

Light and the EM Spectrum

IB PHYSICS | WAVES - LIGHT

Frequency and Light

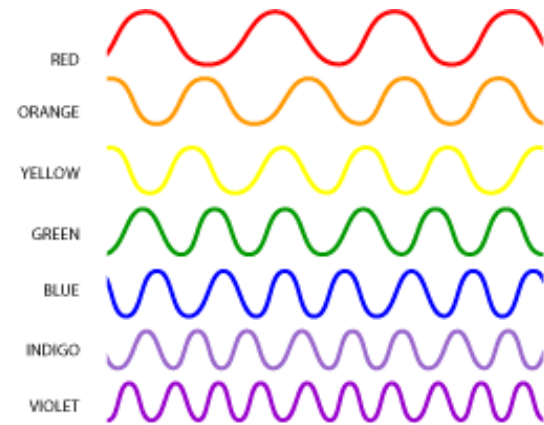
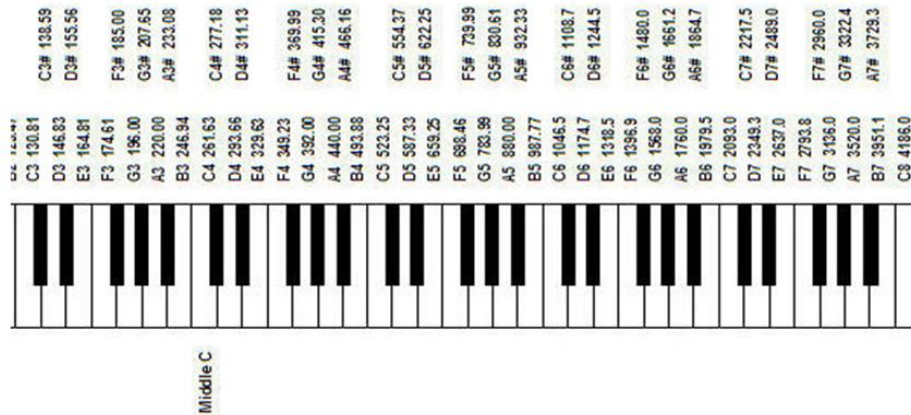
Sound

Change in Frequency

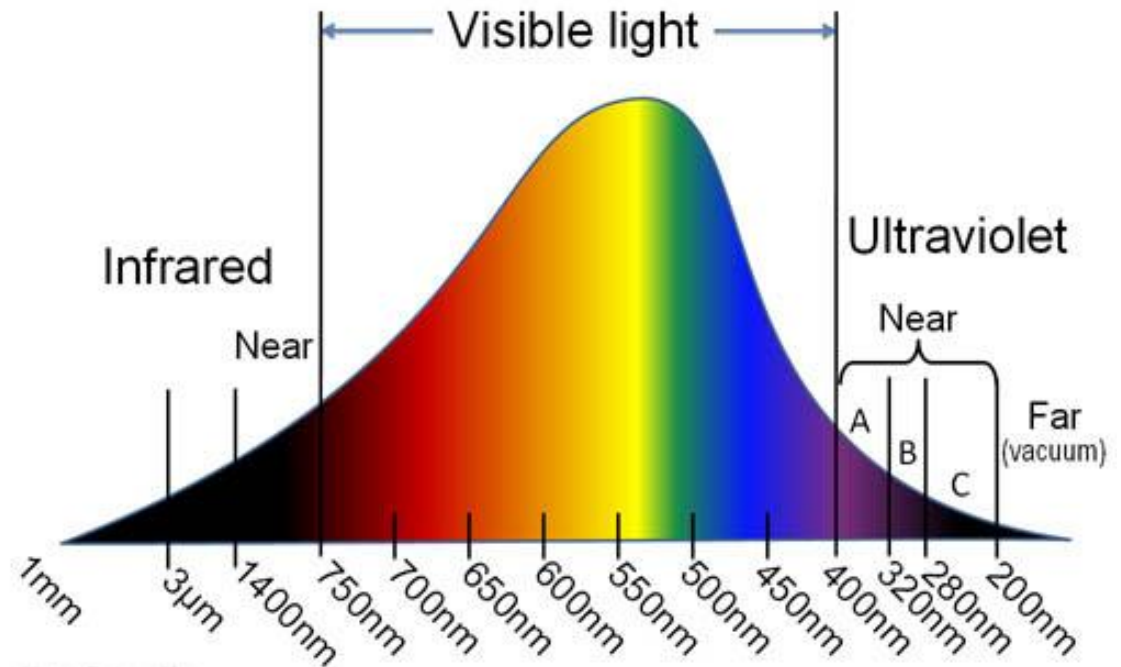
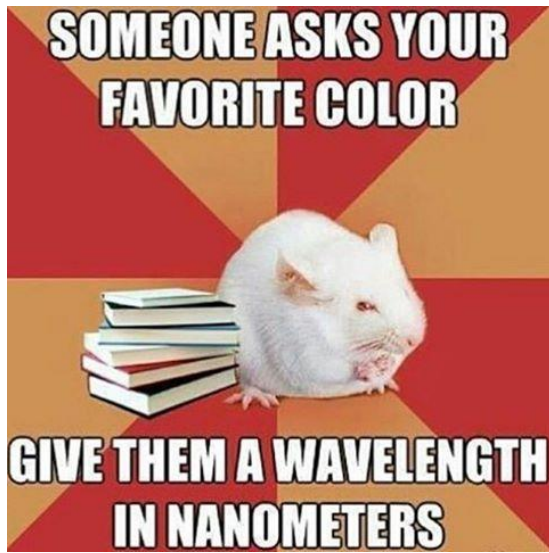


Light

Change in Frequency



Frequency and Light

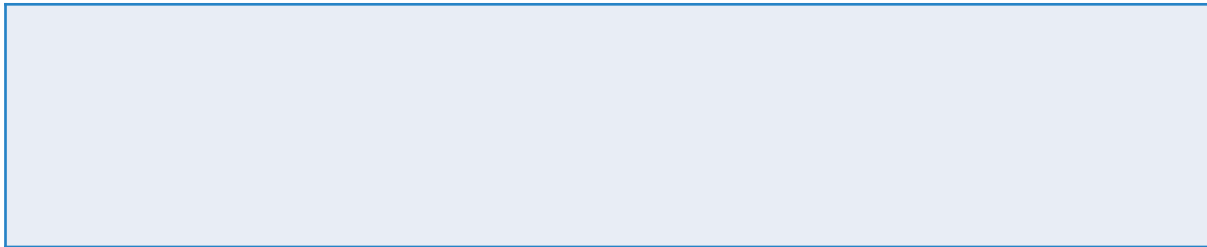


Ken Costello

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

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

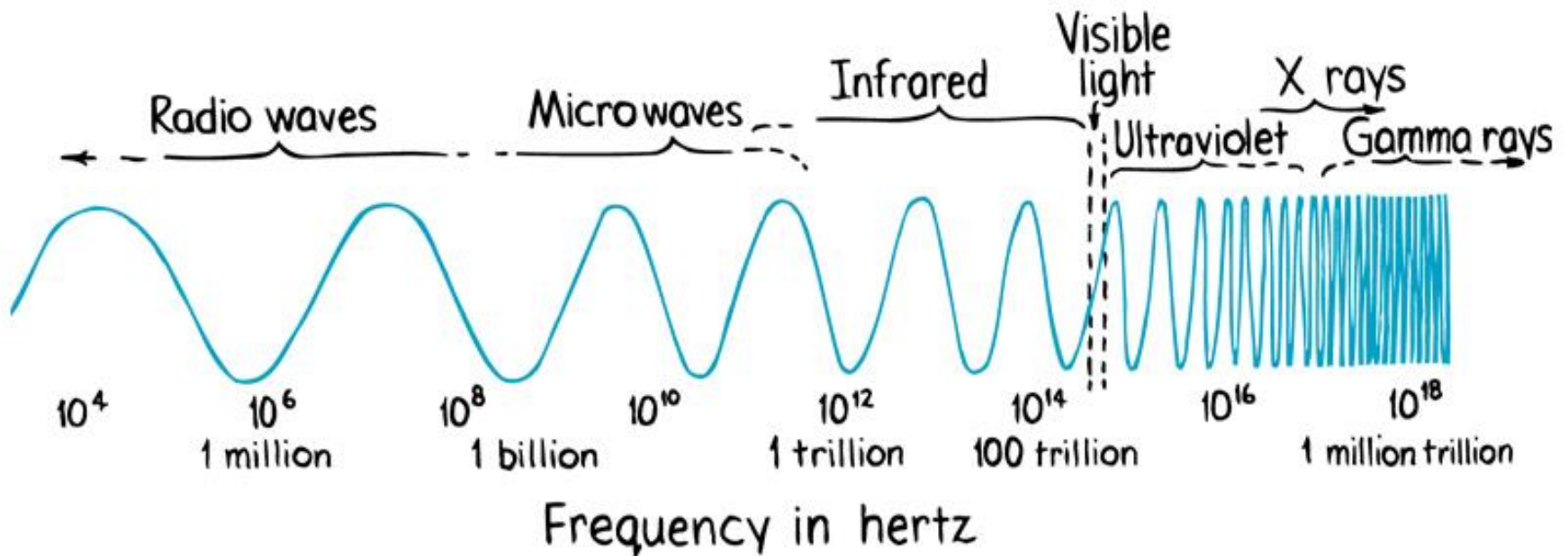
$$v = f \lambda$$

Works the same for electromagnetic waves

$$c = f \lambda$$

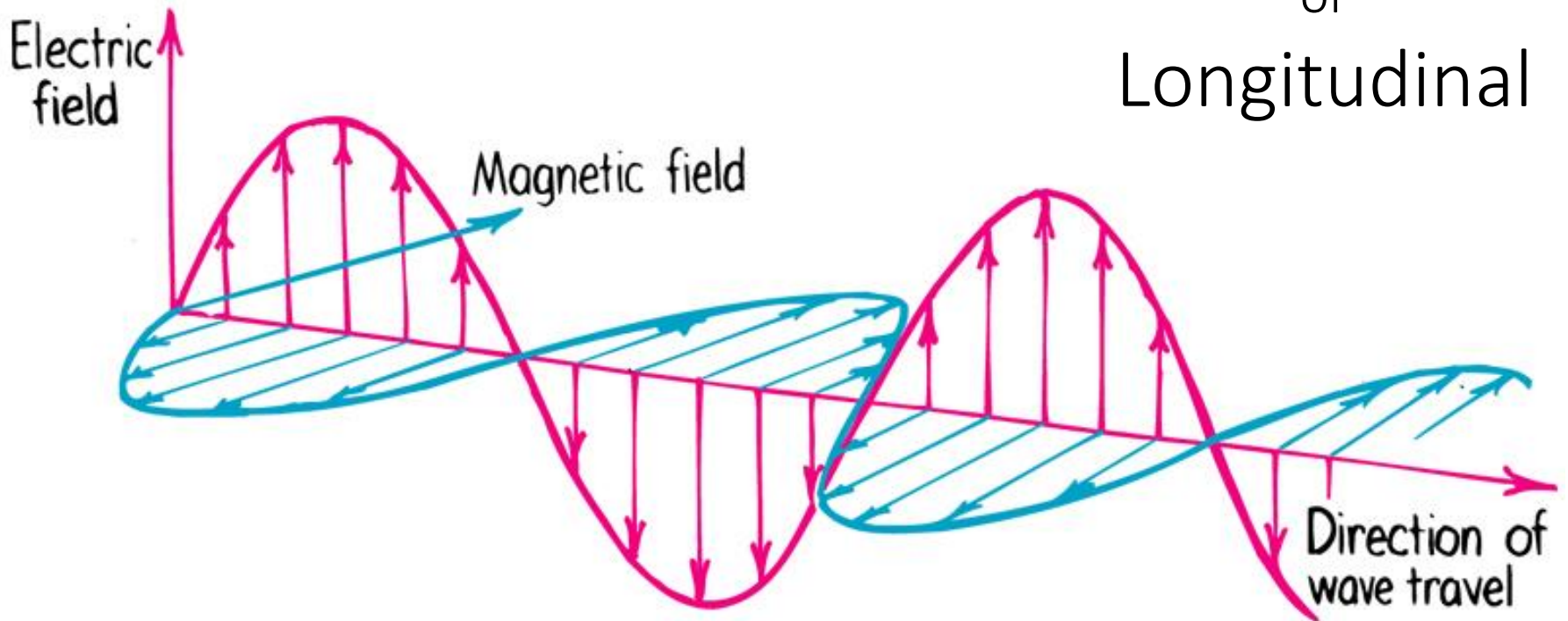
Electromagnetic Spectrum

Visible light is just part of the picture...



Electromagnetic Waves

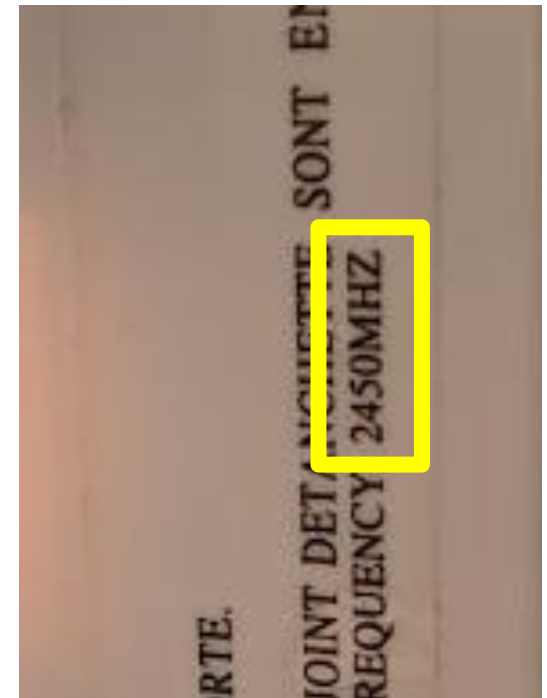
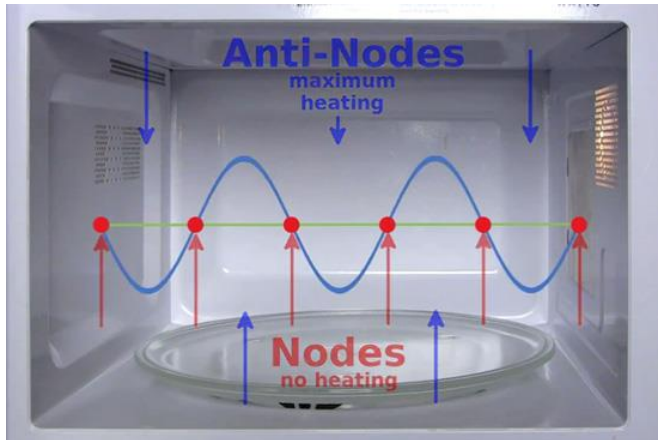
? Transverse ?
or
Longitudinal



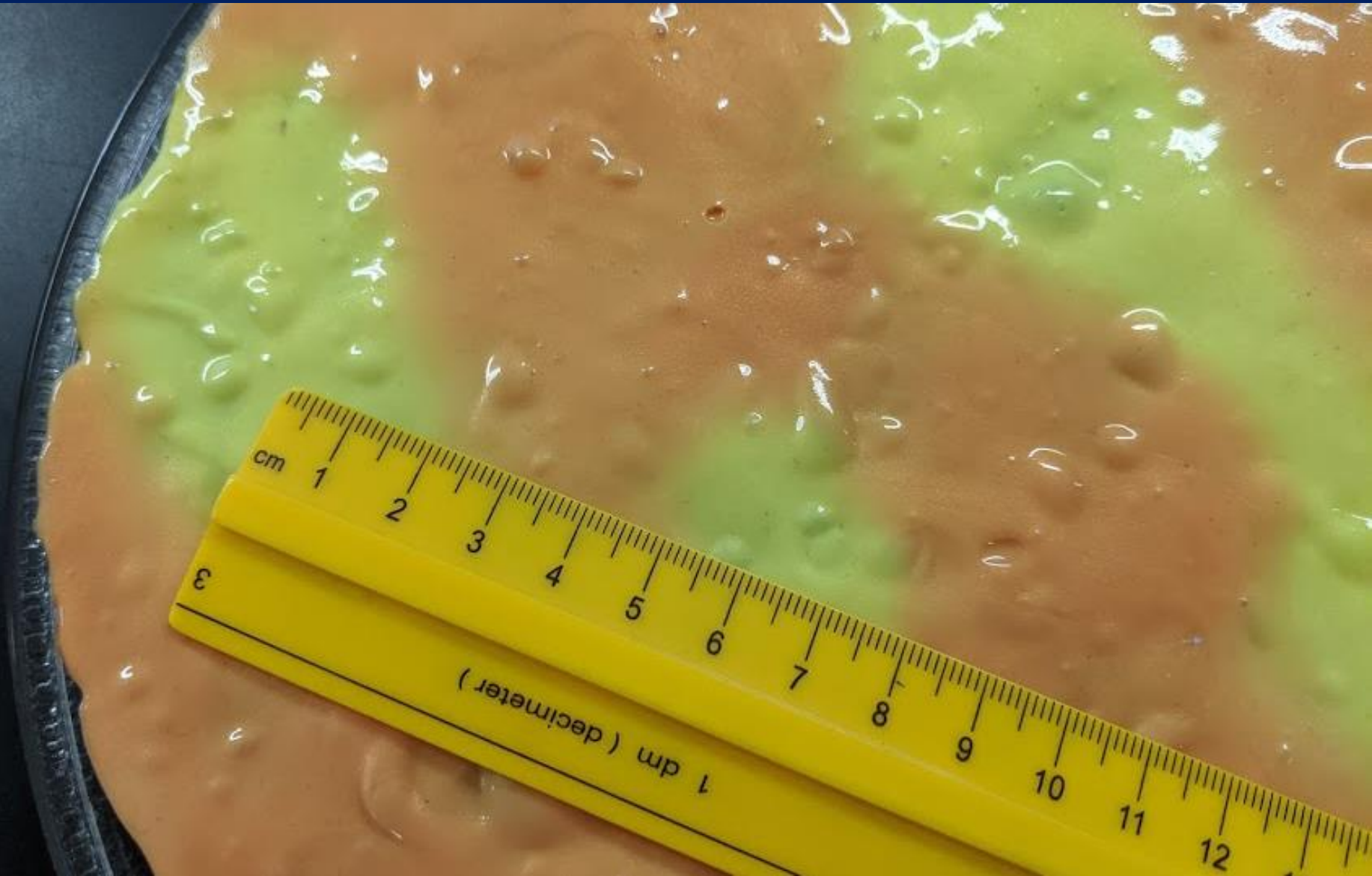
Standing Waves in a Microwave

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

$$v = f\lambda$$



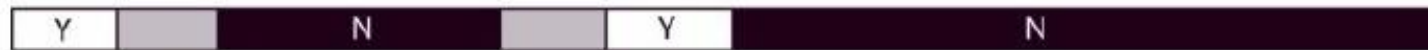
Standing Waves in a Microwave



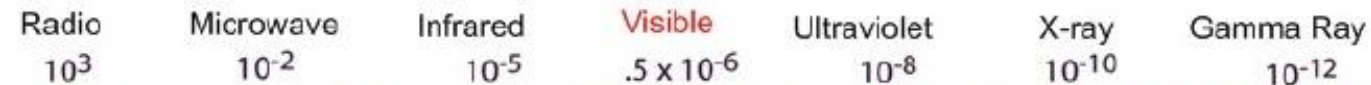
Electromagnetic Spectrum

The Electromagnetic Spectrum

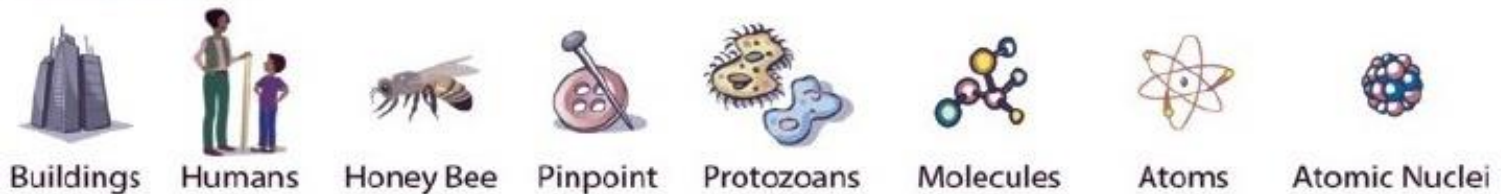
Penetrates Earth Atmosphere?



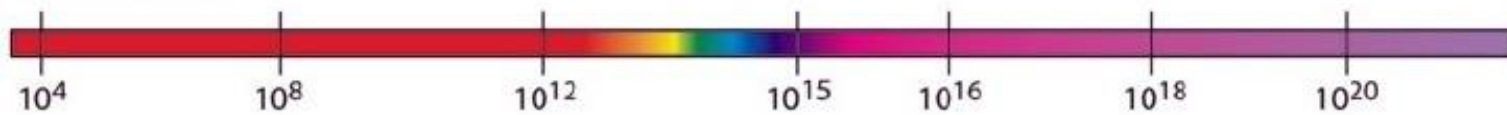
Wavelength (meters)



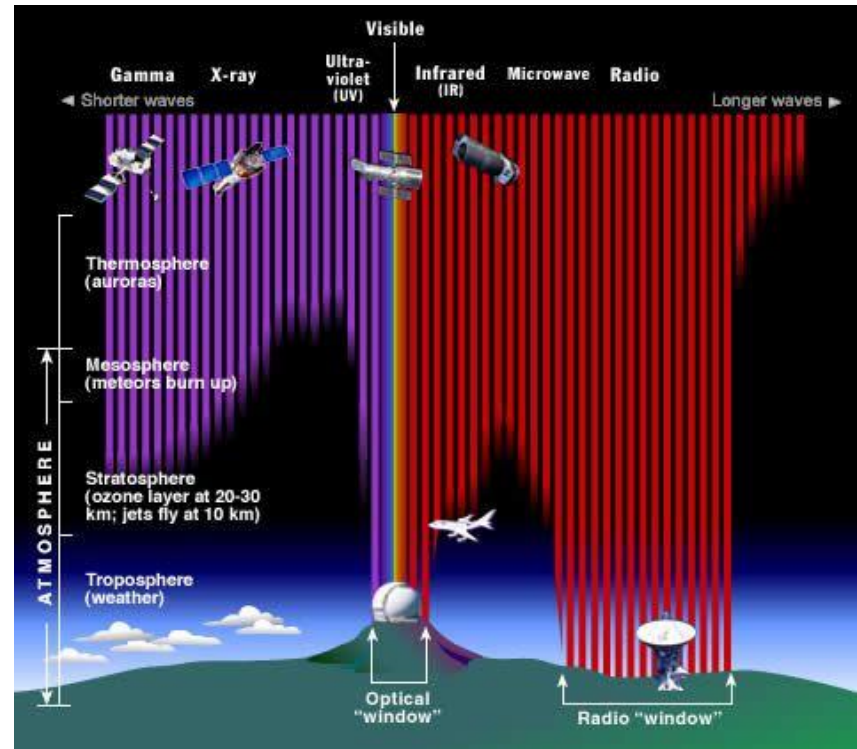
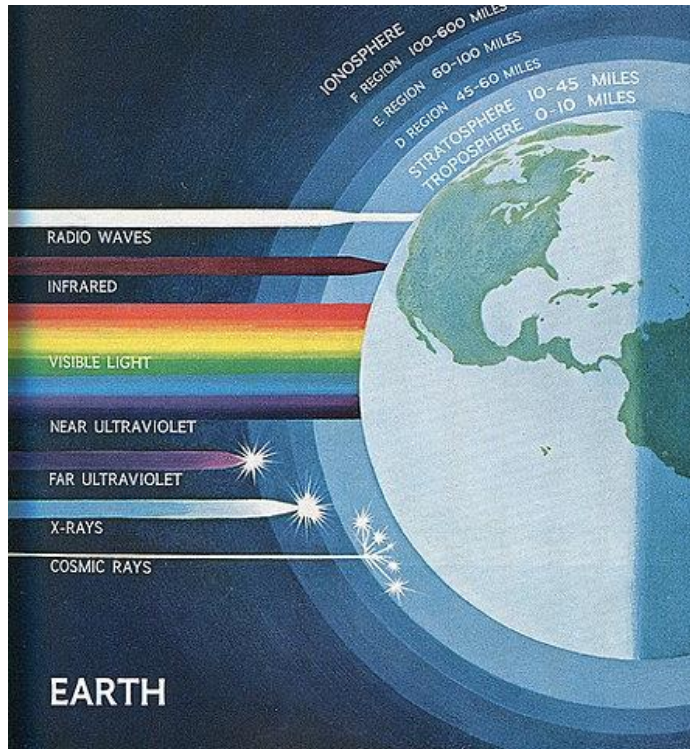
About the size of...



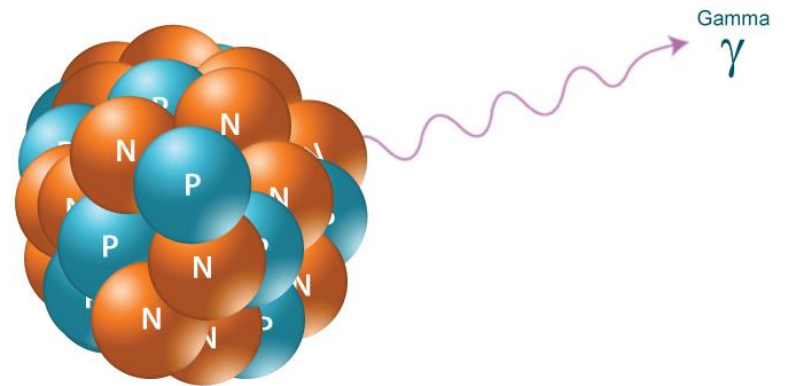
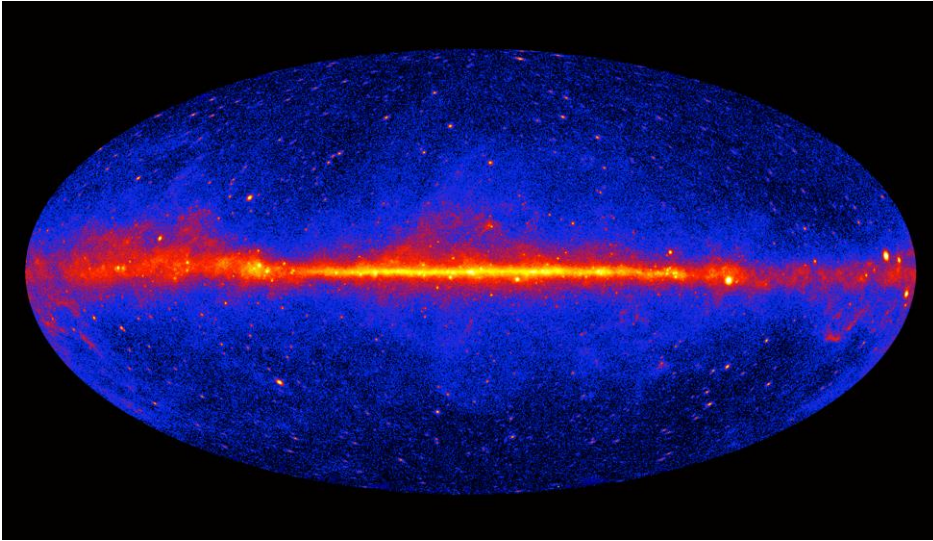
Frequency (Hz)



Not everything makes it to Earth



Gamma Ray



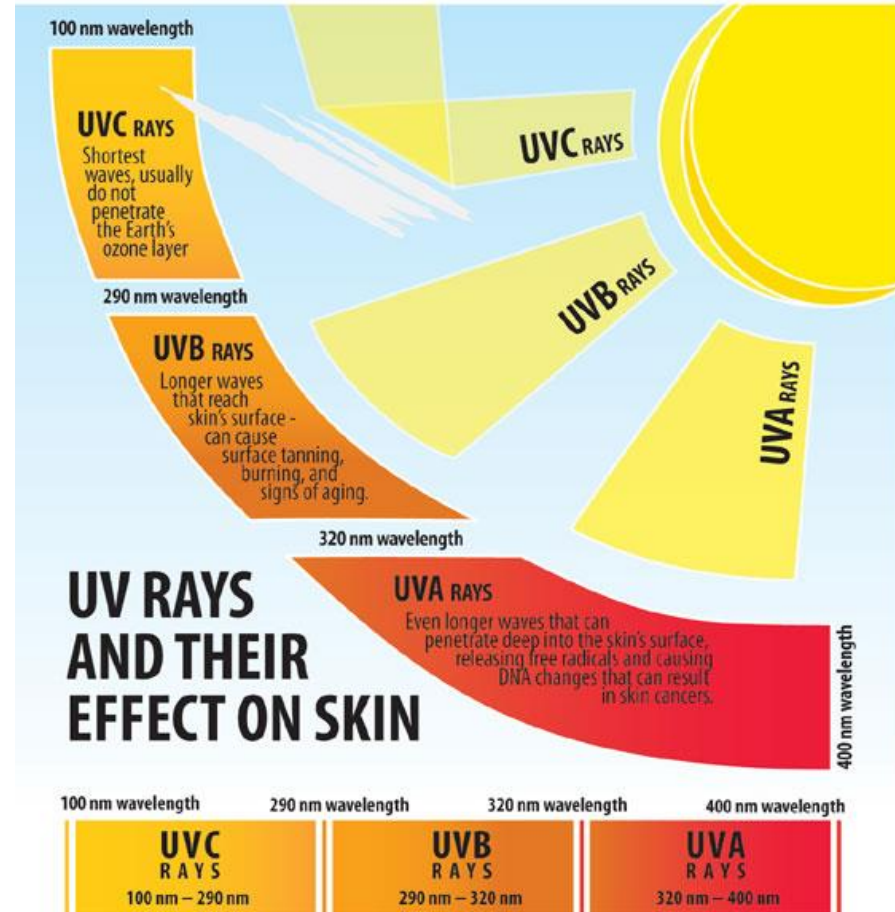
Wavelength: 10^{-12} m | 1 pm

X-Rays



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

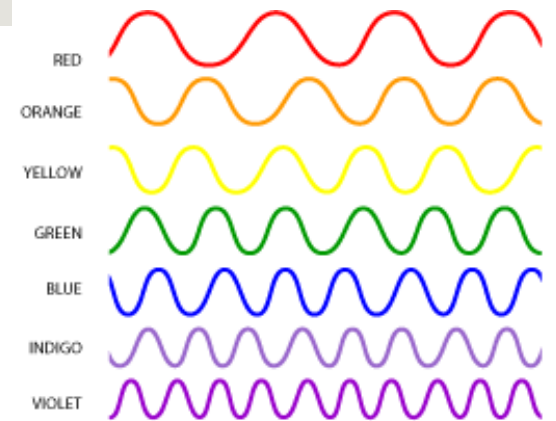
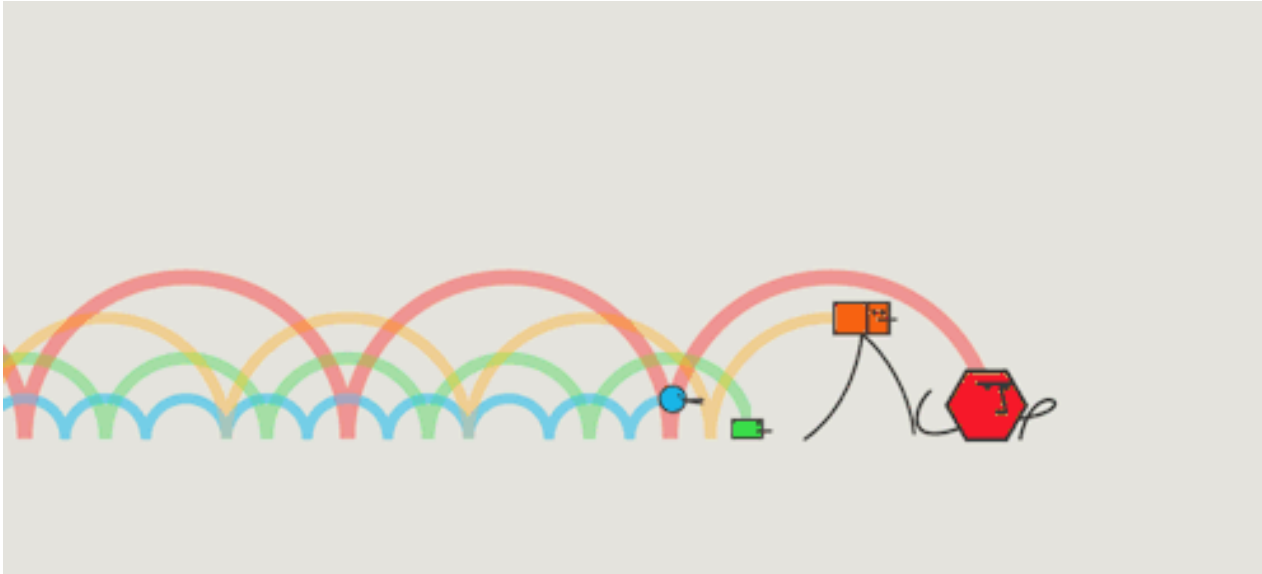
Ultraviolet



The wavelength of UV (ultraviolet) rays is measured in nanometers (or billionths of a meter), abbreviated as "nm."

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



UNITED STATES FREQUENCY ALLOCATIONS

THE RADIO SPECTRUM

NAVY SERVICES COLOR LEGEND

- Blue: Navy
- Green: Army
- Yellow: Air Force
- Red: Coast Guard
- Black: Federal Communications Commission
- White: Unallocated

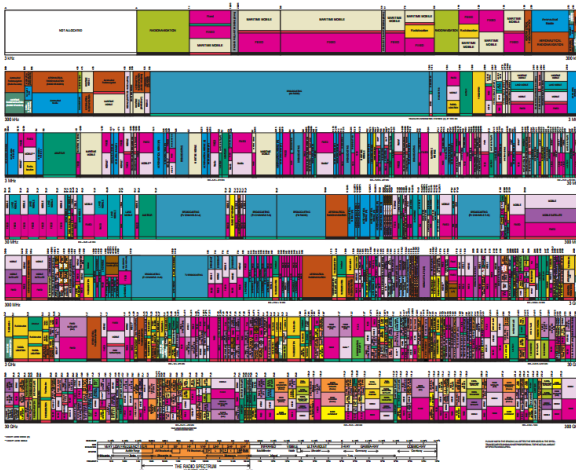
ACTIVITY CODE

- Red: Primary
- Black: Secondary
- Green: Incidental

ALLOCATION USAGE DESIGNATION

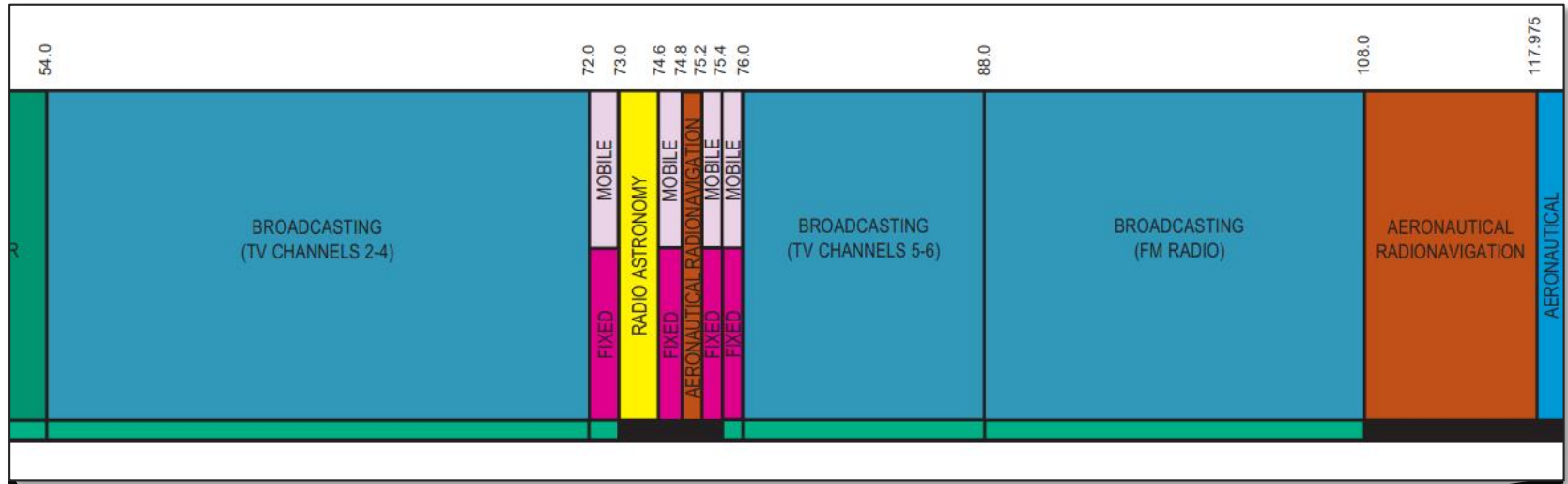
- Blue: Broadcast
- Black: Fixed
- Green: Mobile
- Yellow: Portable
- Red: Variable
- White: Other

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
NIST SPECIAL REPORT 300-107
FEDERAL COMMUNICATIONS COMMISSION
FCC REPORT 03-108



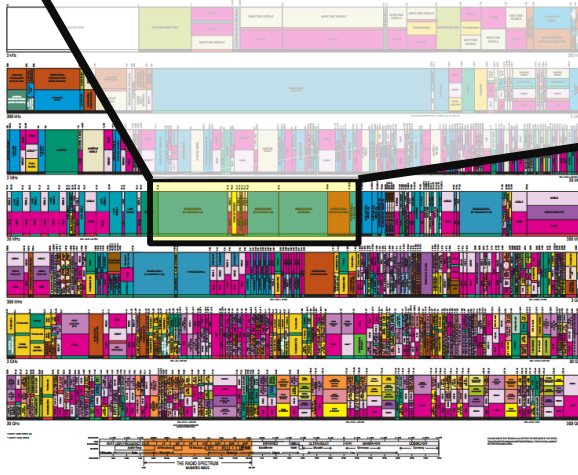
Wavelength: 10^3 m | 1 km

Wireless Data Transfer



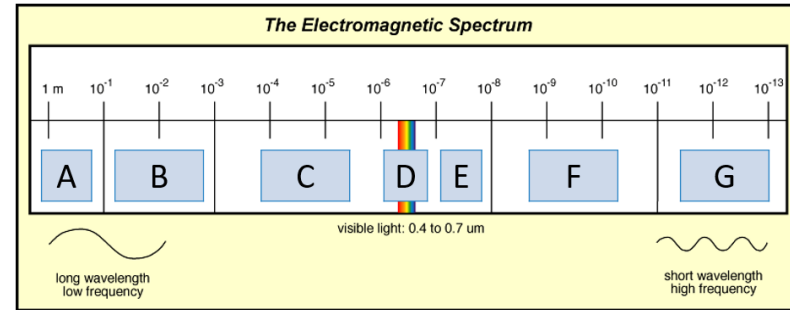
UNITED STATES FREQUENCY ALLOCATIONS

THE RADIO SPECTRUM



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