Waves

**Key Concepts**

* **Waves transfer energy**
* **A force starts a wave**
* **Waves have properties that you can measure**
* **Waves behave in predictable ways**

**WAVES**

A wave is a disturbance that transfers energy from one place to another.

* **Waves** can transfer energy without moving matter the entire distance.
* **Force**: A force is what starts the disturbance that sends a wave through a material or substance.

Example: *An earthquake is the result of a sudden release of energy that was built up in rock. This potential energy came from the tectonic forces pushing and pulling rock.*

* **Compression:** A force that tends to shorten or squeeze something, decreasing its volume. Think press
* **Medium:** A medium is any substance that a wave moves through.

Example: Water is the medium for an ocean wave.

**Kinds of Waves**

**Mechanical/Physical Wave**: This wave transfers energy through matter.

Examples: Sound, water, and earthquake waves.

* **Transverse Wave:** The direction the wave travels is perpendicular to the disturbance. This wave creates an up and down action.

Example: The rope demonstration.

* **Longitudinal Waves**: This wave travels in the same direction as the disturbance.

Example: Coiled spring, sound wave.

**Electromagnetic**: This wave transfers energy through a field. It does not need a medium!

**Waves Have Measurable Properties**

**Properties (Parts) of a wave**

**Wavelength**

Crest

**Amplitude**

**Line at**

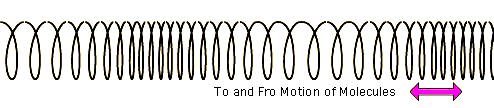
**Rest,**

**Rest Position**

Trough

**Wavelength**

Compression: The areas of a wave being pressed together.



Rarefaction: The areas of a wave being pulled apart.

**Properties** Of A **Wave.**

* **Crest:** The crest is the high point or wave peak.
* **Trough:** The trough is the lowest point or valley of a wave.
* **Amplitude:** This is the distance between a line through the middle of a wave (line at rest) and a crest or trough.

**- Depending upon the kind of wave,**

The amplitude indicates how much

energy the wave is carrying

- The bigger the amplitude the greater

the energy!

* **Wavelength:** This is the distance from one wave crest to the very next wave crest…Or from trough to trough.
* **Frequency**: The number of waves passing through afixed point in a certain moment of time.

**Waves behave in predictable ways when they encounter a medium.**

**Waves react with Mediums!**

1. **Reflection**
   * The bouncing back of a wave when it strikes a barrier.
   * Examples:

-Waves in a pool striking the side

-An echo in a canyon

-Your reflection in a mirror (light waves bouncing off a smooth surface)

**2. Diffraction *it makes the wave different***

* The spreading out of waves through an opening or partial barrier, or around obstacles
* Example: Listen to the TV as you move throughout the house, it will sound different

[**https://www.youtube.com/watch?v=BH0NfVUTWG4**](https://www.youtube.com/watch?v=BH0NfVUTWG4) **Light**

**3. Refraction**

* The bending of a wave as it enters a new medium at an angle different than 90 degrees.
* Example: Objects half in and out of water look split! *Light goes from moving through air to moving through water in the glass. As light moves into the new medium it slows down and bends.*

<https://www.youtube.com/watch?v=Aggi0g67uXM>  
<https://www.youtube.com/watch?v=q73VNpFA-0Q>

**Waves Interact With Other Waves**

**Interference**

* The meeting and combining of waves
* Two waves can add or take away energy from each other.

[**http://www.aplusphysics.com/courses/regents/waves/regents\_wave\_interference.html**](http://www.aplusphysics.com/courses/regents/waves/regents_wave_interference.html)

* 1. **Constructive Interference**
     + Similar waves come together increasing energy.
     + The crests and troughs of two identical waves align.
* This adding of two waves can double amplitude

[Animation](http://www.cosmolearning.com/videos/wave-interference-animation/)

[http://earthguide.ucsd.edu/earthguide/wave\_interference.html](http://earthguide.ucsd.edu/earthguide/diagrams/wave_interference/wave_interference.html)

* 1. **Destructive Interference**
* Similar waves come together decreasing energy.
* The crests and troughs align opposite one another.
* Two identical waves can even cancel each other out completely!

FREQUENCY & WAVELENGTH

**Define wavelength:**

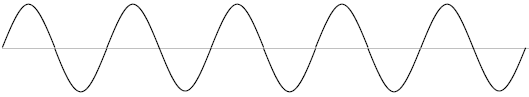
-The distance from one crest to the next, or one trough   
 to the next.

**Define frequency:**

-The number of waves passing a specific point in given  
 amount of time. *Usually written waves per second*.

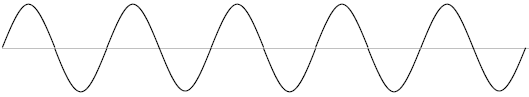
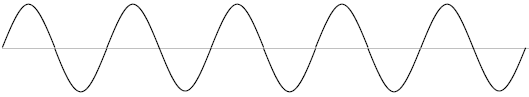
Draw and copy this

Below is a wave with a frequency of 5 Waves per second!



Below is that same wave with a decrease in wavelength!

What is the frequency of the wave below per second?



Answer: 10 waves per second!

When you decreased the wavelength, what happened to the frequency?

Answer: The frequency increased!

What is the relationship between wavelength and frequency?

-**Increase** the frequency you **decrease** the wavelength.

-**Increase** the wavelength you **decrease** the frequency.

**This is an inverse relationship. Inverse means opposite!**

**Thinking about frequency and wavelength…When one gets bigger the other gets smaller and when one gets smaller the other gets bigger!!**

# **ELECTROMAGNETIC WAVES**

# Key Concepts

* Unlike mechanical waves, **frequency** not amplitude **determines the amount of energy of an EM wave.**
* Electromagnetic waves have many uses.
* The sun is the source of most visible light.

* Light waves interact with materials.
* *\*\*\*EM waves are simply different forms of light!!!!!!*
* \*\*\*The EM wave’s **frequency determines the classification of EM wave** (if the wave is radio, gamma, micro waves or visible light etc…)

**Electromagnetic Waves** (EM Wave)

An EM wave is a disturbance that transfers energy through a **field.**

* **EM waves can travel through empty space!**
* **Empty space is a vacuum!**
* **EM waves do not need medium!**
* **Field**: A field is the area around one object where the object can apply a force (push or pull) to another object **without touching it**.

WARNING!

**\*\*\*\*\*\*\*\*END OF MATERIAL FOR TEST # 1!\*\*\*\*\*\*\***

**Electromagnetic Waves: Agsin!**

Key ideas I must know!!!

* EM waves do not need a medium.
* EM waves travel in a vacuum (empty space).
* EM waves do not lose energy as they travel, but they do spread out.
* EM waves can go forever (theoretically)
* Em wave energy is determined by the frequency.

EM waves have amplitude, frequency and wavelength

How EM waves form and travel

* EM waves come from atomic particles that are electrically charged.
* These particles can exert a force (push or pull) on each other through an electric field.
* Example: magnets
* Charged particles can move quickly.
* This movement causes a disturbance or vibration in their electric and magnetic fields.
* The EM wave travels in the form of these vibrations.

Radiation

The transfer of energy in the form of EM waves.

EM waves in a vacuum

* EM waves spread out as they travel.
* The farther from the source, the more spread out the waves are.
* Speed:

- EM waves speed is constant in a

vacuum.

* + 300,000kilometers per second
  + This is the speed of light
  + The suns light reaching us now is 8 minutes old

EM Waves Have Different Frequencies

What do television, radio, microwave, light, and electricity have in common?

*They are all the same form of energy, yet each does something very different!*

Frequency and EM waves

* Each of these forms of EM waves have wavelengths with different frequencies.
* The frequency determines wave characteristics.
* The frequency determines the waves uses.
* Higher frequency waves (more electromagnetic vibrations per second) have more energy.
* Lower frequency waves (with longer wavelengths) have lower energy.
* Electromagnetic Spectrum
  + Range of all EM frequencies
  + Hz, measures EM frequency

**Types of EM Waves**

Radio Waves

* Longest wavelength
* lowest frequency
* lowest energies
* How a radio works
  + Low frequency signal
  + A transmitter attaches the sound code to the signal by changing the wave slightly.
  + It changes the wave by modulating (changing) the amplitude, amplitude modulation AM radio
  + It changes the wave by modulating (changing) the frequency, frequency modulation FM radio
* Television
  + Uses radio waves
  + AM waves for the picture
  + FM waves for the sound

Microwaves

* Shorter wavelengths than radio
* Higher frequencies
* Higher energies
* Radar and cell phones are examples

Radar

* “Radio detecting and ranging”
* Send out microwaves that bounce off objects
* These reflections are changed into a visual image.
* The microwave was discovered by a mistake (radar waves melted a candy bar in a researchers pocket).

Cell Phones

* Use radio waves
* Towers create cells

Visible Light or the Visible EM Specrum

* EM waves that we can see

Infrared light

* EM waves with a frequency between microwaves and visible light
* Sometimes called heat waves
* Examples: sun, toaster, fire
* Pit vipers (snake) can actually see infrared light

Ultraviolet Light

* Frequencies above visible light and below x-rays
* Remember these waves have more energy
* These waves give you sunburn
* Bees and other insects can see ultraviolet light
* This allows them to see nectar guides

X-rays & gamma rays

* Very high frequencies and energy
* Produced by the sun and other stars
* X-rays
  + Pass through soft tissue, not bone
  + Can damage tissue causing cancer
* Gamma rays
  + Highest frequencies
  + Produced by the sun, stars and some radioactive substances
  + Can penetrate soft and hard tissue
  + Can cause cancer
  + Can be used to kill cancer cells

EM Waves and Mediums

When an EM wave encounters a medium or material, it can:

* Reflect: *bounce off*
* Diffract: *bend as it goes through or around barriers*
* Refract: *bend as it enters a new medium*
* Transfer energy to the medium: *usually heat*
  + EM waves travel as potential energy.
  + Example: microwaves do little to air, but when they encounter water, thermal energy is produced!

**How are frequency and wavelength related**? *An inverse relationship*

* As frequency increases, wavelength decreases!
* As wavelength decreases, frequency increases!
* As frequency decreases, wavelength increases!
* As wavelength increases frequency decreases!

EYEBALLS  
**Purpose**:

- Your eye is designed to detect electromagnetic waves.   
- Our eyes can only see visible light (a very small part of the   
 spectrum).

- We cannot see radio waves, microwaves, infrared, ultraviolet, x-rays or gamma rays. *We can only see visible light because our eyes are designed to see that frequency.*

**How does your eye allow you to see?**

[**Interacive Eye**](http://www.nei.nih.gov/health/eyediagram/)

[**See All You Can See: Student Paced**](http://isee.nei.nih.gov/parts/)

[**Student Paced Eye Guide**](http://www.childrensuniversity.manchester.ac.uk/interactives/science/brainandsenses/eye/)

[**Interactive Eye**](http://iknow.net/phys_eye_education.html#_nogo)

[**Virtual Eye Dissection**](http://www.eschoolonline.com/company/examples/eye/eyedissect.html)

1. Light enters through the cornea. A transparent membrane that covers the eye. It acts like a convex lens and refracts light. Like a *window*
2. Light then continues through the **pupil a black circle (hole) in the center)**. The pupil acts like a *window blind* that controls how much light enters the eye.
3. The pupil is surrounded by the **iris (colored portion).** The iris opens and closes the pupil.

When it gets dark, will the iris open the pupil wider, or make it smaller? What about in bright light?

1. Next the light passes through the **lens**. The lens is convex on both sides. This lens has tiny muscles that can stretch and contract the lens to adjust the amount of refraction. The lens focuses light so you can see images near and far. These muscles also adjust the focal point.
2. **Vitreous Fluid**: The light passes through the vitreous fluid. This fluid helps give the eye its shape.
3. The light then passes through the eye to the **retina (on the back of the eye).** The retina has special cells that respond to light and interpret the image.
4. **Rods**: Cells that distinguish white, black and grey. These help with night vision or faint light.
5. **Cones**: Cells that distinguish color. There are three types: red, blue, and green.
6. **Optic Nerve**: Sends a signal to the brain

Nearsighted

Farsighted

**Seeing and Color**

**How you see!**

1. Light hits an object and reflects off it.
2. Your eye detects the wavelength of the reflected light (EM Wave)

**How you see color!**

Color is the wavelengths present in light.

Two factors determine color

1. Wavelengths present in the light
2. Wavelengths absorbed and reflected by the object

Primary Colors of light

* + Your eyes detect only 3 colors
  + **Red, Green, Blue**
  + These colors can combine to make any color
  + These colors of light mixed equally are white or colorless.

Process…

1. Light waves hit an object.
2. Some wavelengths of the light are reflected back to your eye.
3. Some wavelengths are absorbed into the object. Absorbed means disappear and converted to another form of energy (usually heat)
4. **Example: Wavelength determines color**!

-A banana reflects **yellow** wavelengths of light

- The other wavelengths like **red** and **blue**   
 are absorbed and converted to heat

-If an object is black, what does that mean?

*That means the object is absorbing all colors wavelengths and converting into   
 heat.*

-If an object is white what does that mean?

*That means that the object is reflecting all wavelength colors!*

-Can you explain why a darker colored shirt   
 is hotter than a lighter colored shirt?

<https://www.youtube.com/watch?v=IqgxqkkptKQ>

COLOR or Pigments

* **Wavelength or frequency determines color**
* **White light has all the colors of the spectrum**
* A prism refracts white light into the colors of the spectrum: **red, orange, yellow, green, blue, indigo, violet**
* You can see them in order of decreasing wavelength
* The color you see on an object is the color that is reflected back.
* The colors you do not see are absorbed by the object
* Exception:

If you shine red light onto a piece of white paper, the paper will appear red (you limit available wavelengths)

Light Waves Interact With Materials

When an EM wave encounters a medium it can:

* Reflect: bounce off
* Diffract: bend as it goes through or around barriers
* Refract: bend as it enters a new medium
* Absorb: Transfer energy to the medium: usually heat
* Transmit: pass through the medium

Reflection

* Light can reflect off of objects
* *The angle of incidence equals the angle of reflection!*
* Most objects are visible because they reflect light.

Absorption

* The disappearance of an EM wave into a medium, and converted to heat
* Example:
  + Some materials absorb one

frequency of light (color), so that

you only see a reflected or

transmitted color not absorbed.

Transmission

* The passage of EM waves through a medium
* Example: Light through a window.

Kinds of Transmission

Scattering

* The spreading out of light rays in all directions because particles absorb and reflect light
* Fog, dust, mud in water, scratches in glass, can all cause scattering.
* Scattering makes our sky blue

Polarization

* A way of filtering light
* It reduces glare making objects easier to see
* Polarization makes all the electric fields of a light wave vibrate in the same direction.

Materials: Classified according to the amount and type of light they transmit.

* Transparent
  + Materials that allow most light to transmit (pass through) them
  + Examples: glass, plastic wrap, watch face, air
* Translucent
  + Transmit some light, but light spreads out in all directions.
  + You can see light, objects are unclear or barely visible
  + Examples: lampshade, notepaper
* Opaque
  + Objects do not allow any light to pass through.
  + They reflect light, absorb light or both. Example: wood, rock