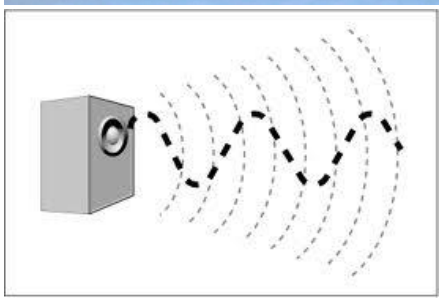
IGCSE MY NOTES

Chapter 3 Properties of Waves, Including Light and Sound

Prepared by: Chern Jiek Lee

3.1 What is a Wave?

Tick below which you think are waves.



Transverse waves: Particles vibrate perp*endicular/ along* the lines of motion and consists of a series of "peaks" and "valleys".

Longitudinal waves: Particles vibrate perp*endicular/ along* the lines of motion and consists of a series of compression and expansion.

Revision:

1kHz = _____Hz
1MHz = _____Hz
1GHz = _____Hz

Question 1:

If a wave starts from 0 meters and then moves up and down sinusoidally 5 times in 1 second. What is the period of the wave? What is the frequency of the wave? *Hint: Draw the wave out first!*

Ans:

Wave Language

Amplitude, *A*: The maximum displacement from the original position. The SI unit for amplitude is in meters.

Wavelength, λ: The horizontal distance between two points that are in phase. The SI unit for amplitude is in _____.

Period, *T*: Time taken for the wave to complete a cycle or return to its original displacement. The SI unit for periods is seconds.

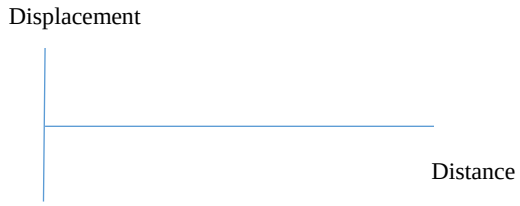
Frequency, *f*: The number of complete cycle's in a second (How many times did the wave go up, down and up again or down, up, and down again in 1 second). The SI unit for frequency is hertz (Hz) OR seconds^{-1}.

Hence, relationship between **frequency** and **period** is

$$f = \frac{1}{T}$$

How to "Draw" Waves and What Information can We Derive from Them

Graph 1 Displacement-Distance



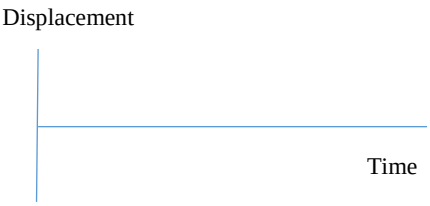
Can we find the period of the wave from the D-D graph directly?

_____

Can we find the wavelength of the wave from the D-T graph directly?

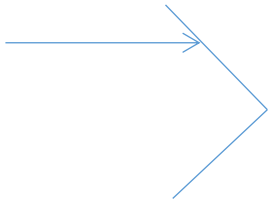
_____

Graph 2 Displacement-Time



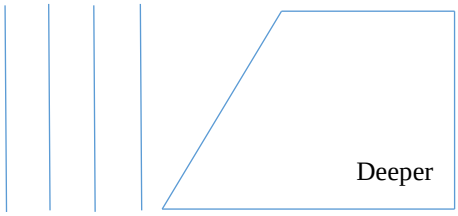
A wave can undergo this 3 phenomena:
Reflection, Refraction, Diffraction

Reflection: Change of direction when it collides with a reflective barrier.

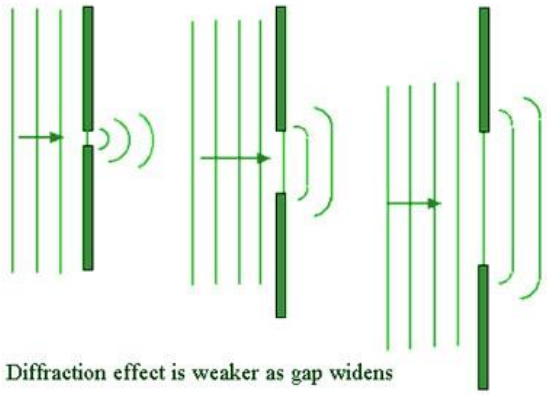


Refraction: Change of direction when it goes through a change of medium. Eg. Water waves change direction when there is a change in the speed of the water. The speed of the water changes when there is a change in the depth of the water. From deep to shallow waters the wave's speed *increases/ decreases* as the wavelength becomes shorter. From shallow to deep waters the wave's speed *increases/ decreases* as the wavelength becomes longer (*Hint: recall* $v = f\lambda$). Refraction occurs when the direction of motion is *not perpendicular* to border between the deep and shallow regions. Eg. tsunami

Hint: *1) Draw a line representing the direction of the wave propagation.*
2) Draw the normal line.



Diffraction: Spreads when it passes through an opening or an edge. Diffraction increases when the size of the gap decreases or the wavelength of the waves increases. Eg. Sea coves



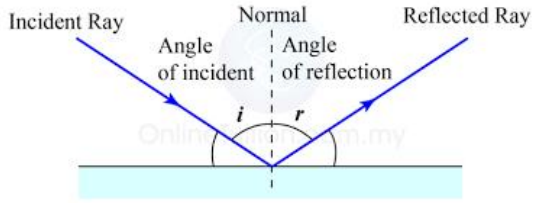
Wave equation:

Speed (m/s) = Frequency (Hz) x Wavelength (m)
v = f x λ

3.2 Light

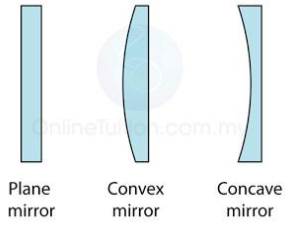
Light is a wave because it undergoes the same 3 phenomenon that waves go through

Reflection

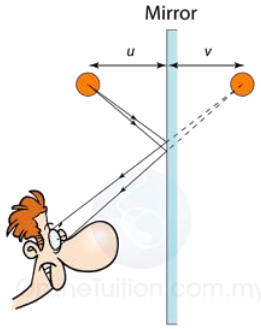


$i = r$

Types of mirror



Reflection in plane mirror

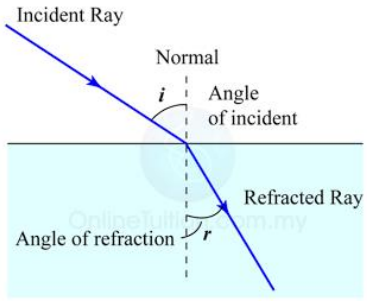


The image form is

1) Upright
2) Virtual
3) Laterally inverted
4) Same size as object

Refraction

Refraction is the bending of light ray at the boundary of two medium as the light ray propagates from a medium to another with different density.



When light passes through a medium which is denser

$$i > r$$

When light passes through a medium which is less dense

$$i < r$$

Snell's law states that the value of (sin i) / (sin r) is constant for light passing from one given medium into another

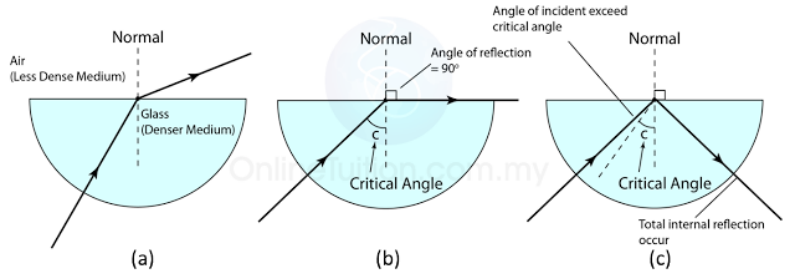
$$\frac{\sin i}{\sin r} = constant, n$$

Here *n* is the refractive index. Remember that *n>1*
Another equation for refractive index is

$$Refractive\ index, n = \frac{speed\ of\ light\ in\ vacuum}{speed\ of\ light\ in\ medium} = \frac{c}{v}$$

Note: The greater the refractive index, the denser is the medium. Hence, the speed of light in the medium will be slower.

Total internal reflection and the critical angle



Where

$$n = \frac{1}{\sin c}$$

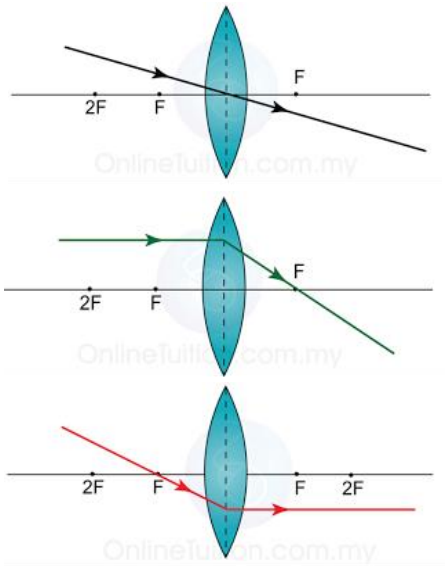
Note: The light ray must propagate from an optically denser medium to an optically less dense medium. The angle of incident must exceed the critical angle.

Some phenomenon related to internal reflection and the critical angle

1) Mirage
2) Rainbow

Converging lens (convex lens)

There are 3 rules for drawing ray diagram for convex lens



Note: The characteristics of the image form using a convex lens is always either virtual or real; upright or inverted; magnify or diminish. DO NOT memorize the characteristics for different object positions. Try to use the 3 rules and draw them out!!!!

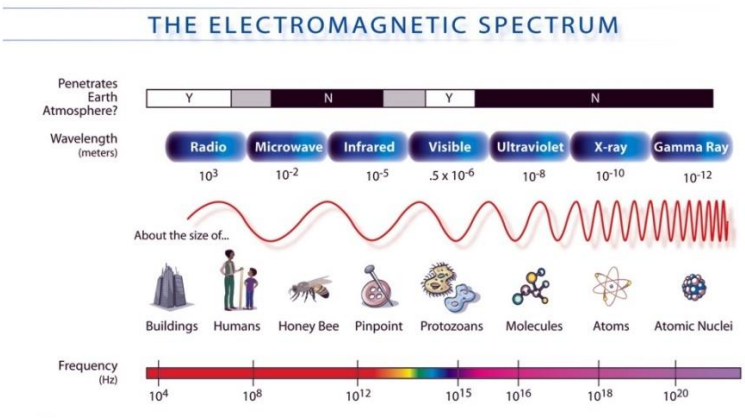
Dispersion of light

Refraction by a prism: When light is refracted by a prism, the incidence ray is not parallel to the emergent ray, since the prism's sides are not parallel. If a beam of white light is passed through a prism it is **dispersed** into a **spectrum**. White light is a mixture of colours, and the prism refracts each colour by a different amount – red is deviated the least and violet the most.

Electromagnetic Waves

Electromagnetic waves are transverse waves. It consists of electric field and magnetic field components. It can propagate without the need of a medium to carry them unlike mechanical waves. The speed that electromagnetic waves travel at is $3x10^8$ ms^{-1}. If this number seems familiar it's because that's the speed of light. Light is a wave or more specifically an

electromagnetic wave. There are 7 types of waves in the electromagnetic spectrum.

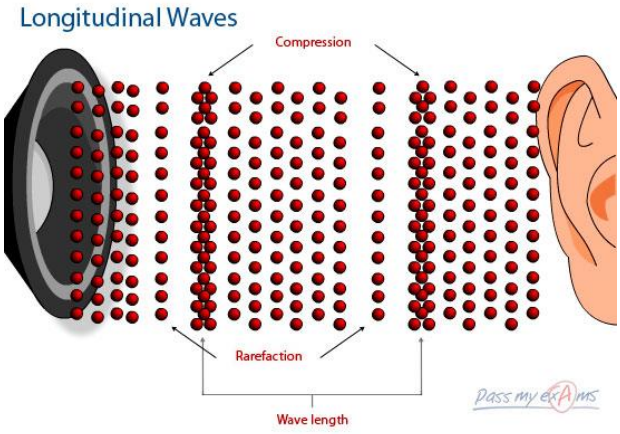


Mnemonic time!

R M I V U X G

3.3 Sound

Sound waves are mechanical waves as they require a medium to propagate through. Another example of mechanical waves is water waves and a slinky. Sound waves travel through solid, liquid and gas by "passing along" the vibration from one particle to the next. Hence, sound travels fastest through _____, then ___ _____ and finally through _____



Difference between pitch and loudness:

Pitch: Is related to the frequency of the sound. The greater the frequency, the higher the pitch. Human vocal range is between 80 Hz to 1100 Hz. Soprano singers would be in the higher range of frequency while bass singer would be on the lower! Sound waves less than 20 Hz are known as infrasound while those above 20 kHz are known as ultrasound.

Loudness: Is related to the amplitude of the sound. The bigger the amplitude the louder the sound.

Speed of sound is highest in solids (concrete: 5000m/s) then in liquids (pure water: 1400m/s) and slowest in gases (**air: 330m/s**)