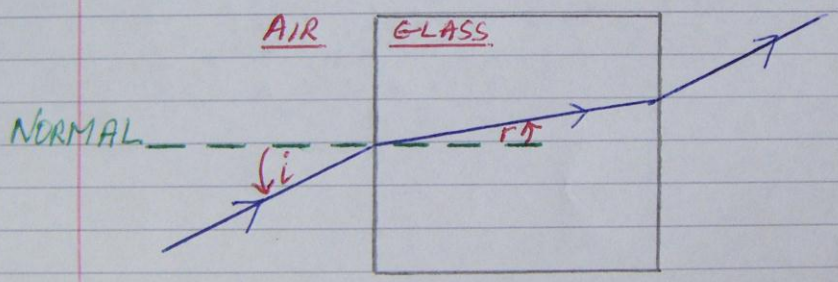
CfE LIGHT – BMcMULLEN

Refraction – This is the change in the speed of light of a wave if it passes from one medium to another.

eg Air → Water, Air → Glass, Water → Glass, Air → Diamond etc

- When light passes from air into glass its speed reduces from $3 \times 10^8 ms^{-1}$ to $2 \times 10^8 ms^{-1}$. This change in speed defines refraction.



- When light passes from air into glass or any other medium, it will bend towards the normal.

ie $i > r$

Less dense to more dense medium.

Where angle of incidence > angle of refraction.

- The rays of light entering and leaving the block are parallel.

Lenses

The two types of Lens that we will look at are:

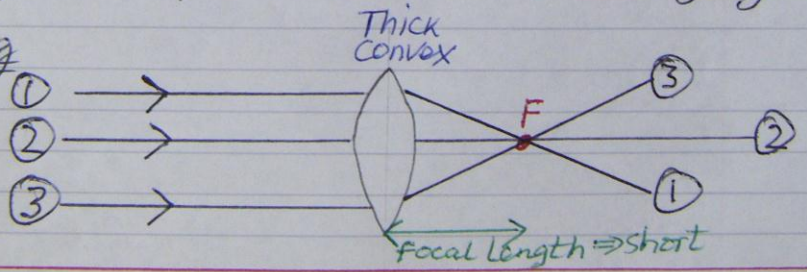
- Convex Lens (Converging Lens)
- Concave Lens (Diverging Lens)

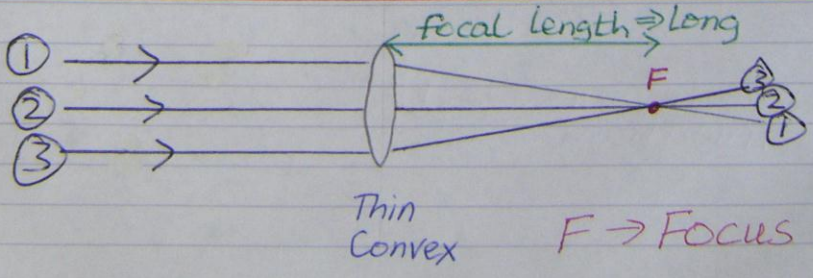
• Convex Lenses

This type of Lens is shaped like a rugby ball.

- When parallel light passes through a convex lens the light will converge (come together) at a point. This is why this type of lens is often referred to as a converging lens.

eg





Thin Convex

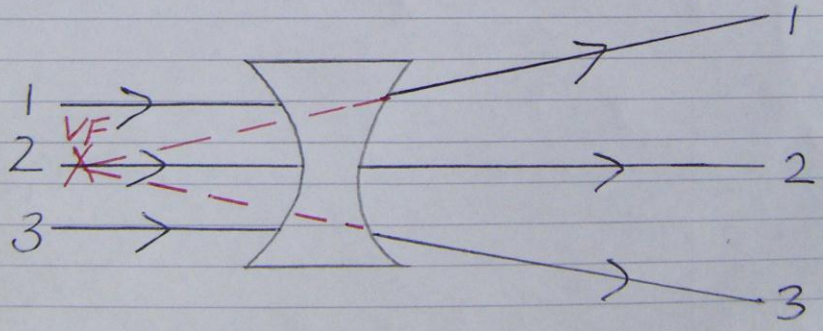
F → Focus

- The focal length of a convex lens is measured from the centre of the lens to the focal point F, where the rays of light meet.
- The thicker convex lens (more powerful) has a smaller focal length than the thinner convex lens.

Concave Lenses

- Concave lenses curve inwards like a cave.
- When parallel light passes through a concave lens the light will diverge (move apart).
  This is why this type of lens is often referred to as a diverging lens.

eg



VF ⇒ Virtual Focus.

- There is no focus point with a concave lens though a virtual focus can be achieved.
  This can be shown in the diagram above.

The Human Eye

Visible light is detected by our eyes.

The visible light detected then passes through our eyes until a signal finally reaches the brain.

The order of passage of the light is:

CORNEA
PUPIL
LENS
RETINA
OPTIC NERVE
BRAIN

CPL ROB

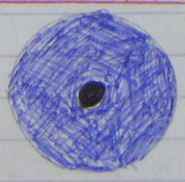
*NB The IRIS which is the coloured area of the eye is not mentioned in the line up above.

Why?

Light does not pass through the IRIS. The Iris surrounds the pupil.

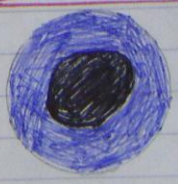
eg

IN BRIGHT LIGHT



SMALL PUPIL
∴ LARGE IRIS

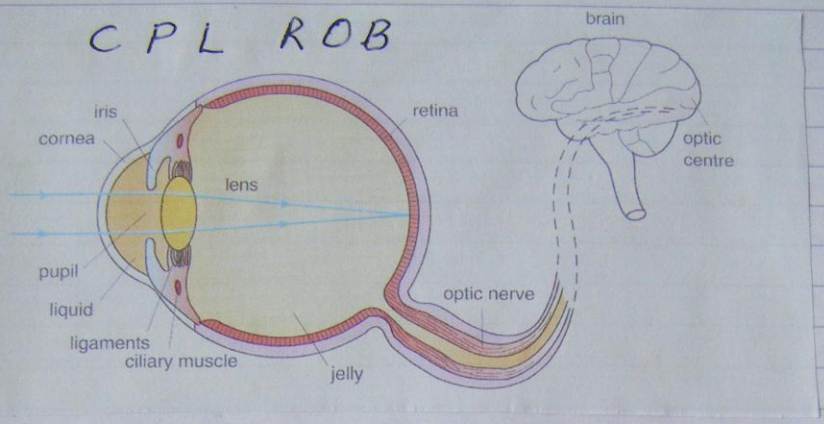
IN THE DARK.



LARGE PUPIL
∴ SMALL IRIS

KEY
BLUE – IRIS BLACK-PUPIL

C P L ROB



- **C – Cornea**
  This is the outer part of the eye and acts like a cling film cover so that dust and grime cannot enter.

- **P – Pupil**
  This is the hole in the middle of the Iris which allows light to enter the eye.

- **L – Lens (convex)**
  The convex lens focuses the light on to the Retina. (glasses or contacts are required in addition if a sight defect exists)

- **R – Retina**
  This is the screen of an eye where an image is focussed.

- **O – Optic Nerve**
  This is the nerve that transmits visual information from the retina to the Brain using electrical pulses.

- B – Brain

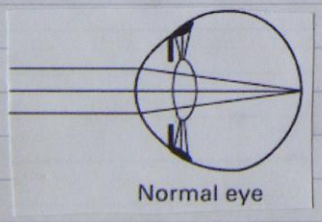
The Brain is used to turn the upside down image from the Retina the 'right way up'. This also involves an energy change from Electrical Energy to Light Energy.

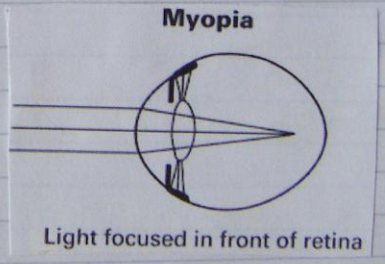
Sight Defects

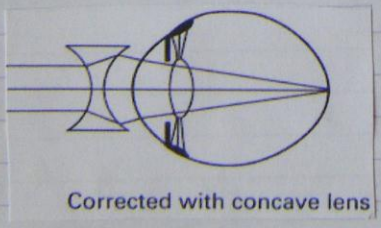
Short and long sight are caused by a failure in the eyes convex lens to focus light on the Retina.

1) Short Sight (Myopia)

- The rays of light focus short of the Retina.
- This can be overcome by wearing concave lenses in glasses or contact lenses.





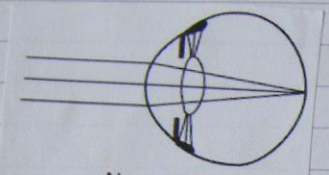


Remember the phrase:

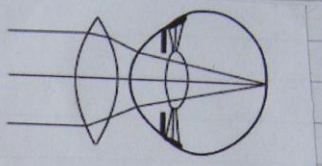
McMullen Lives in a Cave as he is Short Sighted.

2) Long sight - (Hypermetropia)

- The rays of light focus beyond the Retina.
- This can be overcome by wearing convex lenses in glasses or contact lenses.

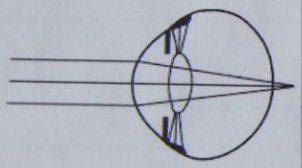


Normal eye



Corrected with convex lens

Hypermetropia



Light focused behind the retina

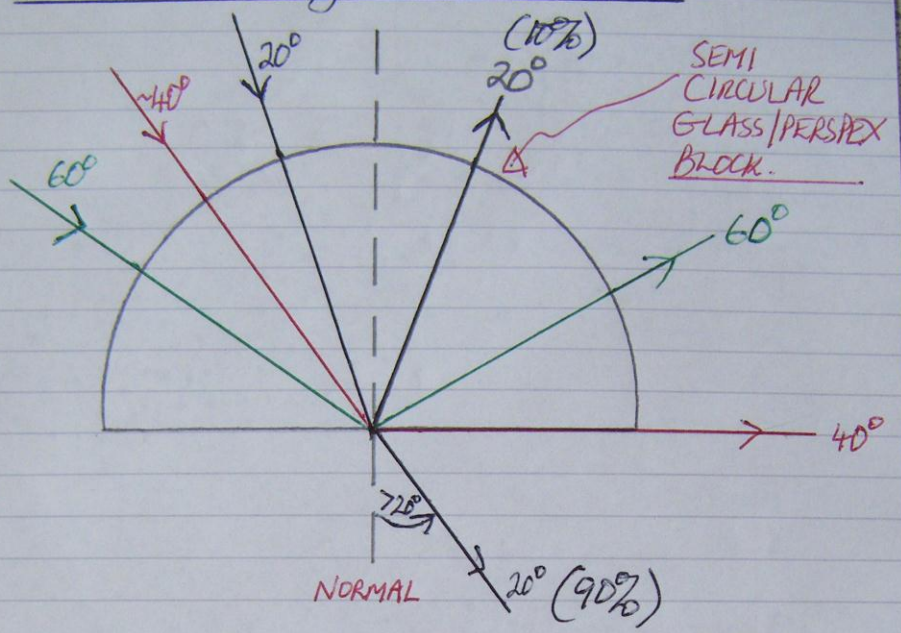
To remember this then just reverse the phrase learned for short-sight.

Conclusion and Summary

- Short sight involves close up objects being clear and sharp, but far away objects appear blurred.
- Short sight is cured with concave lenses.

- Long sight involves far away objects being clear and sharp, but close up objects are blurred.
- Long sight is cured with convex lenses.

Critical angle and T.I.R



- 20° ray in the block

90% of the light Irradiance is refracted out into the air at an angle > 20°.
10% of the light Irradiance is totally internally reflected (T.I.R) inside the block.

- 40° ray in the block.

The light moves through the block and then into the air at 90°.
This is the critical angle of material.

- Critical Angle → The angle of light in a medium which will allow the light to come out into the air at 90°.

Ie light moves along the air/medium boundary

- 60° ray in the block

The angle of the light in the block is now greater than the critical angle of the medium.

The light will be totally internally reflected (T.I.R) inside the medium.

Conclusion and summary

- $\theta_M < \theta_c$

90% of the light Irradiance is refracted, with the remaining 10% reflected.

- $\theta_M = \theta_c$

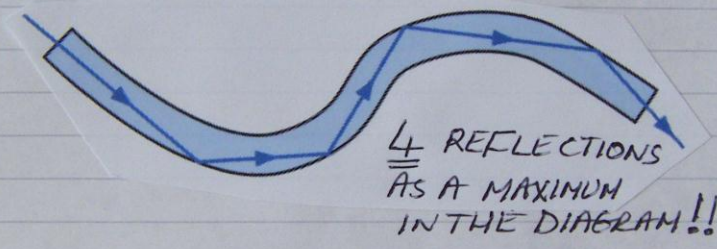
The light will come out of the medium and into the air at 90° ie along the air to medium boundary.

- $\theta_M > \theta_c$

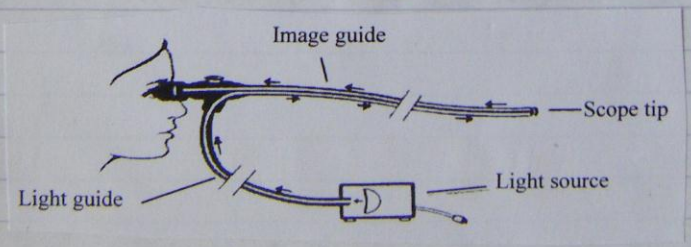
Total Internal Reflection (T.I.R) of light will occur inside the medium.

Applications of Total Internal Reflection (T.I.R)

- An optical fibre is a thin strand of glass.
- Optical fibres transfer visible light from its source by T.I.R.
- Optical fibres are used in the Telecommunications industry and are applied with landline telephones, broadband and TV from Virgin Media.



- In medicine an Endoscope is an instrument used by doctors to examine the inside of a patient without opening them up.



This application uses two bundles of optical fibres: 1) Light Guide 2) Image Guide.

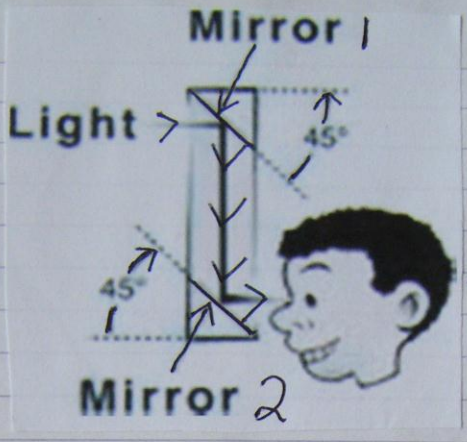
1) Light Guide

This is used to shine light into the patient. As optical fibres can only transfer visible light it is sometimes called 'cold light' as no heat energy is transferred.

2) Image Guide

This allows the doctor to see inside the patient. Each of the thousands of fibres in the bundle transmit light separately and at the tip of the Endoscope the visible light is focussed to produce an image.

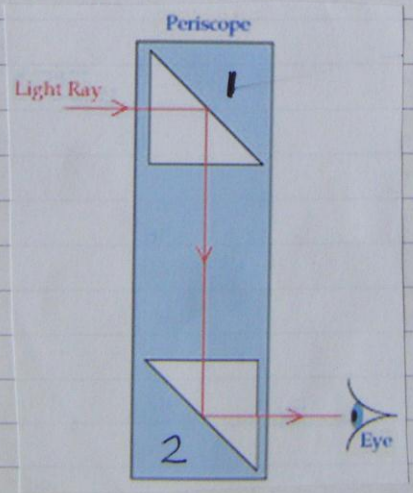
- In submarines, periscopes are used by submariner crews to see objects above the water level, while they are submerged.
- Simple periscopes can be made by using a vertical tube with mirrors placed at a 45° angle at the top and bottom of the tube.
- These devices collect light from an image, and direct that light from the top mirror to the bottom mirror of the periscope.



A very happy LHS Physics Student!!

In submarines the periscopes are designed with two prisms instead of two mirrors. Due to lengths of up to 18 metres the two mirrors would not be sufficient to carry the image from the top to the bottom of the periscope.

The two prisms used are 45° prisms!!



* Light does not bounce, Light reflects!!

The captured light reflects off prism 1 then prism 2 and finally enters the viewers eyes.