

#### THE ELECTROMAGNETIC SPECTRUM



Light

### What type of a wave is light?

Light is a little odd, but if anything it is a Transverse Wave

#### If light is a wave, then what is waving?

It is a fluctuating electric and magnetic field and is often called Electromagnetic Radiation



### The Electromagnetic Wave

#### All waves require a medium to travel through!!!!

#### ..... Except Light!?!? It moves through space propagating itself



## How fast is light?





#### The speed of light represents the Universe's speed limit

All types of light travel at the same speed **3\*10<sup>8</sup> m/s** In a vacuum



#### Practice

The distance between the State Capitol and Westlake High school is 33.2 miles. How long would a flash of light take to get from one to the other?

$$\begin{array}{rcl} 33.2 \ \mbox{mi} & 1609 \ \mbox{m} \\ & 1 \ \mbox{mi} \end{array} & = 53418.8 \ \mbox{m} \\ v = d/t & \longrightarrow & t = d/v & \longrightarrow & t = 53418.8/(3 \times 10^8) \\ & t = 1.78 \times 10^{-4} s \end{array}$$

If the distance between the Earth and the Sun is 1.49\*10^11 m, how long does it take light to move between the two?

$$t = d/v \longrightarrow t = (1.49 * 10^{11})/(3 * 10^8) \begin{vmatrix} t \\ 0 \end{vmatrix}$$

$$t = 496.7s$$
  
or 8.28 min

## **Bell Ringer**

- A light year is the distance light can travel in a year. How far is this in meters?
- 2. The closest star to us (Proxima Centauri) is 4.24 light years away. How far away is that in meters?
- 3. Earth is 149.6 billion meters away from the Sun. How many times would a spaceship have to travel back and forth between the two to equal the distance between Earth and Proxima Centauri?

## The Electromagnetic Spectrum

There is much more to light than what the eye can see!



#### https://www.youtube.com/watch?v=fpx7hsoYEt4

#### **Chart of the Electromagnetic Spectrum**

| Size<br>reference   | fe                             | otball fiel       | man<br>d | 's height       | basel           | ball       | papercl<br>thick | lip<br>ness<br>pape<br>thickne | r cel           | bacte        | eria Viru | ses                          | eter mole       | ato        | m<br>B<br>p                   | o<br>subaton | nic<br>→ |
|---------------------|--------------------------------|-------------------|----------|-----------------|-----------------|------------|------------------|--------------------------------|-----------------|--------------|-----------|------------------------------|-----------------|------------|-------------------------------|--------------|----------|
| wavelength          | 1                              | i.                | 3        | 1               | 1ft             | 1 cm       | 1 mm             | 1 1                            | 1 mil           | 1,μ          | 5         | Ē                            | 1 nn            | 1 A        | 9                             | 1 pr         | n        |
| λ (m)               | 10 <sup>3</sup>                | 10 <sup>2</sup>   | 10       | 1               | 10-1            | 10-2       | 10-3             | 3 10-4                         | 10-5            | 10-6         | 10-       | 7 10-8                       | 10-9            | 10-10      | <sup>0</sup> 10 <sup>-1</sup> | 10           | 12       |
| wavenumbe           | er                             |                   |          |                 |                 | 1          | 1                | 1000                           | 1               |              |           |                              |                 | -          | 1                             |              |          |
| (cm <sup>-</sup>    | <sup>1)</sup> 10 <sup>-5</sup> | 10-4              | 10-3     | 10-2            | 10-             | 1 <b>1</b> | 10               | 10 <sup>2</sup>                | 10 <sup>3</sup> | 104          | 10        | <sup>5</sup> 10 <sup>6</sup> | 107             | 7 108      | 10 <sup>9</sup>               | 10           | 10       |
| electron vo         | I <u>t ı</u>                   | 1                 | Е        | 1               | 4               | 12         | E.               | 1                              | 1               | 1            | 1         |                              | 8               | E          | 1                             | 1            |          |
| (e\                 | 10-9                           | 10-8              | 10-7     | 10-6            | 10-5            | 10-4       | 10-3             | <sup>3</sup> 10 <sup>-2</sup>  | 10-1            | 1            | 10        | 10 <sup>2</sup>              | 10 <sup>3</sup> | 104        | 105                           | 10           | \$       |
| frequency           |                                | 1 MHz             | 1        | 1               | GHz             | 1          | _                | 1 THz                          |                 |              | 1 PHz     |                              |                 | 1 EHz      |                               |              | 1 ZHz    |
| (Hz)                | 105                            | 10 <sup>6</sup>   | 107      | 10 <sup>8</sup> | 10 <sup>9</sup> | 1010       | 1011             | 10 <sup>12</sup>               | 1013            | 1014         | 1015      | 1016                         | 1017            | 1018       | 10 <sup>19</sup>              | 1020         | 1021     |
| ds                  | Radio Spectrum                 |                   |          |                 |                 |            |                  | Terahert                       | z Inf           | Infrared     |           | raviolet                     |                 | X-ray      |                               | Gamma        |          |
| Ban                 | Broadcast and Wireless         |                   |          | reless          | Microwave       |            |                  |                                | Far IR Mi       | ar IR Mid IR |           | Near Extreme UV              |                 | Soft X-ray |                               |              |          |
| Sources and Uses of |                                |                   |          |                 |                 |            |                  |                                |                 |              |           |                              |                 |            |                               |              |          |
| © 2                 | sed with nerm                  | ission, Rev2C 6-1 |          |                 |                 | Λ = 3x     | 10%freq          | = 1/(wn*                       | 100) = 1.       | 24x10*%      | VI        |                              |                 | 50-        | R Resea                       | rch Associ   | ation 🐿  |



# Does Light carry Energy?

Yes!!!! Sunlight is warm ... You can power things with photovoltaic cells ... Plants get energy through photosynthesis

#### So how do you measure the energy light carries? -It all travels at the same speed -It has no mass

For most waves, you measure the energy they carry by looking at the amplitude. Light breaks the rules again!!!



Through this experiment we realize that the energy light carries is not proportional to its amplitude, but rather to its frequency!

## Light and Energy



From the Photoelectric Effect we learn: Increase Amplitude = More Electrons Increase Frequency = Higher Energy Electrons





How much energy does Blue light ( $\lambda$  = 460nm) have?

$$c = \lambda * f$$
  

$$3 * 10^8 = (460 * 10^{-9}) * f$$
  

$$f = \frac{3 * 10^8}{(460 * 10^{-9})}$$
  

$$f = 6.52 * 10^{14} \text{ hz}$$

$$E = h * f$$
  

$$E = (6.63 * 10^{-34}) * (6.52 * 10^{14})$$
  

$$E = 4.32 * 10^{-19} J$$

# Does Light experience a Doppler Shift? YES!!!!!!!



**BLUE SHIFT** 

**RED SHIFT** 



### **Galaxy velocities**





THESE NORTHERN PRECINCTS APPEAR RED, WHICH PROBABLY MEANS THEY'RE MOVING AWAY FROM US, WHEREAS THESE BLUER REGIONS ARE APPROACHING US. I BELIEVE THE DISTRICT MAY BE ROTATING IN SPACE.



MY CAREER AS AN ELECTION ANALYST WAS SHORT-LIVED.