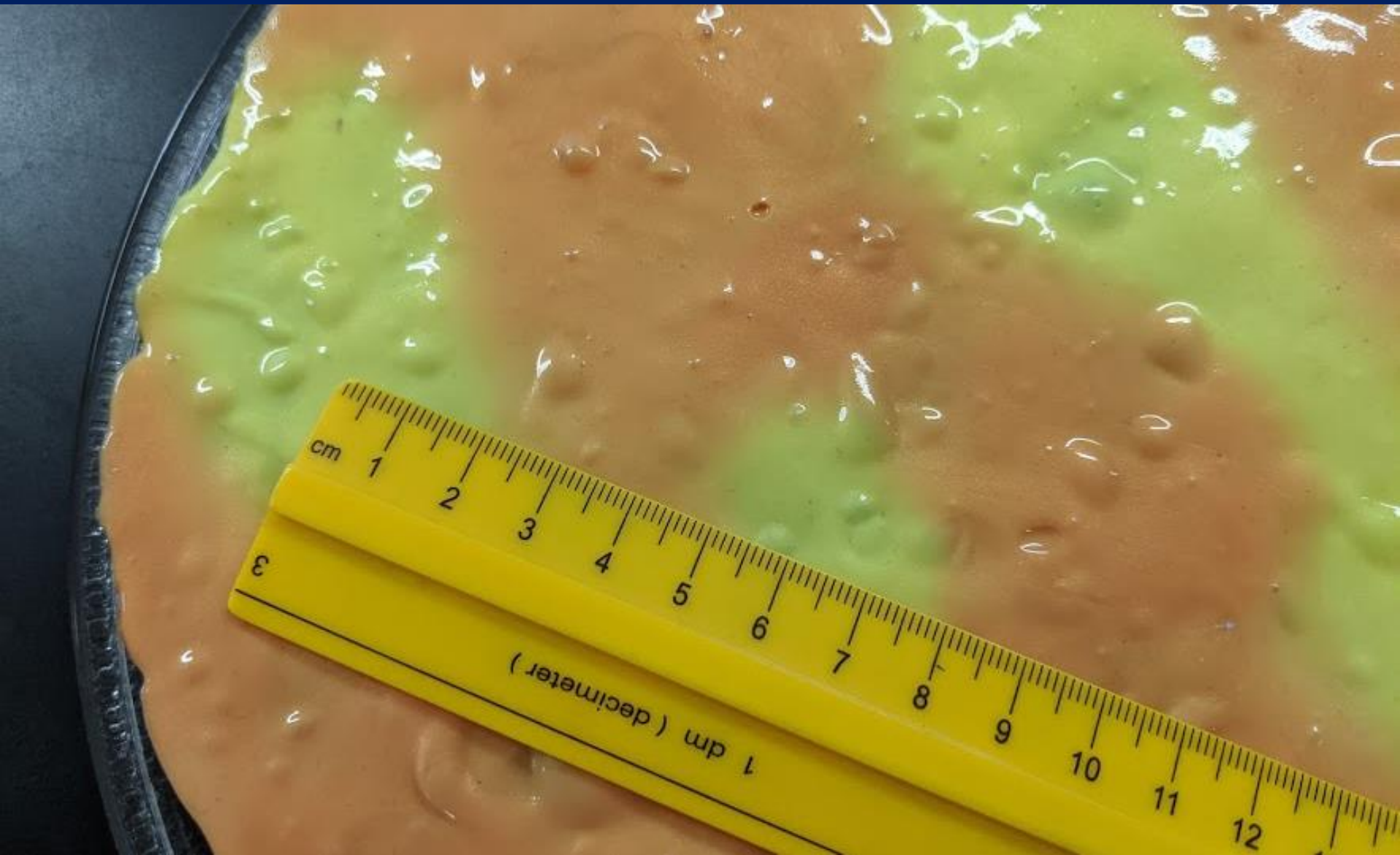
How far between antinodes of a 2450 MHz standing wave in a microwave?

$v = f\lambda$

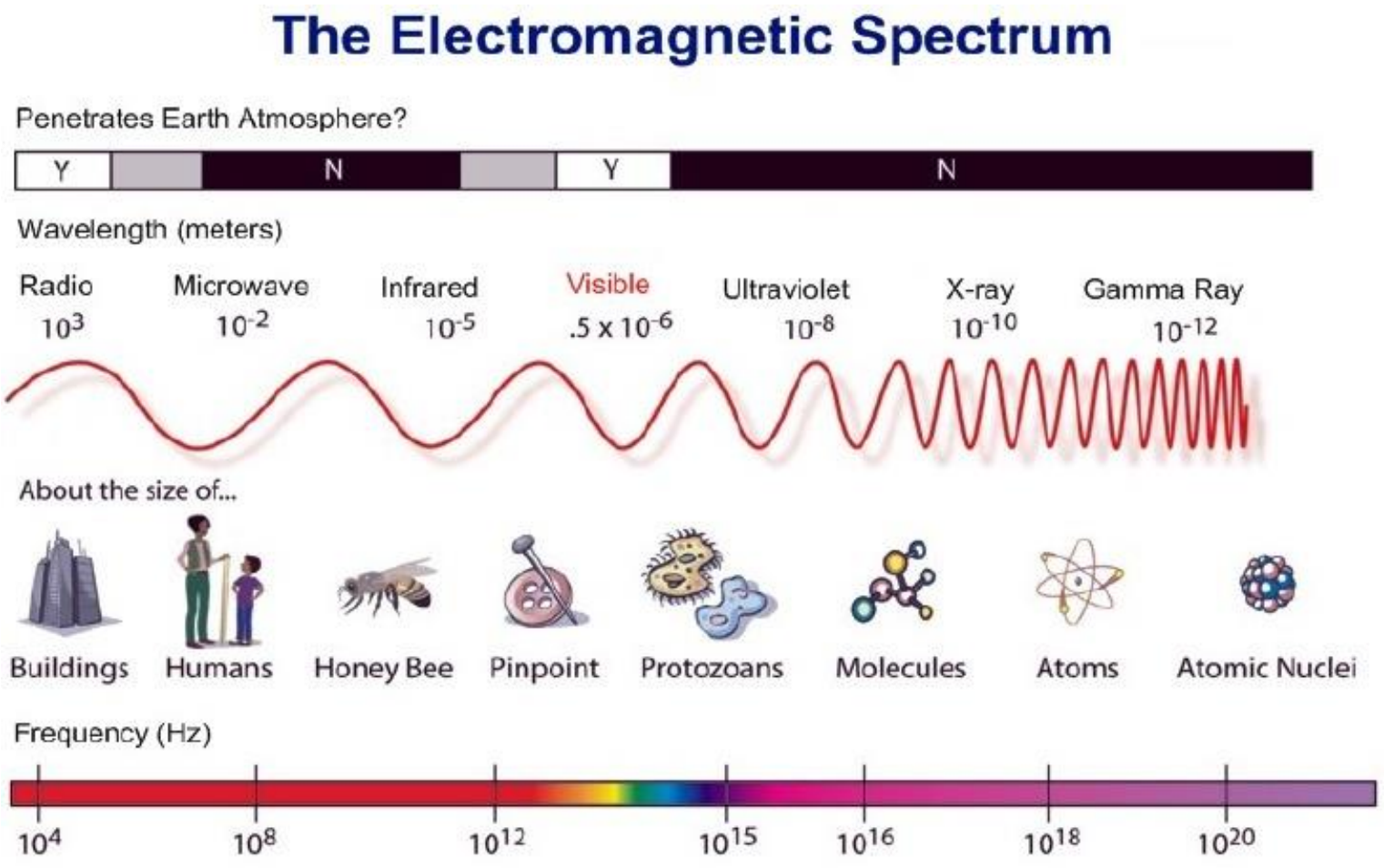




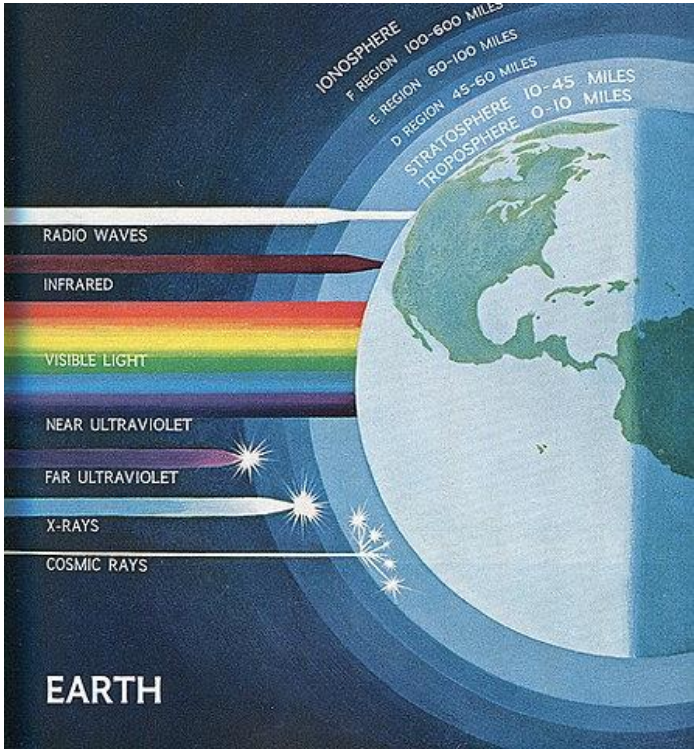
Standing Waves in a Microwave

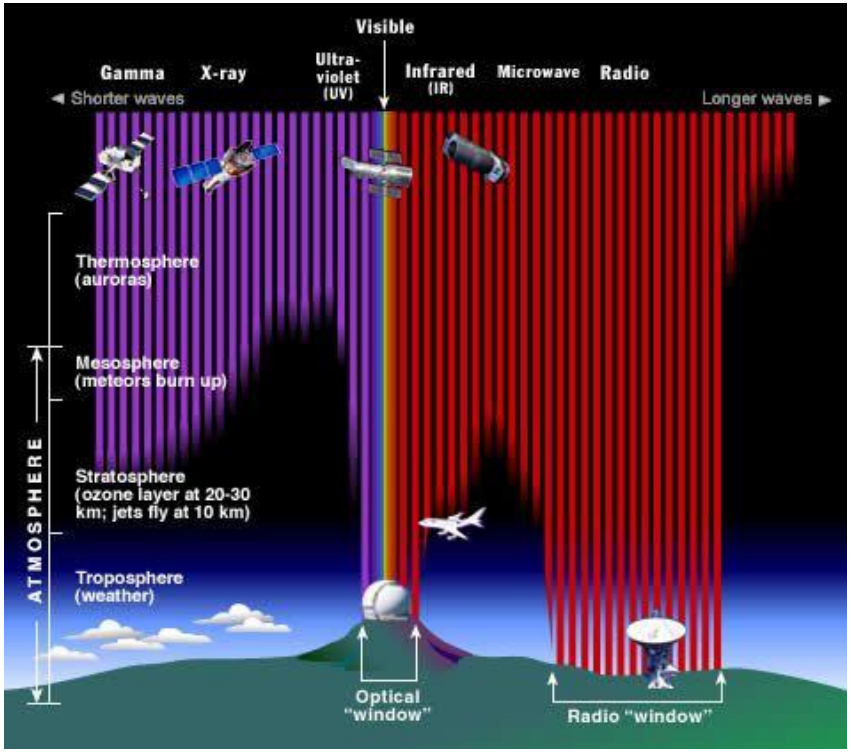


Electromagnetic Spectrum

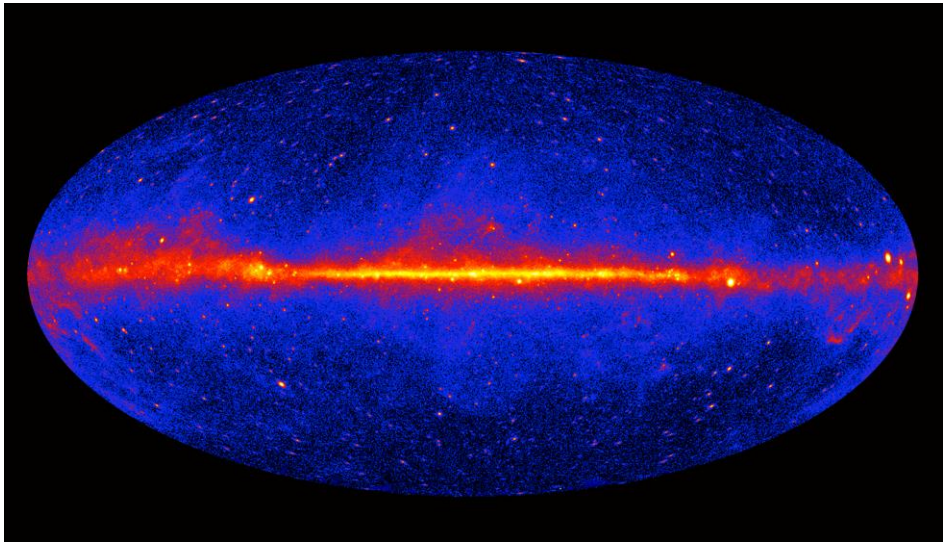


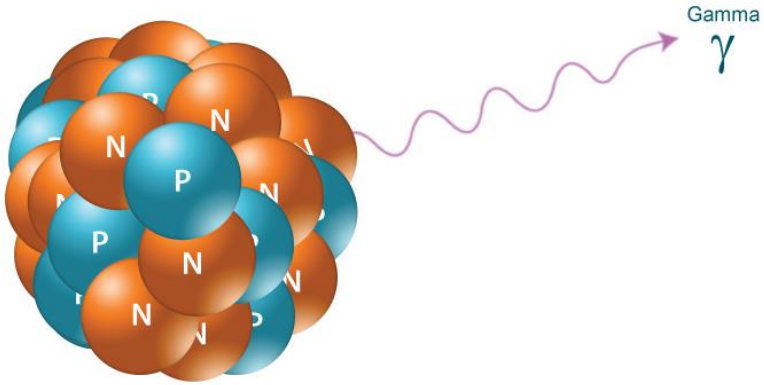
Not everything makes it to Earth





Gamma Ray



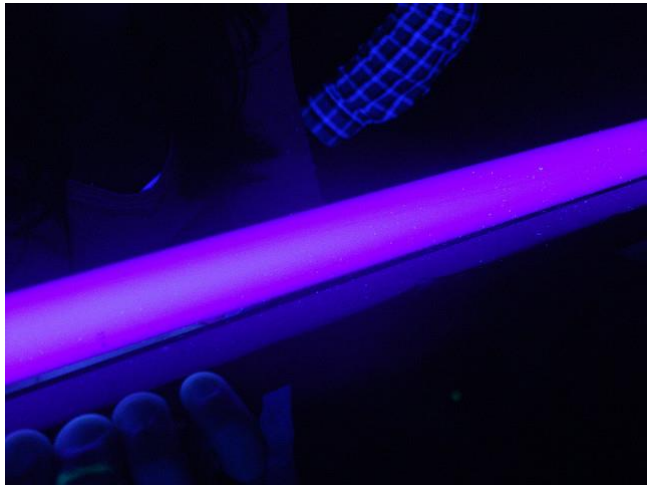


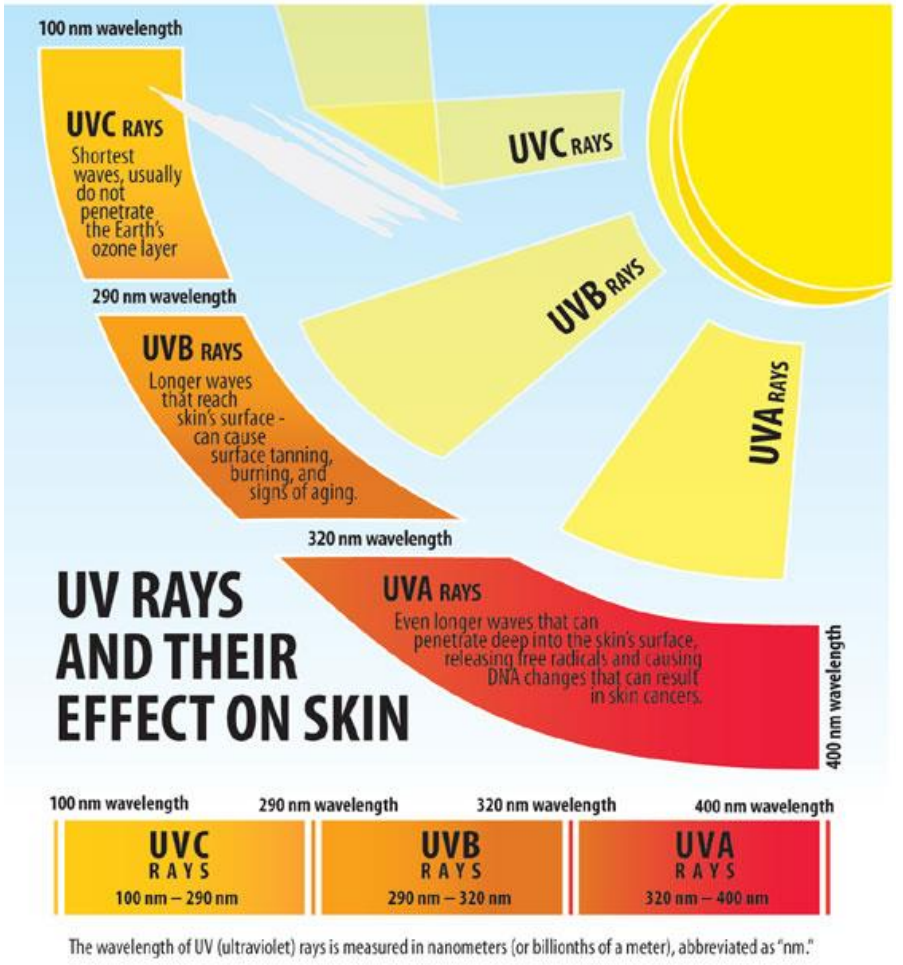
Wavelength: 10^{-12} m | 1 pm

X-Rays

Wavelength: 10^{-10} m | 10 nm

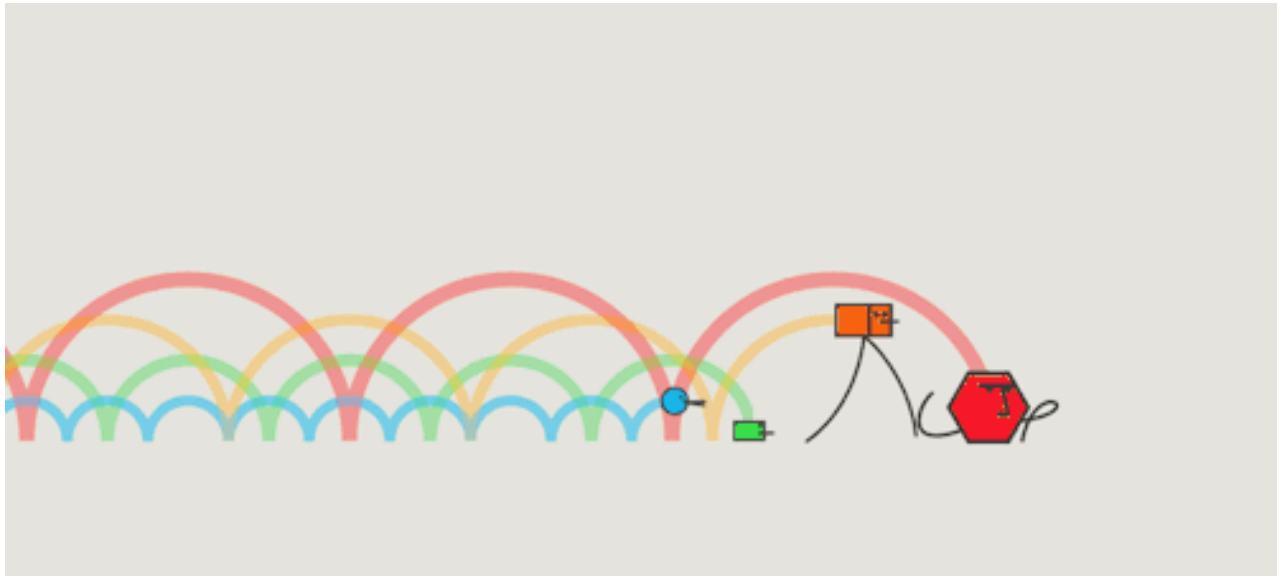
Ultraviolet

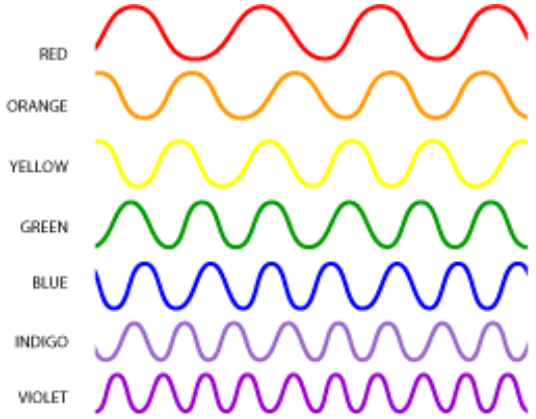




Wavelength: 10^{-8} m | 10 nm

Visible Light





Wavelength: 0.5×10^{-12} m | 500 nm

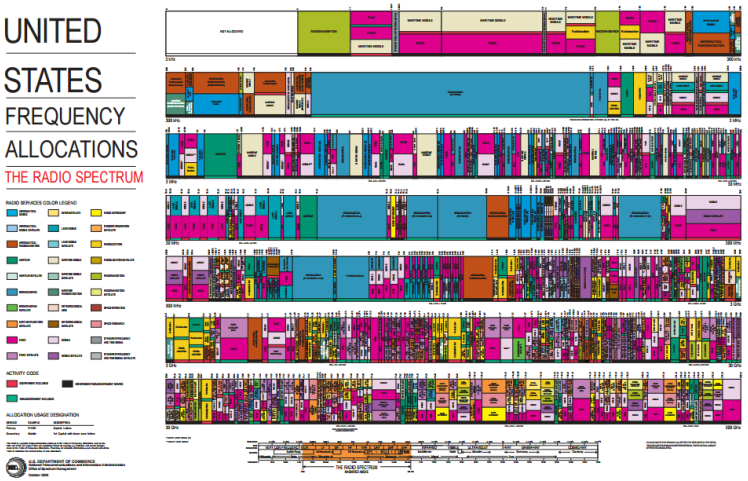
Infrared

Wavelength: 10^{-5} m | 0.01 mm

Microwaves

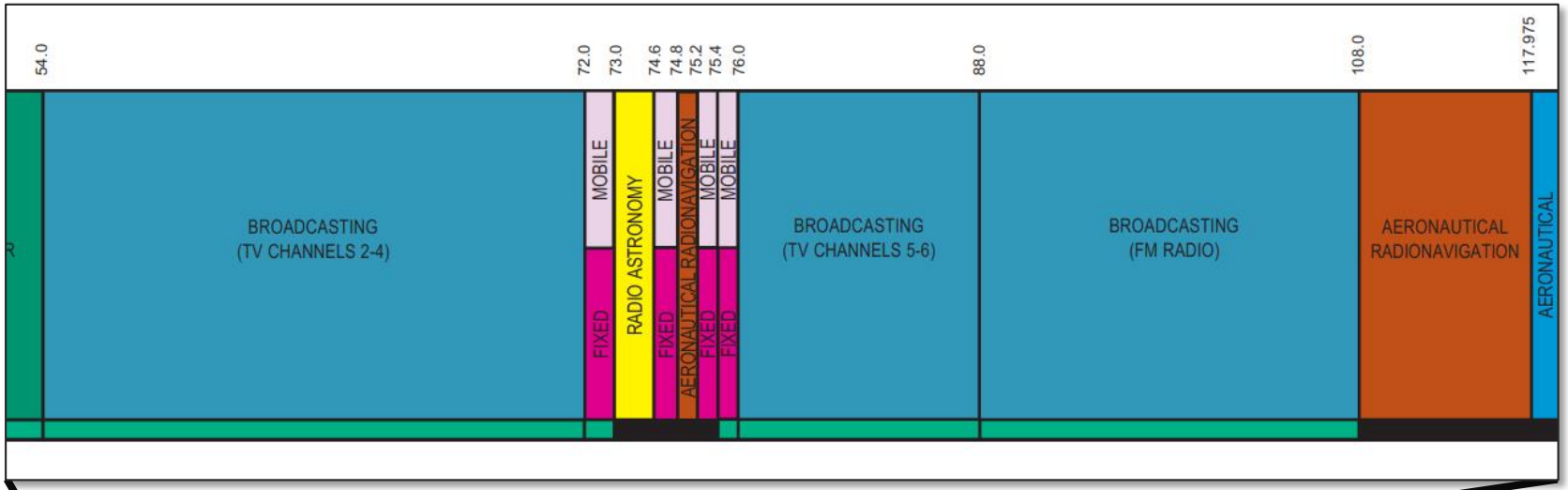
Wavelength: 10^{-2} m | 1 cm

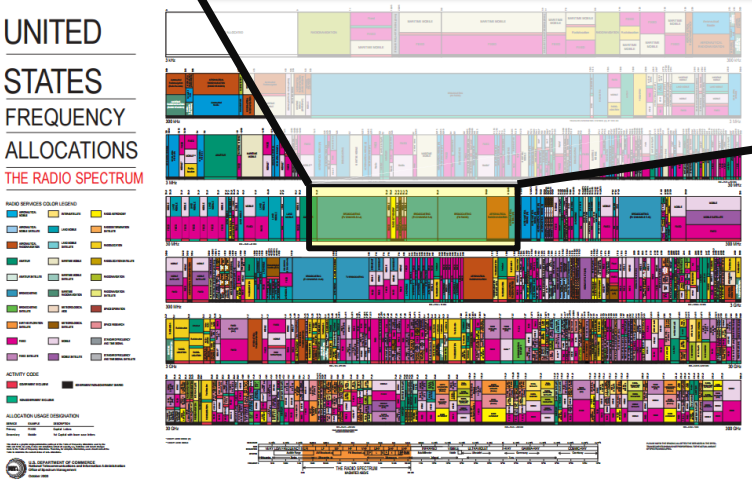
Radiowaves



Wavelength: 10^3 m | 1 km

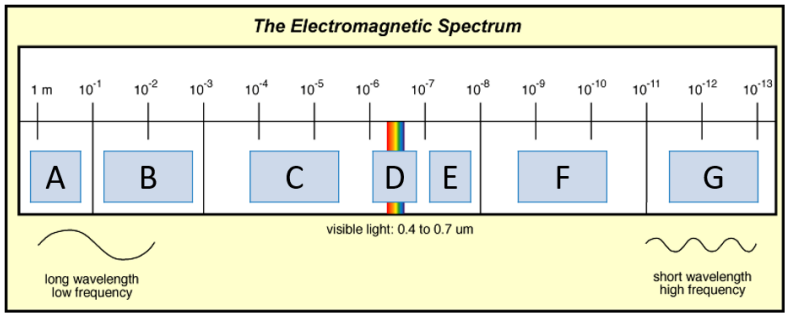
Wireless Data Transfer





Can you name them? You should.

A	
B	
C	
D	
E	
F	
G	



Lesson Takeaways

- ❑ I can identify and use the speed of light to solve wave problems with the wave equations
- ❑ I can estimate the wavelength magnitude for the different EM waves
- ❑ I can provide real world examples for each of the electromagnetic waves