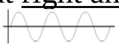
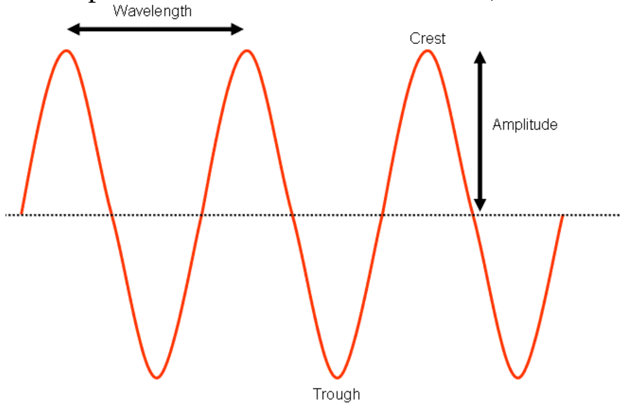
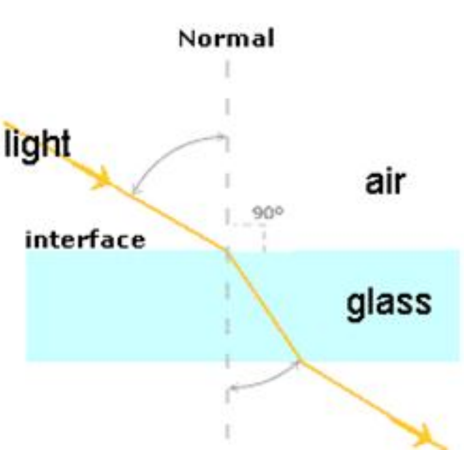
Topic 1 – Visible light and the Solar System

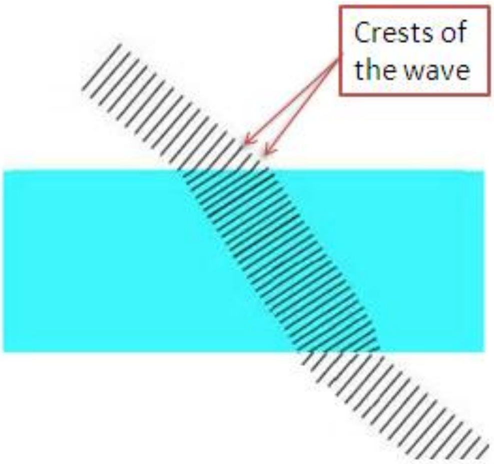
- **SOLAR SYSTEM**
- **History:**
- The early Greek astronomer Ptolemy thought the Earth was in the centre of everything, with the Sun and the planets circling (moving in orbits) around it – the geocentric model
- Over 1000 years later, the Polish astronomer Nicolaus Copernicus suggested a different model in which the Sun is at the centre of the Solar System, and the Earth and other planets orbit around it – the heliocentric model (note that the model also shows that the moon orbits round the Earth)
- The telescope was invented at the end of the 16th Century, allowing scientists to see objects in space in much greater detail than with the naked eye…
- Galileo Galilei utilised the telescope to discover four of Jupiter's moons:
    - He plotted the movements of the four moons and found they orbited round Jupiter, and NOT round the Earth
    - This led him to support Copernicus's heliocentric model of the Solar System (and reject Ptolemy's geocentric model)
- As telescopes improved, more and more discoveries were made, including the planets Uranus and Neptune and the dwarf planet Pluto
- The heliocentric model's principal idea of planets orbiting round the sun is accepted today, but we now know that the orbits are ellipitical (oval) rather than circular
- **WAVES**
- Luminous objects in space give out visible light that travels as waves of energy
- Many objects in space don't give out much visible light but give out other types of energy-carrying waves, like radio waves and microwaves
- **Transverse waves – e.g electromagnetic waves, sea waves:**
- Waves in which particles vibrate at right angles to the direction that the wave is going are called transverse waves 
- Transverse waves do not need a medium in which to travel (→can travel through space) – e.g electromagnetic waves (visible light, radio waves, microwaves – see topic 2)
- Sea waves are also examples of transverse waves...
    - When waves hit a cliff/shore, energy is transferred→wearing cliff away
    - This happens without transferring matter (i.e water particles move up and down as the wave passes…they aren't carried to the shore)
        - Note: this is true for longitudinal waves as well
- **Longitudinal waves - e.g sound waves:**
- Sound waves are not transverse – they are longitudinal:
    - In a sound wave, the particles vibrate back and forth in parallel with the direction that the wave is going, forming areas where air particles are spread out and areas where they are pushed together 
    - Longitudinal waves need a medium in which to travel, which is why sound cannot travel through a vacuum (i.e can't travel in space)
- **Seismic waves (see topic 4 for more details):**
- Earthquakes and explosions produce seismic waves that travel through the earth:

- Seismic waves can be either longitudinal or transverse (see topic 4 for more details on this)…:
  - Longitudinal - rock material is pushed and pulled
  - Transverse - rock material is moved up and down or side to side
- **Properties of waves:**
- Frequency:
  - This is the number of waves passing a point each second
  - Measured in Hertz (Hz). 1 Hz means 1 wave passing per second
- Wavelength: distance from a point on one wave to the same point on the next wave (measured in metres)
- Amplitude: maximum distance of a point on the wave from its rest position (measured in metres)
- The top of the wave is called the crest, the bottom the trough

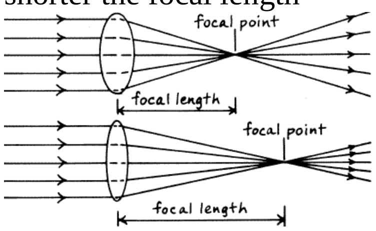


- **Wave speed:**
- The wave speed refers to how fast the energy in a wave travels
- **<u>1.</u>** Wave speed (metre/second, m/s) = distance (metre, m) / time (second, s)
  - E.g a wave carries a surfer 52 metres in 8 seconds...→wave speed =52/8 = 6.5 m/s
- **<u>2.</u>** Wave speed is also linked to the wave frequency and wavelength…
  - Wave speed (m/s) = frequency (Hz) x wavelength (m)
  - E.g if waves of 13m wavelength have a frequency of 0.5 Hz…
  - →Wave speed = 0.5 x 13 = 6.5 m/s
- **TELESCOPES**
- Different types of telescopes are used today to detect these 3 different types of waves (visible light, radio waves, microwaves)
- The data collected helps scientists make conclusions about our Universe
- Also, the invention of photography has allowed astronomers to make more detailed observations than they could by just making drawings
- **REFRACTION**
- Light travels in straight lines, however it can change direction when it moves into a different material (e.g from air into water)
- This is called refraction and happens at the boundary (‘interface’) between two materials (‘mediums’)
- The ‘normal’ line is at a right angle to the interface



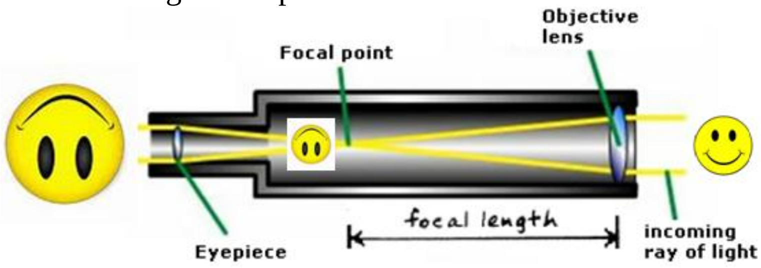


- **Why does refraction occur?**
- Refraction occurs because light travels at different speeds in different mediums – fastest through air, slower through glass and water
- When moving from air to water/glass (or from deep water to shallow water), light slows down...
  - 1. →refracts towards the normal
  - 2. The wavelength of the wave also decreases (diagram on the right – lines are closer together in glass)
  - Note: the amplitude and frequency of the light wave does not change
- When moving from water/glass to air (or from shallow water to deep water), light speeds up...
  - 1. →refracts away from the normal
  - 2. The wavelength of the wave also increases (diagram on the right – lines are further apart in air)
  - Note: the amplitude and frequency of the light wave does not change
- **REFRACTING TELESCOPES**
- A lens is a transparent block capable of changing the directions of parallel light waves
- Convex lenses:
  - Curved on both sides→are thicker/fatter in the middle
  - Converge light rays (i.e brings them together)→focusing them onto a 'focal point'
  - The distance between the focal point and the lens is called the focal length of the lens
  - The thicker the lens, the greater the converging power of the lens→the shorter the focal length

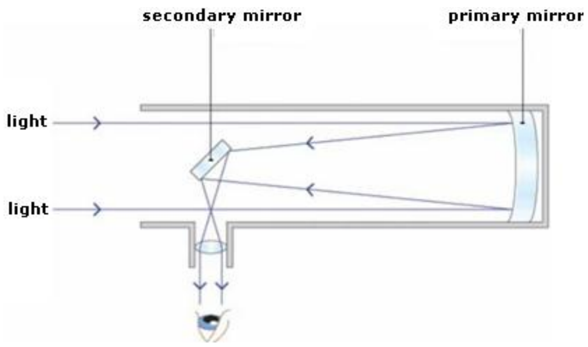


  - The focal length of a convex lens can be found by focusing the image of a distant object onto a piece of paper and measuring the distance from the paper to the lens

- In a refracting telescope...:



  - Light rays pass through a convex lens known as the objective lens, focusing the image (at the 'focal point') inside the tube
    - The image formed inside the microscope is smaller (than the original object) and is upside down
  - Another lens known as the eyepiece lens is used to magnify this image (i.e make it bigger...note the image is still upside down – not a problem when viewing space)
- **PROBLEMS OF REFRACTING TELESCOPES**
- 1. When light waves reach a boundary between two different materials, not all the light refracts and passes through the material. Some is reflected (bounces back)…:
  - →Whenever light passes through a lens, some is reflected→making the image fainter
- 2. Refracting telescopes need to be very long to have large magnifications (i.e to make the object many times bigger)
  - Large lenses can be used to improve the magnification but they're heavy and are difficult to make into perfect shape→images have distorted colours
- These problems of refracting telescopes are overcome by reflecting telescopes…
- **REFLECTING TELESCOPES**



- **How they work:**
  - Reflecting telescopes use two mirrors to focus the light rays
  - When parallel light rays hit the curved primary mirror they reflect back into the tube (no refraction) where they hit a flat secondary mirror
  - The image is subsequently focused inside the tube
  - The eyepiece lens then magnifies the image
- **Comparison with refracting telescopes:**
  - The concept of focusing the image inside tube and then magnifying it using the eyepiece lens is the same as in the refracting telescope
  - However, the use of two mirrors instead of an objective lens means the image is less faint (because rays are reflected back into the telescope, they're not lost) and allows the telescope to be smaller
  - →Reflecting telescopes are mostly used nowadays because of the need to view very faint, distant stars