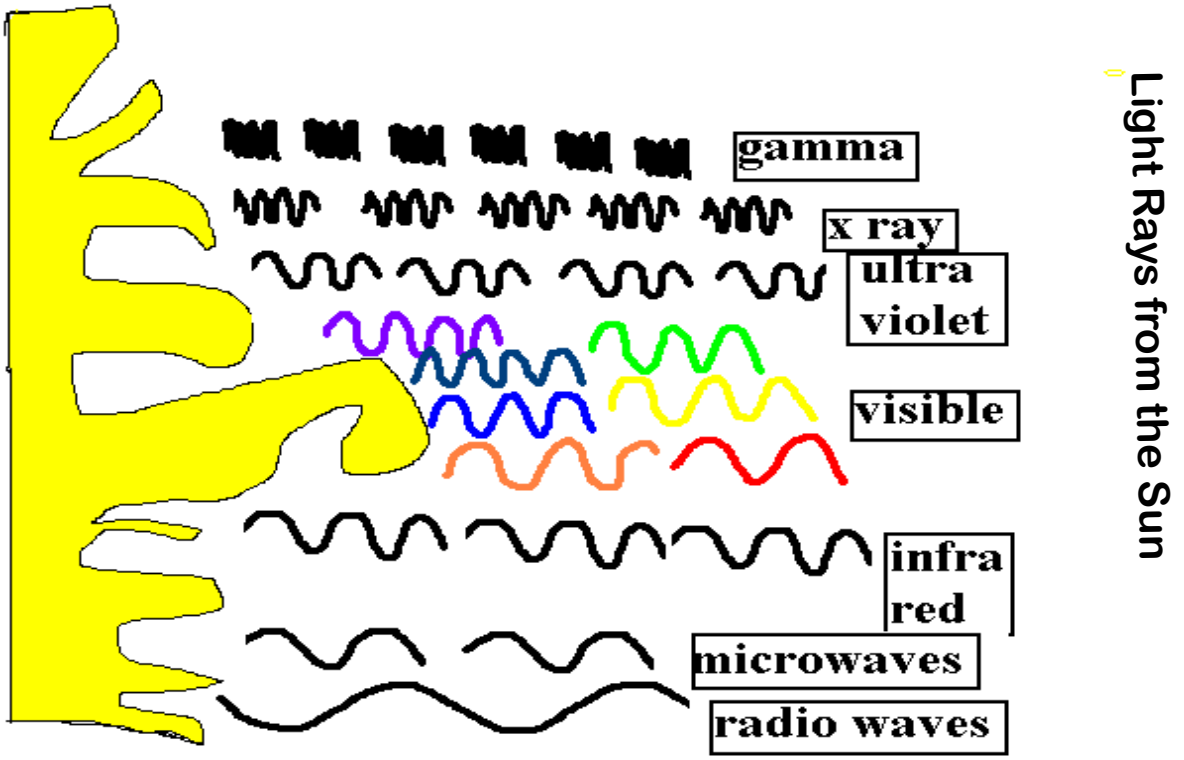
Lesson 9.6 Nature and Properties of Light

For many centuries Scientists have debated on the nature of light. Is it a wave? Is it a stream of particles?
Research Question
What is the accepted theory of the nature of light today?
Is a photon of light a particle or a wave?

What we call light is actually part of electromagnetic radiation and the light we see with our eyes is a very small part of this Electromagnetic Spectrum. The sun transmits a lot more than just visible light. Many of these rays are harmful and without the invisible shield around the earth we call the ozone layer, we would literally be toast!



Research
Report to the class on one of these forms of light:
- *wave size*
- *uses*
- *Effects on humans*

1. Wave nature of light

Light waves are often depicted as a **Transverse** wave.
This is the same type of wave as water waves or waves on a string:
Waves appear to move along the string as the particles on the string move up and down.
This can be demonstrated with ribbons tied to a long thick string or spring as waves are generated from one end.
Also try a useful Learning Object:
https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_en.html

So the **energy** is transferred along the medium while the **matter** vibrates up and down.
Question
There is lots of examples of waves happening around you where energy moves one way and matter moves another. Can you find some?

One example is waving a flag about

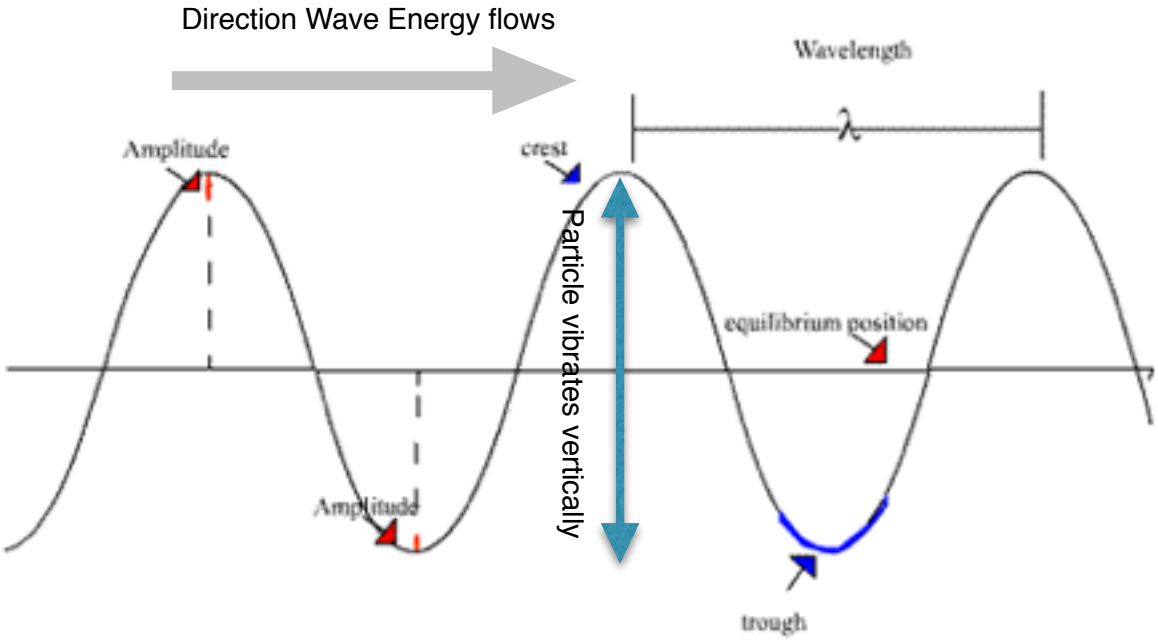
link: https://www.google.com.au/url?

sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=0ahUKEwin3IHx5MTNAhVBE5QKHbcKDtkQjRwIBw&url=http%3A%2F%2Fbestanimations.com%2FFlags%2FAustralia%2FAustralia.html&psig=AFQjCNF4qb4qIRILvYYJNK2NpnCtQF_Zww&ust=1466999387753236

The Characteristics of a wave

- Series of crests and troughs showing the maximum amplitude of the wave.
- Equilibrium Position showing the original position of all points before the wave was generated and the position all points vibrate through.
- The wavelength which is the distance between crests (or toughs)
- Direction the wave travels
- Frequency of the wave which is the number of waves or cycles moving past any point per second.
- velocity of the wave in m/s which is defined by:

Velocity= frequency x wavelength or $V = f\lambda$



Example: finding wave velocity

Frequency of wave = 500 hz (hertz = waves per second)
Wavelength = 1cm = 0.01m
Velocity = 500 x 0.01 = 5m/s

Do Activity *9.7 Investigating waves*

2. Light Sources

As we have seen light from the sun comes in many forms, not all of which is helpful to us. Light for seeing is also available through artificial sources.

Because Light is a form of energy; to make light energy is needed.
Question. What energy is converted to make:

- *candle light*
- *light from a bulb*
- *lightning*
- *light from phosphorescent paint*

Further Research Questions

1. *What differences are there between different types of light bulbs? Look up Incandescent, Halogen, Fluorescent and LED bulbs?*
2. *LED's have lots of advantages for future lighting needs what are they and what disadvantages do they have?*

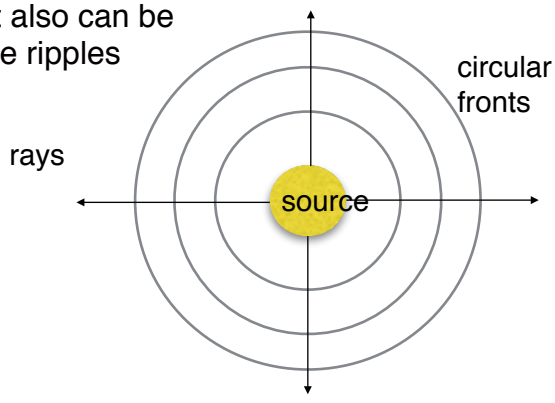
3. Properties and Movement of Light

Comparing Light and Sound
Light and Sound have a lot in common but Sound is only a wave. Light also acts like particles. Which properties below are true of light and sound and which are for light only? Tick the box if it's true

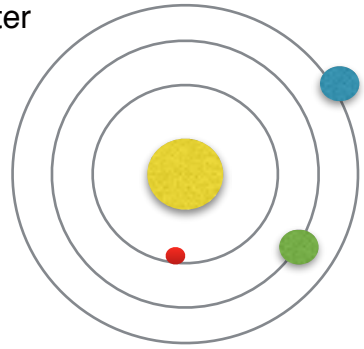
Property	Light	Sound
Travels in straight lines		
Gets weaker as it travels away from the source		
Can go through things		
Can go through itself		
Travels through a vacuum		
Reflects off things		
Bends when medium changes		
Can be focussed to a point by curved shapes.		
Can interfere with itself to cause weak and strong areas.		

Light movement is usually represented as a ray but it also can be thought of as wave fronts moving out from a source like ripples in water.

As the wave fronts grow as they move outward, the energy spreads out and each point on the wave has less energy.



Imagine the source as the sun and earth as one point on the outer wave front and mercury and Venus on the inner wave fronts.
Q, Which planet what get the most intense light?
Q. Explain why energy is not lost as it spreads out even though it appears weaker?



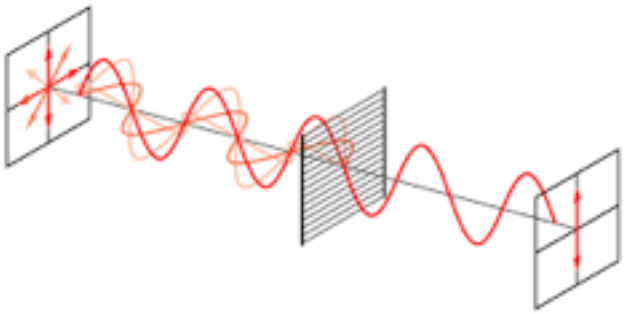
Light waves mix together

The light we have all around us, we call **ambient** light. These are waves that have come from lots of different sources (sun, house lights, TV screens etc.) and can actually weaken each other. Even just light from the sun gets reflected so many times as it moves around that it's no longer the same as it originally was.

When light waves mix together crests can meet troughs and cancel each other out. But what usually happens is that because they are all different amplitudes and orientations they weaken each other as they travel through each other.

Remember the waves are continuous and keep moving undisturbed through air and we only see the light when it shines or reflects on something. A good example of seeing light is when you watch rays coming from a projector shining on the dust in the air at the movie theatre.

Because light is so mixed in its amplitude, wavelength and orientation, we usually only get a watered down version.
Today however scientists and engineers have created intense, coherent, monochromatic light called **LASER** light. The word LASER is an acronym for Light Amplification by Stimulated Emission of Radiation.



How LASER light is made is quite complicated but the basic principle is to produce light that is only one type of frequency and wavelength , to make it stronger by superimposing the waves on top of each other and filtered so that only polarised (one direction) light gets out

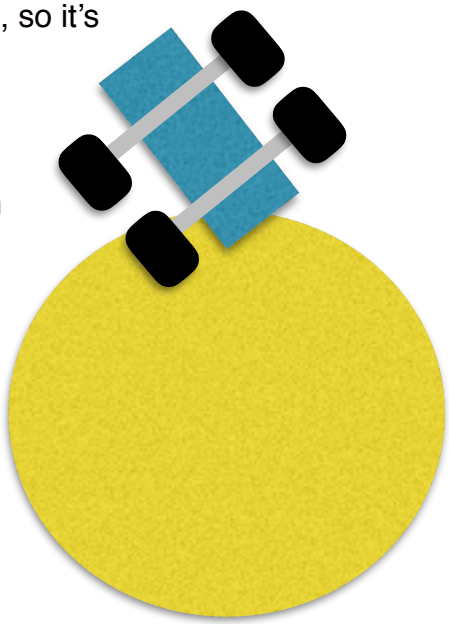
Light hitting a Barrier

Just as Sound waves can do one or more of three things when it hits a barrier, so can Light.
Q. Can you name them?

1. Go straight through
2. Refracted.
3. Reflect
4. Be absorbed.

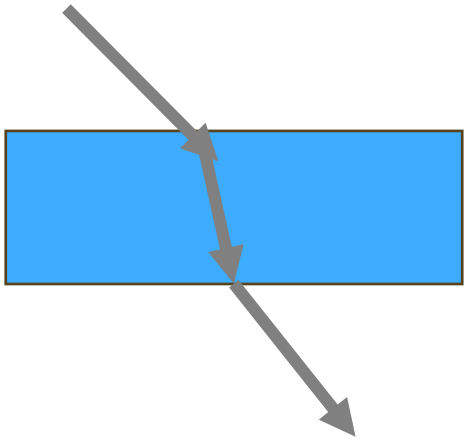
Refraction
Materials that light can go straight through are called **transparent.**
Q. What does **opaque** and **translucent** mean in regards materials and light?

When light goes through different materials it does change. The speed and wavelength changes. The maximum speed of light is a constant value is 300 million meters per second and this is the speed in the vacuum of space. In air, water and glass it slows down. It actually goes slower the more dense the material.
This means for glass it goes about 200 million metres per second, so it's still scooting along faster than you or I could catch it.

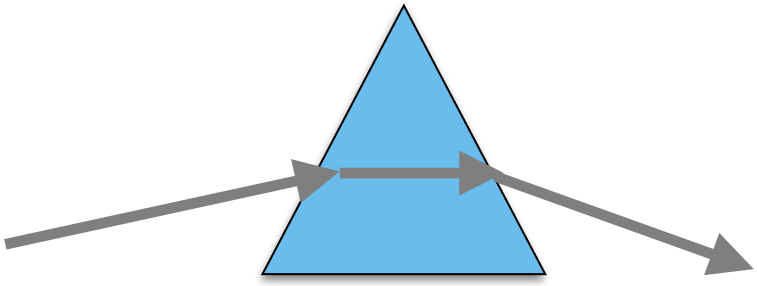


One interesting feature about waves and particles that slow down when they go through something; is that if they don't hit head on, they turn.
For light this is called refraction or bending.
Example:
What happens to a Go Kart if it hits a sand bog shown in the diagram? Why?
Waves do the same.

So light bends when it hits a transparent medium like glass.
Bending inwards into glass and outwards into air.

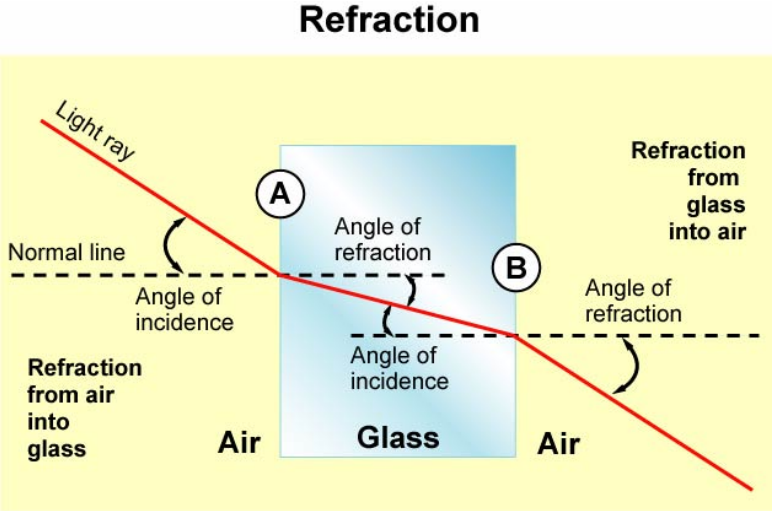


Emerges parallel with rectangles

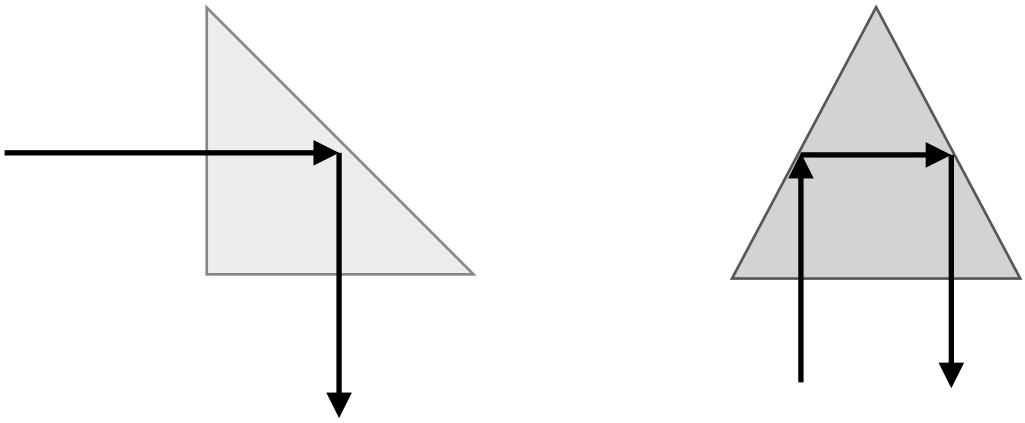


Emerges around the wide base with triangles

The amount of bending depends on the density of the material and the angle of incidence.
If it's more dense, the angle of refraction is smaller than the angle of incidence



Total Internal Reflection
It is even possible for the light, instead of emerging from the glass to be totally internal reflected if the angle is too big.



Note:
1. Light doesn't bend if it hits the surface at right angles.
2. It only gets totally internally reflected when its supposed to emerge from the glass at a large angle.

Research the use of Total Internal Reflection in one of the following and report to class:
1. *Prismatic binoculars or cameras.*
2. *Fibre Optics*
3. *Diamond brilliance.*

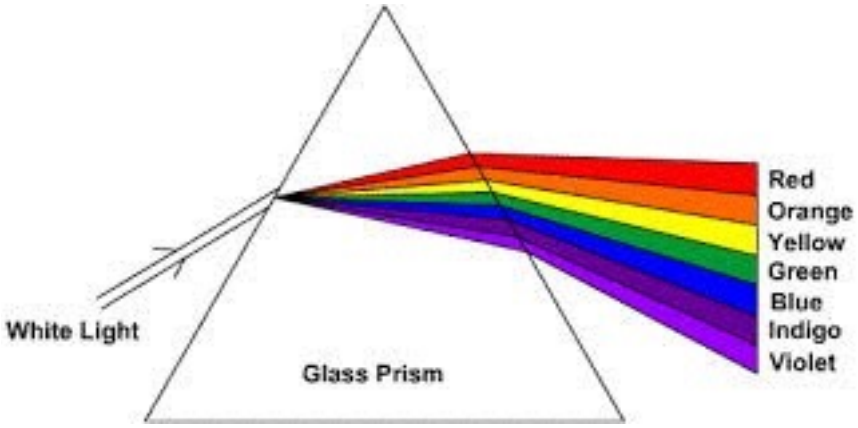
Dispersion and colour.
The amount of bending of light not only depends on the density of the medium but also the type of light wave. Small wavelengths bend more than long wavelengths.

White light from the sun is a mixture of colours. Traditionally we have split the visible spectrum into seven colours called the rainbow.

Red Orange Yellow Green Blue Indigo Violet (ROYGBIV)

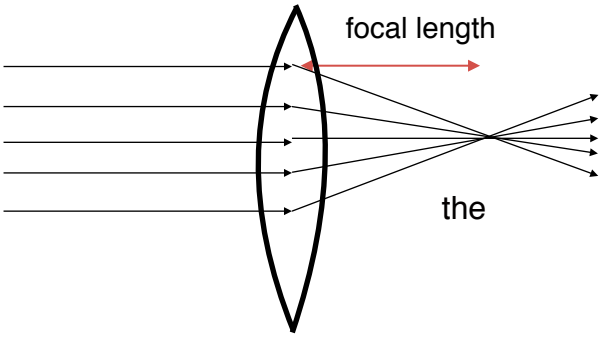
Long waves ⟷ Short Waves

So refraction splits white light up into its's colours. This is called **Dispersion.**
This can be seen in bending through a triangular prism. Because bending occurs at both surfaces in the same direction amplifying the separation.



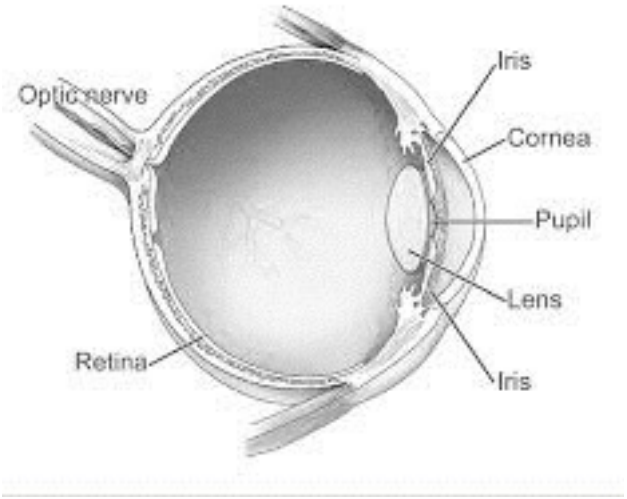
Rainbows in the sky appear after rain because water droplets act as tiny triangular prisms dispersing the light to our eyes.

Lenses
An optical convex lens bends light so that it is focussed to a point. These lenses are curved so light bends more at the edges than the middle. The greater the curve the shorter the focal length.



A convex lens can make images that can be focussed onto a screen. These can be:

- Small Images as in a camera or even our eyes which have a flexible convex lens projecting images onto the retina screen in the back of of our eyeball.
- Large Images projected onto a screen by a data or movie projector.



If the lens is brought very close to an object, a larger image can also be focussed but not onto a screen, only with our eyes. Lenses used for this are called magnifying glasses.

Of course the greatest application of lenses today is for spectacles or eye glasses. When you get to a certain age, wearing glasses becomes a necessity especially for reading.

Glasses however can be made for shortsighted and longsighted people and every other sight dysfunction in between.

Optical Research Questions to choose from:

1. *What is the difference between a convex and concave lens?*
2. *What is the difference between real and virtual images?*
3. *What is the difference between short and longsightedness?*
4. *How is an image focussed using lenses?*

Do Activity 9.8 Investigating Refraction