Focus 1 – Reflection of Light

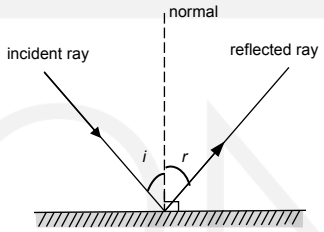
Central Idea / Skill: Visibility and Line of Sight

- Reflection is the bouncing of light as it hits upon a surface.

Laws of Reflection

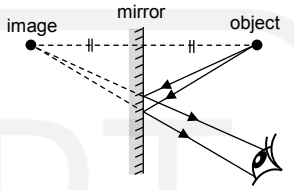
1st Law of Reflection
The incident ray, the reflected ray and the normal to the reflecting surface all lie in the same plane.

2nd Law of Reflection
The angle of incidence *i* is equal to the angle of reflection *r*.



Mirrors

- An image formed in a plane mirror is
  1. laterally inverted,
  2. upright,
  3. at the same distance from the mirror as the object,
  4. the same size as the object,
  5. virtual.



Locating an image formed by a mirror

Focus 2 – Refraction of Light

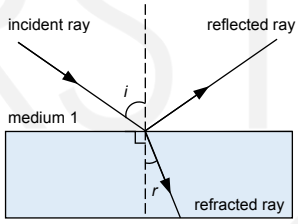
Central Idea / Skill: Change in Speed and Directions of Light Ray in Different Medium

- When a ray of light travels from a transparent medium to another at a certain angle, part of the light will be reflected at the boundary. The rest of the light will bend into the other medium. This bending of light is known as refraction.

Laws of Refraction

1st Law of Refraction
The incident ray, the normal and the refracted ray all lie in the same plane

2nd Law of Refraction (also known as Snell's Law)

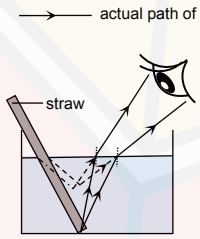


For two particular medium, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant. That is $\frac{\sin i}{\sin r} = \text{constant}$

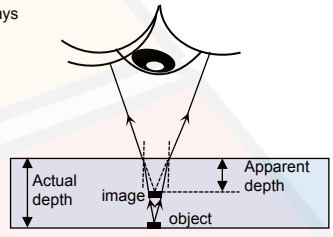
Refractive Index (RI)

- + The refractive index of a medium n is defined as the ratio of speed of light in vacuum c to the speed of light in the medium, v.
- The RI is also equal to the ratio of the sine of angles of ray of light travelling from vacuum into the medium. That is $n = \frac{c}{v} = \frac{\sin i}{\sin r}$.
- The medium with a larger RI is said to be optically denser. As light travels into an optically denser medium, it bends towards the normal.

- For simplicity, the RI of air is taken to be equal to the RI of vacuum i.e. 1. The speed light in air and vacuum are both taken to be 3 x 10^8 m/s.
- Visual effects of refraction



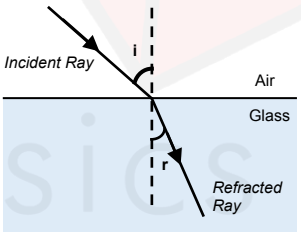
The straw appears bent.

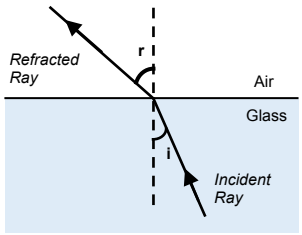


The water appears shallower than it is.

Principle of Reversibility

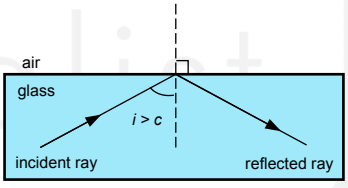
- The principle of reversibility of light states that a ray of light will take the same path if its direction of travel is reversed.



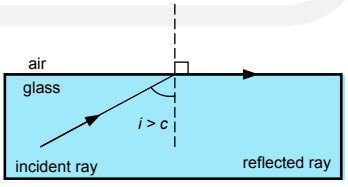


Total Internal Reflection

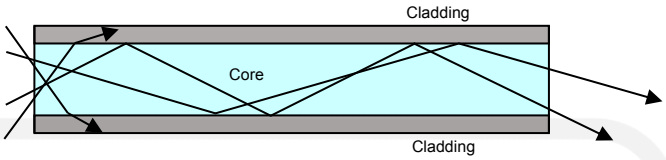
- + The critical angle c is the angle of incidence in an optically denser medium that gives an angle of refraction of 90 ° in the optically less dense medium.
- The relationship between critical angle c and the refractive index n is $\sin c = \frac{1}{n}$



- + Total internal reflection refers to the complete reflection of a light ray incident on an interface with a less dense optical medium when the angle of incidence is greater than the critical angle.
- The following 2 conditions leads to total internal reflection (TIR),
  1. Light is travelling from optically denser medium to optically less dense medium
  2. the angle of incidence i is larger than the critical angle c



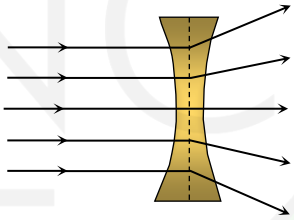
- One application of TIR is optical fibres. Optical fibres are made up of a core of glass or plastic with high RI, coated by another material of lower RI. Light travels along a fibre by total internal reflection at the boundary.
- In the communication industry, optical fibres can carry laser light which carries information such as telephone conversations, computer data and television pictures.
- Advantages of using optical fibres:
  - they can carry light round bends and in places where it would be difficult or dangerous to supply electricity (e.g. under the sea)
  - they can carry information over great distances at high speed.
  - they can carry more information than a copper wire cable.

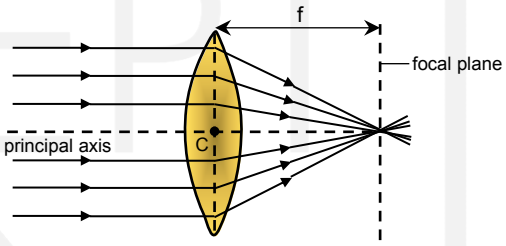


Focus 3 – Refraction by Thin Lenses ***Central Idea / Skill: Relationship between u, v and f***

- A lens is a piece of clear plastic or glass with curved surfaces.

Types of Lenses



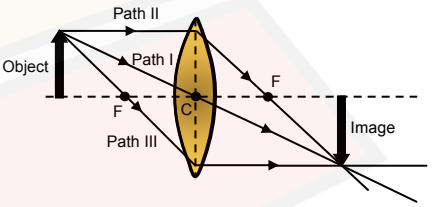


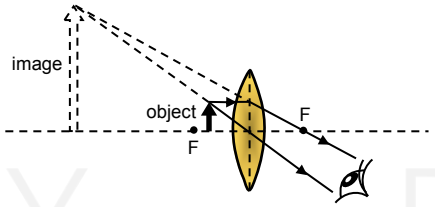
Diverging (Concave) Lens
- A Diverging Lens is thinner in the middle.
- A parallel beam of light that passes through a diverging lens will spread out (diverge).

Converging (Convex) Lens
- A Converging Lens is thicker in the middle.
- A parallel beam of light that pass through converging lens will meet (converge) at a point.
- Terminology:
  - *(a) Optical Center (C) is the center of the lens.*
  - *(b) Principal Axis is a line through the optical center of the lens and is perpendicular to the center of the lens.*
  - *(c) When rays of light are traveling parallel and close to the principal axis pass through the lens, they will all bend and meet at one point on the principal axis. This point is called the principal focus, F.*
  - *(d) + Focal Length (f) is the distance between the principal focus (F) and the optical center (C) of the lens.*

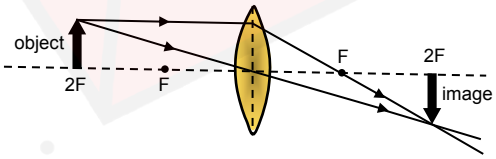
Ray Diagrams for Lenses

Construction Rules for Ray Diagram
Path I - A ray through the optical center will not be deviated.
Path II - A ray parallel to the principal axis is refracted by the lens to pass through F.
Path III - A ray through F is refracted parallel to the principal axis.

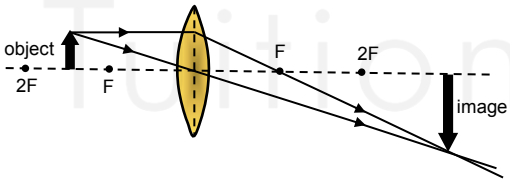




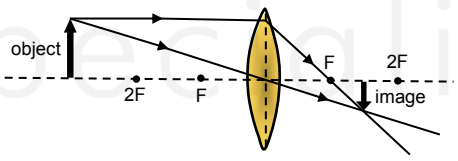
Position of Object	Description	Use
u < F	Image is formed behind the object, same side as the lens. Image formed is enlarged, upright and virtual.	Magnifying Glass



Position of Object	Description	Use
At u = 2F	Image formed at position equals to 2F. Image formed is same-sized, inverted and real.	Photocopier – making equal-sized copies



Position of Object	Description	Use
F < u < 2F	Image is formed at position beyond 2F. Image formed is enlarged, inverted and real.	Projector



Position of Object	Description	Use
u > 2F	Image formed at position between F and 2F. Image formed is diminished, inverted and real.	Camera