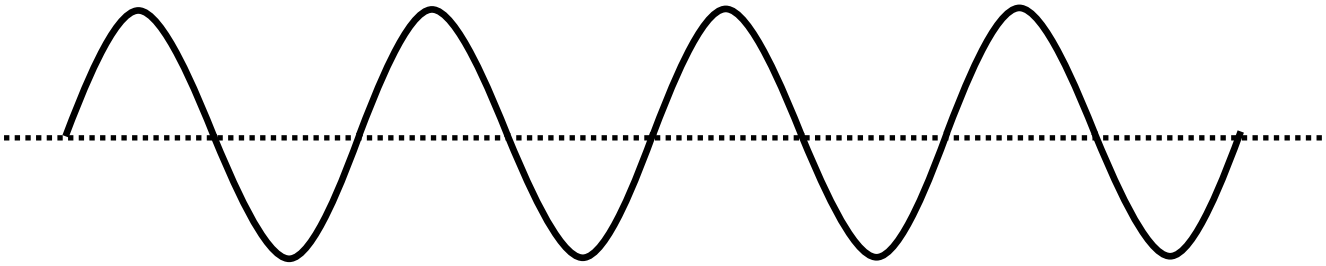
Waves

Physicists use waves to describe light, and sound.



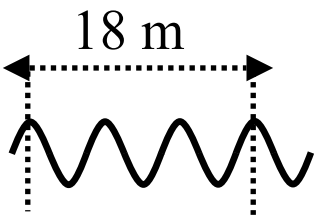
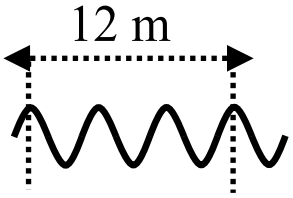
Waves carry energy. The amplitude of a wave is a measure of the energy it carries.

Waves repeat. The time it takes for a complete wave is called its .....

The number of complete waves that pass a point is called the .....

The distance between identical points on a wave is called the .....

The speed of a wave is related to its frequency and wavelength by: .....

A water wave has a period of 6 seconds. Determine the frequency of the wave.	A wave has a wavelength of 5.4 m and has a frequency of 5 m. Find the speed of the wave	Find the wavelength of this wave. 
A wave has a frequency of 0.25 Hz. Calculate the period T of the wave	This wave has a speed of 20 m s^{-1} Calculate its frequency. 	A wave has a period of 0.04 s It has a wavelength of 10 m. Calculate its speed.

Properties of Waves

All waves exhibit these properties

Reflection

Refraction

Interference

Diffraction

Refractive Index and Snell`s law

A pencil in water appears broken.

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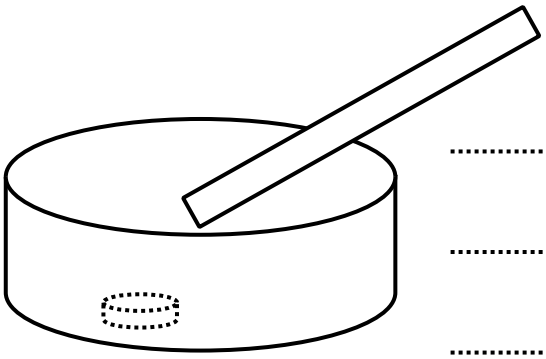
Willebrord Snell (1580-1626)



The ruler and the pound coin

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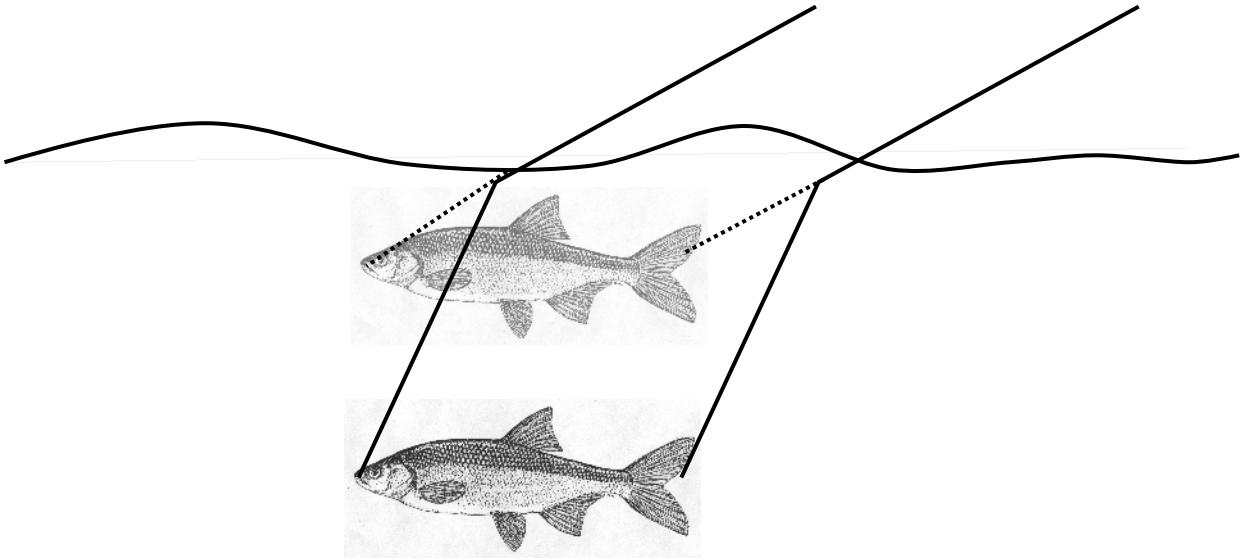

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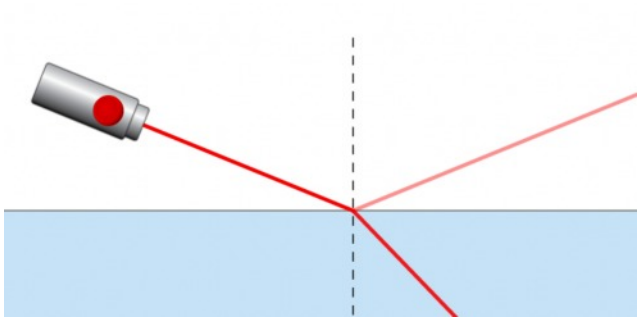
A monochromatic beam of light from a laser pen is shone into water. The beam is refracted.



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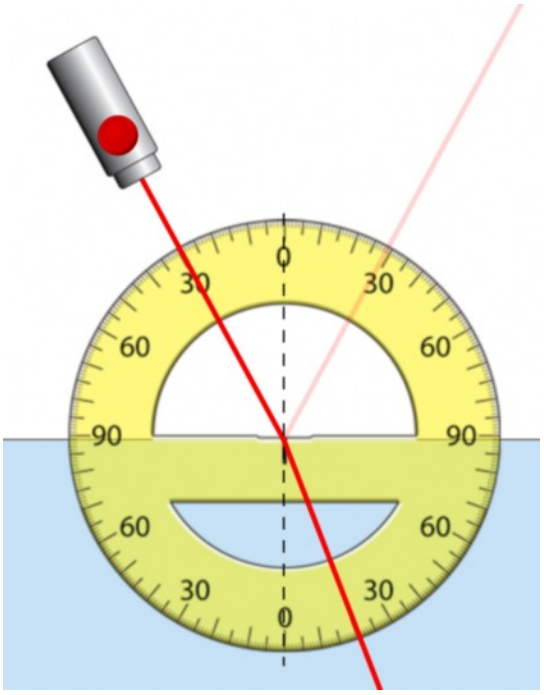
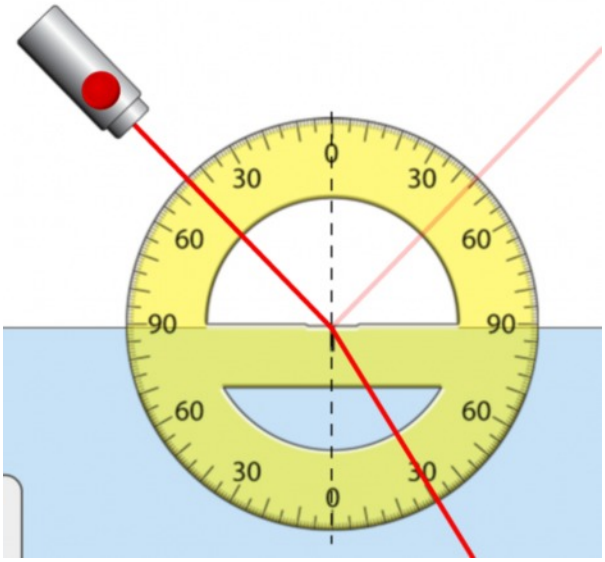
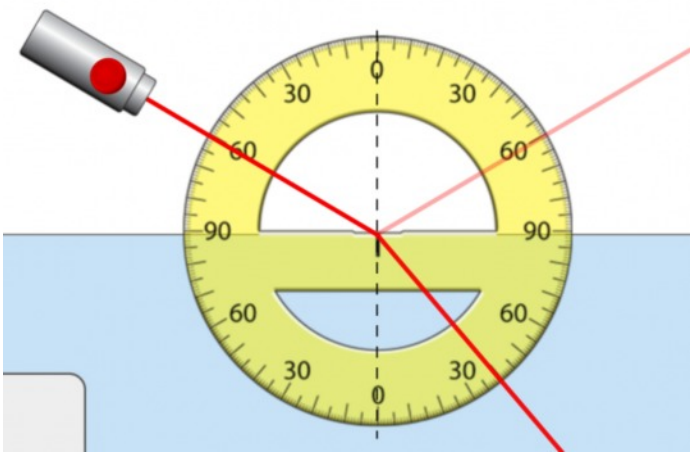
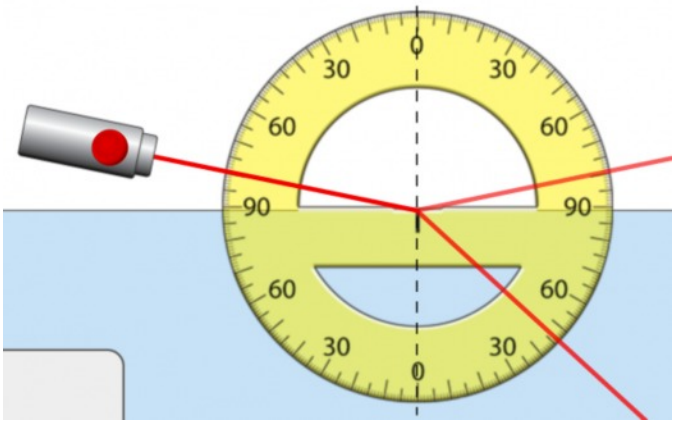
Refractive Index and Snell`s law calculations









Refraction data

Angle of incidence	Angle of refraction	sin i	sin r	

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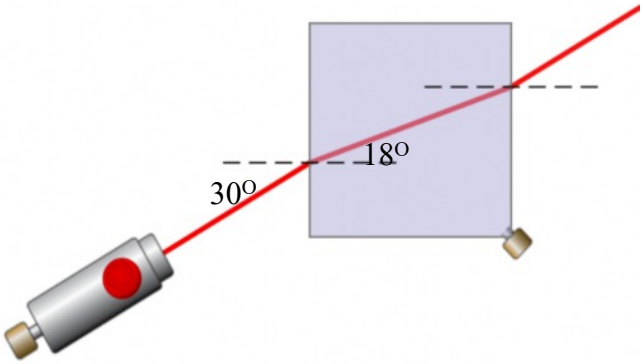
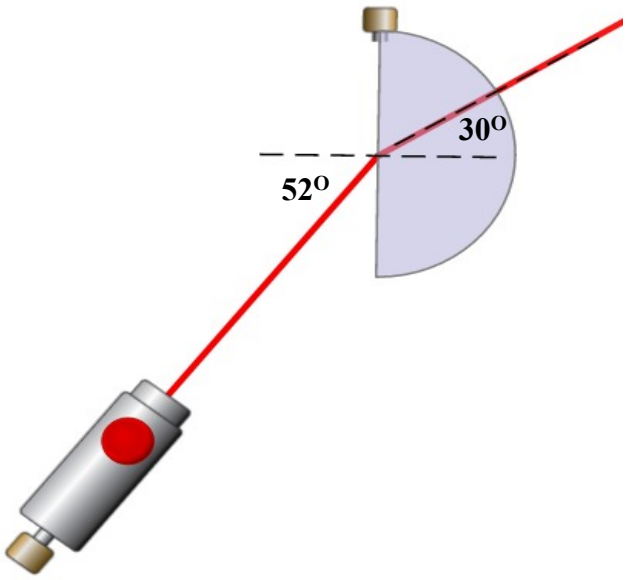
$$\frac{\sin i}{\sin r} = n$$

Examples

Find the refractive index of these pieces of glass





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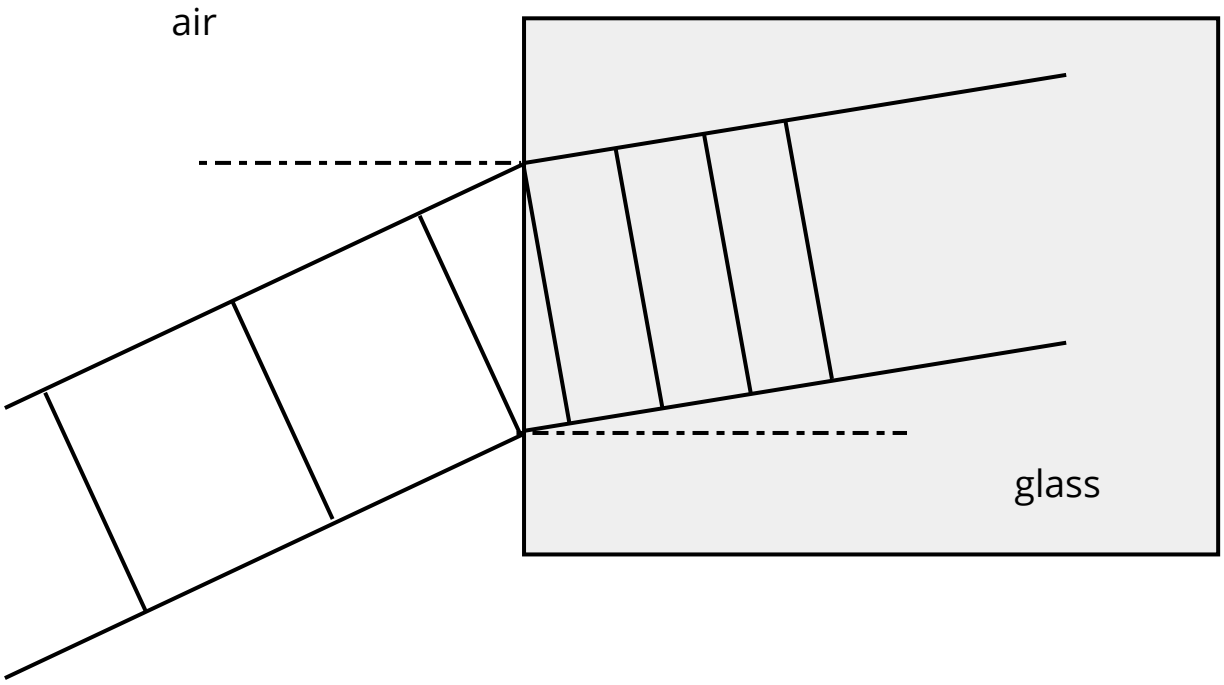
Snell`s Law: Wavelength, wave speed and frequency



Light waves approaching the glass are refracted. The direction changes and as can be seen the wavelength in the glass becomes smaller.

Now the colour of the light depends only on the frequency of the light.

The light rays change wavelength but do NOT change frequency. This must mean that the speed of the waves must decrease in the glass.

$$n = \frac{\lambda_{air}}{\lambda_{glass}} \qquad n = \frac{v_{air}}{v_{glass}} \qquad n = \frac{\sin\theta_{air}}{\sin\theta_{glass}}$$

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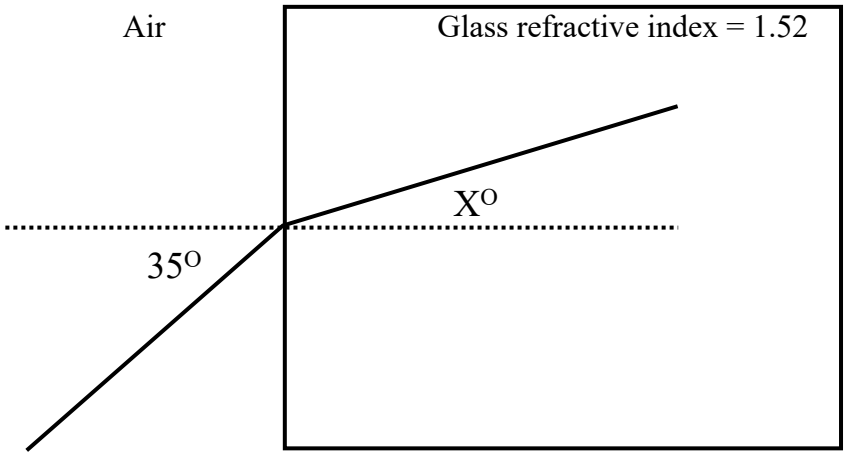
$$\frac{\lambda_{air}}{\lambda_{glass}} = \frac{v_{air}}{v_{glass}} = \frac{\sin\theta_{air}}{\sin\theta_{glass}}$$

Example



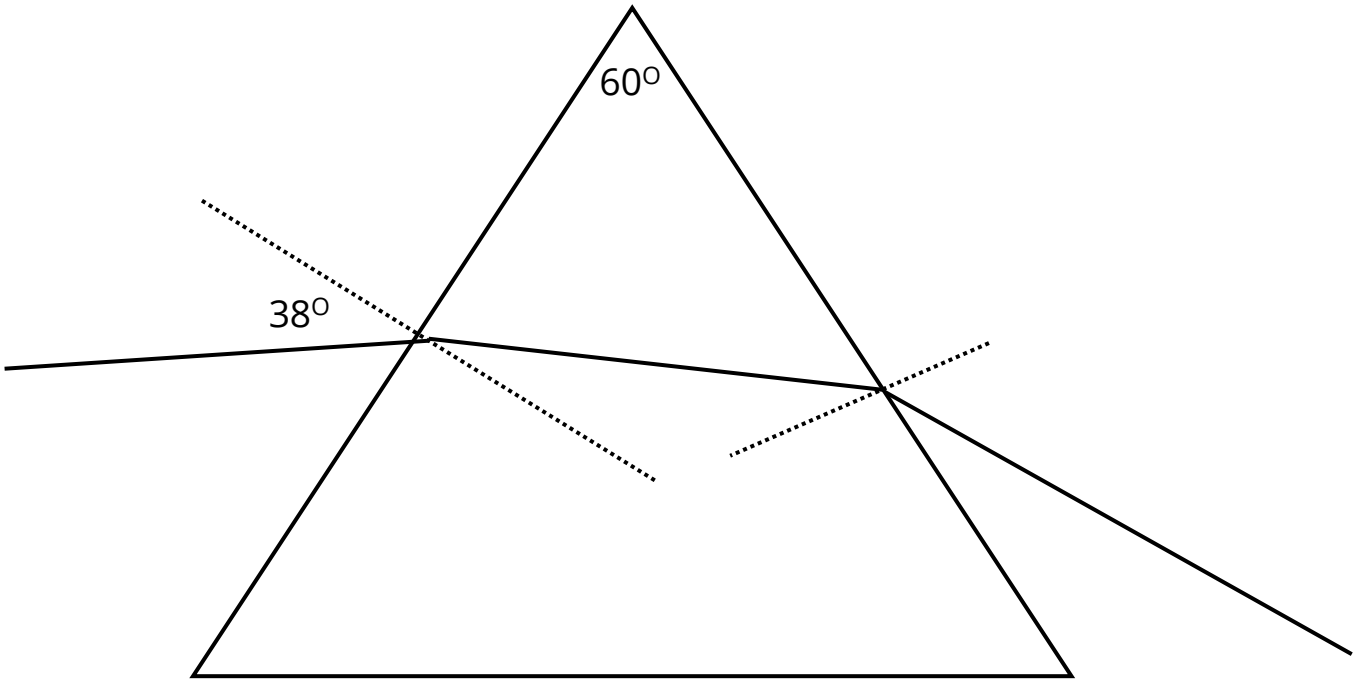
Determine the angle of refraction X in the glass.

If the speed of light in air is taken to be 3×10^8 m s^{-1} then find the speed of light in the glass

The wavelength of the light in the air is 650 nm. Determine the wavelength of the light in the glass.

The Prism

Red light Refractive index of the glass = 1.52



Dispersion

Blue light .....

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Red Light .....

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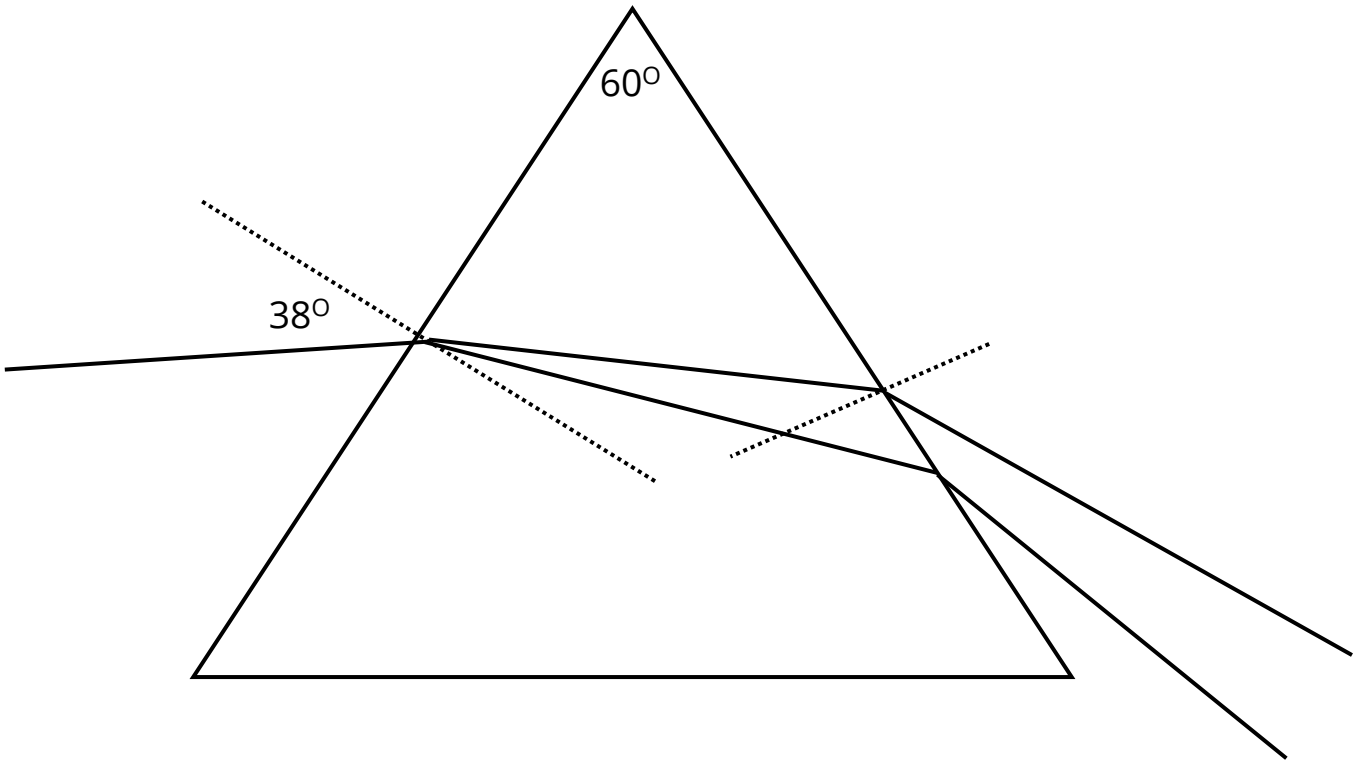
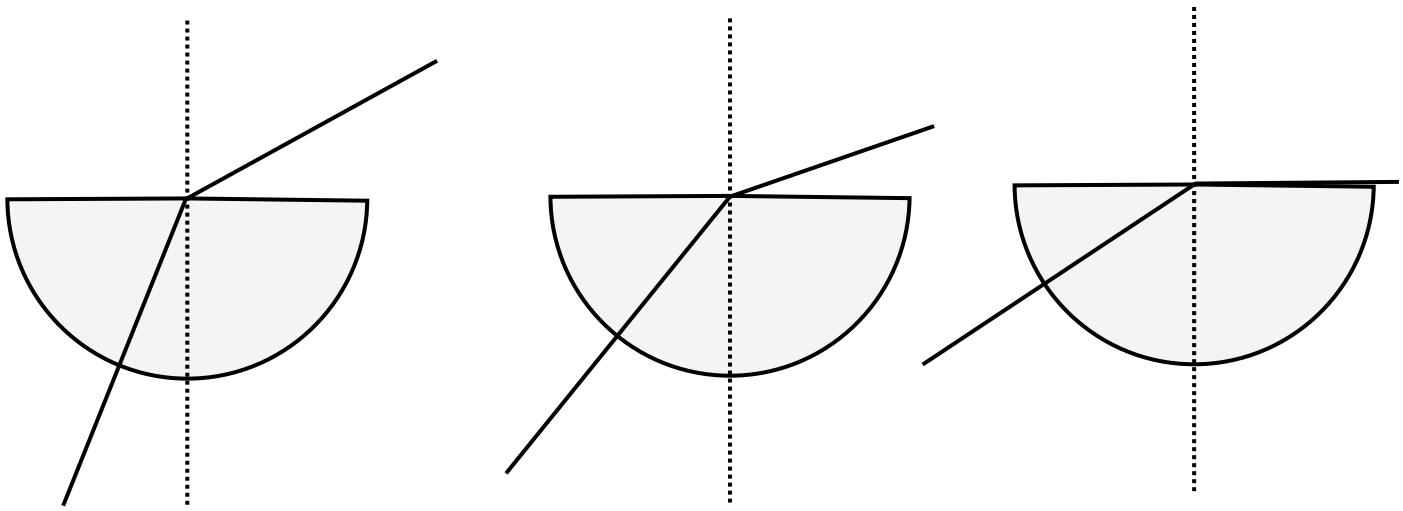
Red light Refractive index of the glass = 1.52
Blue light refractive index = 1.55



Total Internal reflection

A ray of monochromatic light is passes through glass or water out into the air the emergent ray bends away from the normal.



Increasing the angle in the glass .....

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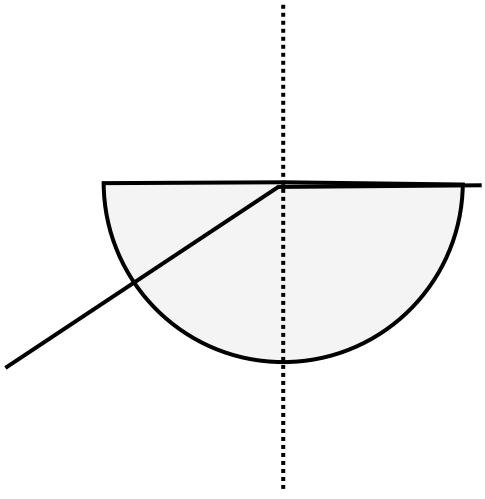
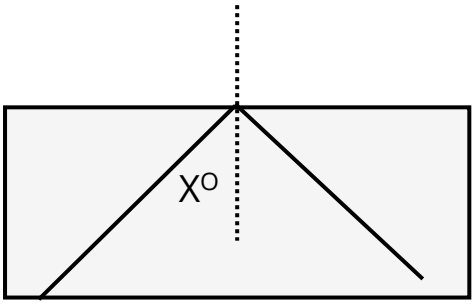
The critical angle

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



Examples



A ray of light from a lamp at the bottom of a swimming pool is at the critical angle to the normal.

The refractive index of the water is 1.33.

Determine the size of the critical angle.

Material	Refractive Index	Critical Angle
Water	1. 33	
Glass	1. 50	
Diamond	2.4