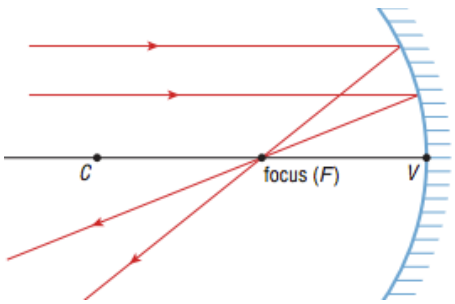
Grade 10 Science

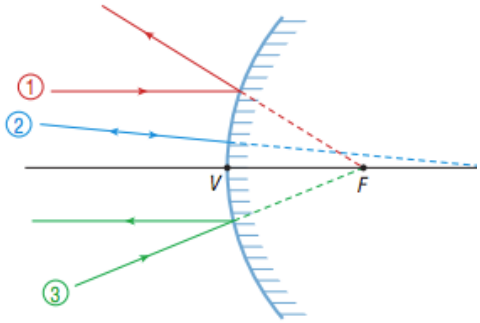
Light and Geometric Optics

Class 11

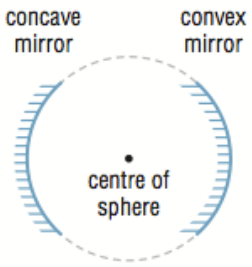
Images in Curved Mirrors

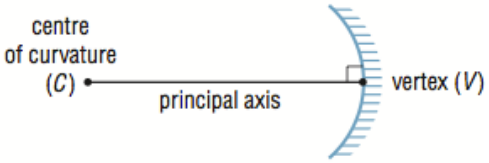
- Concave (converging) mirror – a mirror shaped like the inside of a spoon
- Convex (diverging) mirror – a mirror shaped like the outside of a spoon

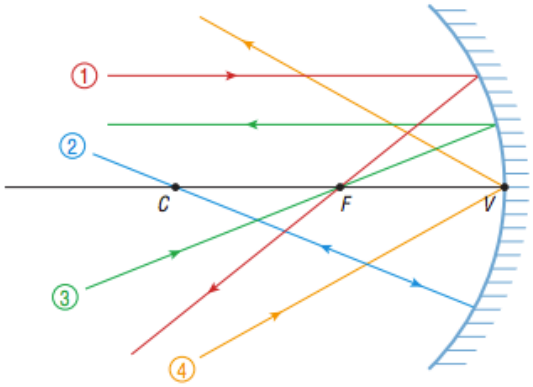




- **Centre of Curvature** – centre of the sphere, labeled as C
- **Principal axis** – the line going through the centre of curvature and the centre of the mirror
- **Vertex** – the point where the principal axis intersects the mirror, labeled V
- **Focus** – where parallel light rays converge



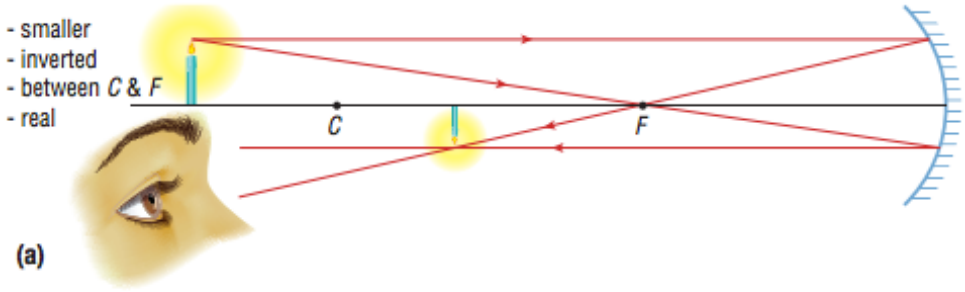




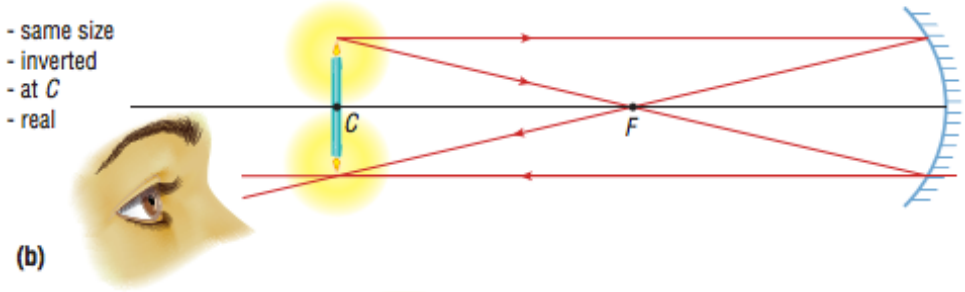
1. A light ray parallel to the principal axis is reflected through the focus. This is how the focus is defined.
2. A light ray through the centre of curvature is reflected back onto itself. This rule makes sense because any line through the centre of curvature is a radius of the circle formed by the mirror. A radius is always at 90° to the mirror. A ray along the normal has an angle of incidence of 0°. This means that the angle of reflection is also 0°. The reflected ray will return back on the same path.
3. A ray through *F* will reflect parallel to the principal axis. This rule uses the fact that the angle of incidence is always equal to the angle of reflection. Even if you switch the incident and reflected rays, the light will still follow the same path; only the direction will change. This principle is called the reversibility of light.
4. A ray aimed at the vertex will follow the law of reflection. Because the principal axis is perpendicular to the surface of the mirror, the angle of incidence can be easily measured.

- Real Image – an image that can be seen on a screen as a result of light rays actually arriving at the image location

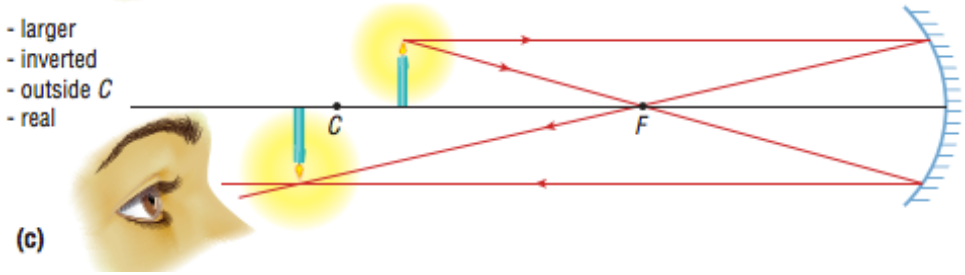
Beyond C



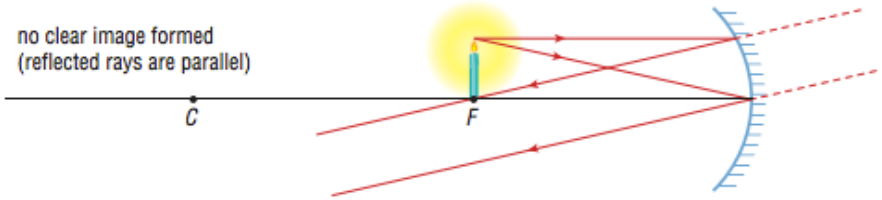
At C



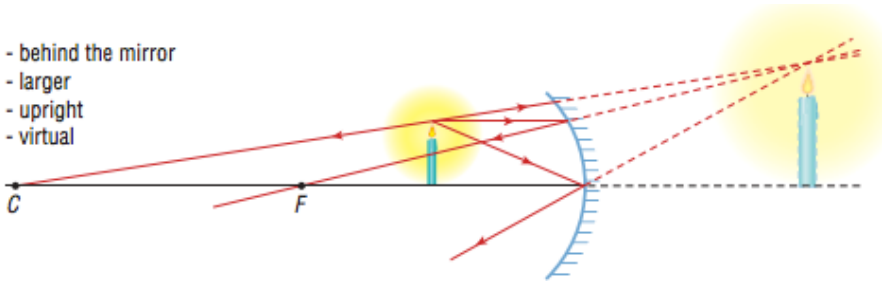
Between C and F



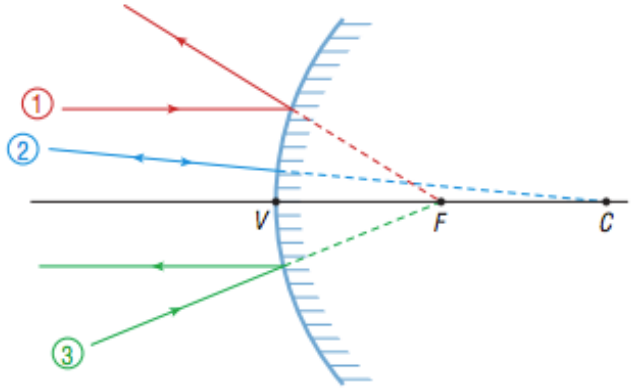
At F



Inside F

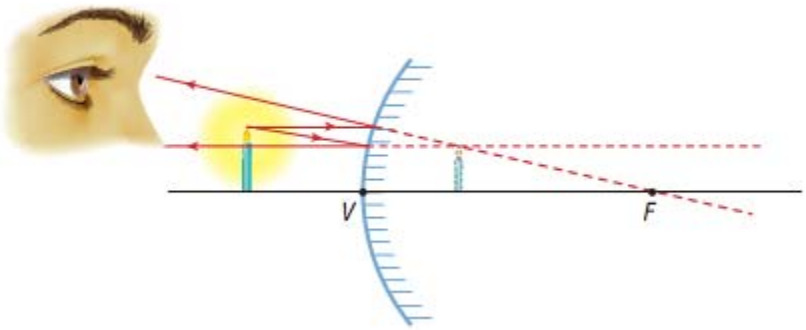


OBJECT	IMAGE			
Location	Size	Attitude	Location	Type
beyond *C*	smaller	inverted	between *C* and *F*	real
at *C*	same size	inverted	at *C*	real
between *C* and *F*	larger	inverted	beyond *C*	real
at *F*	no clear image			
inside *F*	larger	upright	behind mirror	virtual



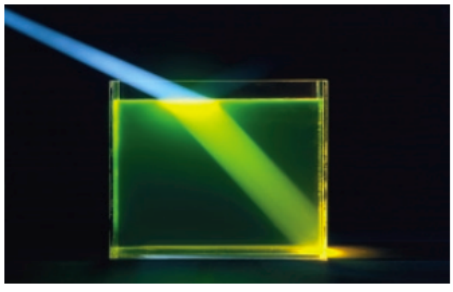
1. A ray parallel to the principal axis is reflected as if it had come through the focus (*F*).
2. A ray aimed at the centre of curvature (*C*) is reflected back upon itself.
3. A ray aimed at the focus (*F*) is reflected parallel to the principal axis.

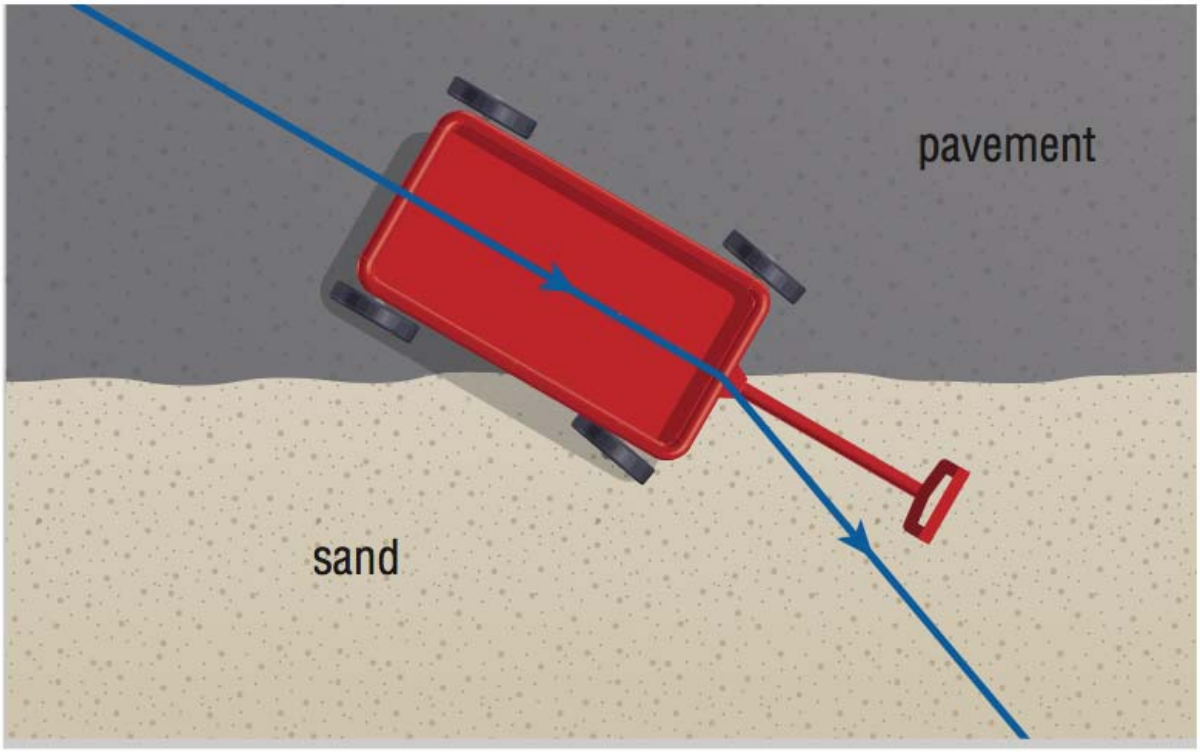
- Smaller
- Upright
- Behind Mirror
- Virtual

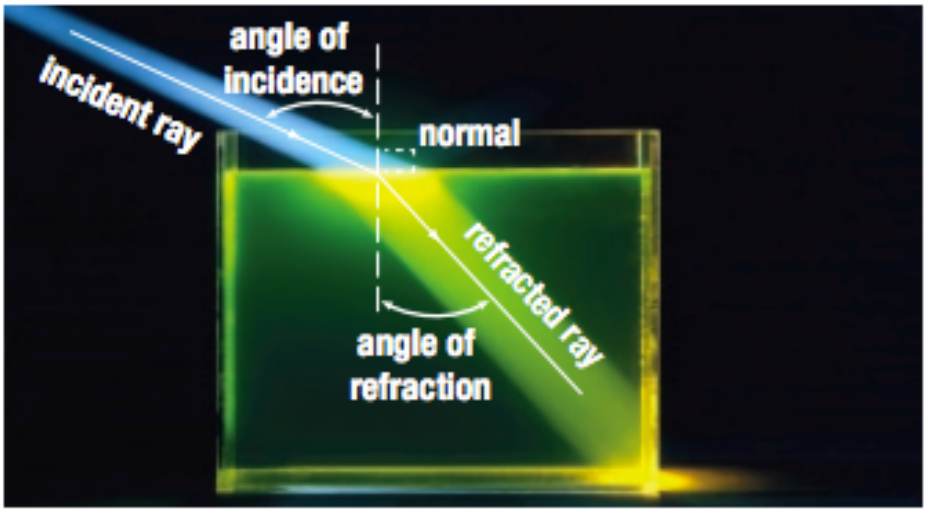


Refraction

- **Refraction** – the bending or change in direction of light when it travels from one medium into another
- Light slows down when it travels in different medium
  - Vacuum = 3.0 x 10^8 m/s (ideal)
  - Water = 2.26 x 10^8 m/s
  - Acrylic = 1.76 x 10^8 m/s







- Light bends towards the normal when the speed of light in the second medium is less than the speed of light in the first medium
- Light bends away from the normal when the speed of light in the second medium is greater

The Index of Refraction

- The speed of light is different for each medium but it is always less than the speed of light in a vacuum
- Index of refraction (n) = c/v
  - c = speed of light in vacuum
  - v = speed of light in the medium
- Index of refraction (n) = $\sin\theta_i/\sin\theta_R$
  - θ_i = angle of incidence
  - θ_R = angle of refraction

Checkpoint

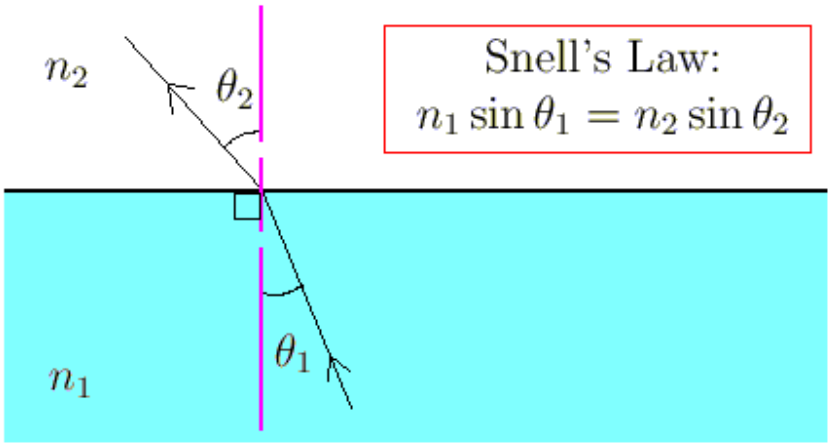
Medium	Index of refraction (*n*)
air/vacuum	1.00
ice	1.31
pure water	1.33
ethyl alcohol	1.36
quartz	1.46
vegetable oil	1.47
olive oil	1.48
acrylic	1.49
glass	1.52
zircon	1.92
diamond	2.42

a) The speed of light in NaCl is 1.96×10^8 m/s. Calculate the index of refraction for NaCl.

b) Calculate the speed of light in olive oil

Snell's Law

- Used to find the indices of refraction OR the angle of refraction



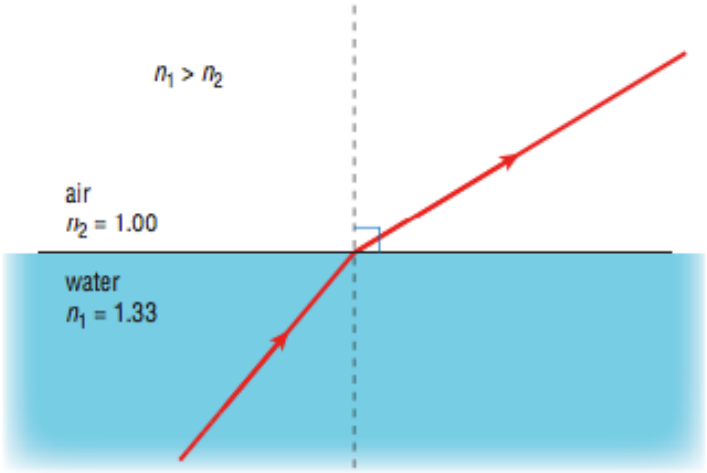
Checkpoint

a) A ray of light is passing from air (n=1.00) to water (n=1.33) at an angle of incidence of 45°, calculate the angle of refraction.

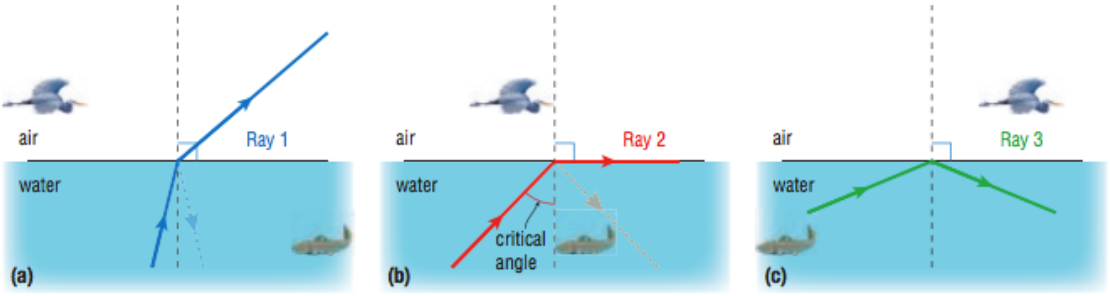
a) You have an unknown medium. You pass a ray of light from air (n=1.00) to the medium at an angle of incidence of 52° and find that the angle of refraction is 35.4°. What is the unknown medium?

Total Internal Reflection

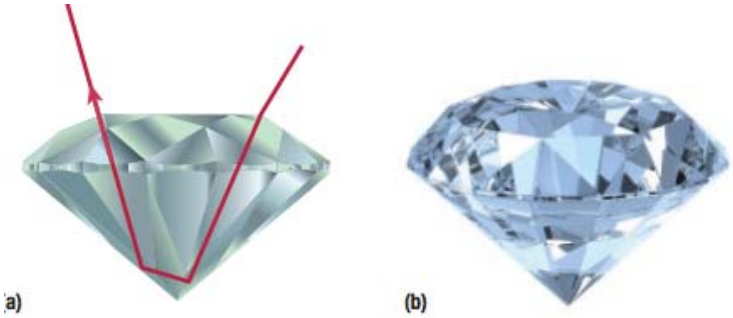
- Critical Angle = the angle of incidence that produces a refracted angle of 90°

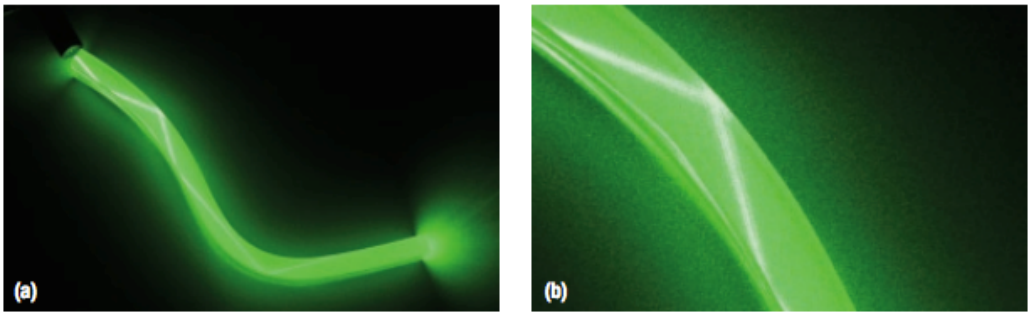


- When you increase the angle of incidence past the critical angle, the refracted ray will no longer exit the medium but will reflect back instead
- Total Internal Reflection Occurs when:
  1. Light is travelling more slowly in the first medium than in the second
  2. The angle of incidence is large enough that no refraction occurs in the second medium.
- Water has a critical angle of 48.8°



- The sparkle in diamonds is due to the total internal reflection of the light inside the diamond

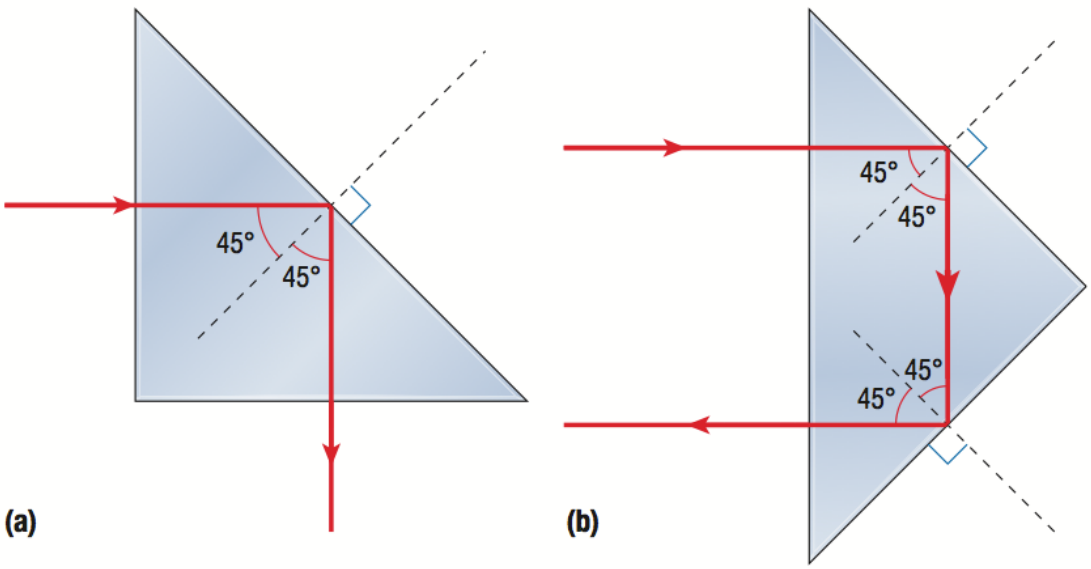




- Fibre Optics must transmit information using light so the cable must have a small critical angle
- Prisms are also objects that can undergo total internal reflection

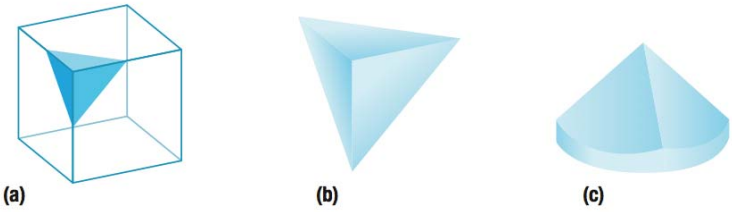
Triangular Prisms

- Critical angle for glass is 41.1°
- If angle of incidence is greater than 41.1°, total internal reflection will result
- Prisms reflect better than mirrors since mirrors absorb some light and the silvered surface of the mirror deteriorates over time
- Most optical devices such as cameras and binoculars use prisms instead of mirrors



Retro-reflectors and Prisms

A retro-reflector is an optical device that returns incident light back the same direction from which it came



Found in road signs and road paint