TOTAL INTERNAL REFLECTION 15 APRIL 2014

Lesson Description

In this lesson we:

- Define the conditions for total internal reflection to occur
- Explain how total internal reflection is used in optical instruments

Summary

Total Internal Reflection

Consider a ray of light moving from water to air. It will speed up and will change direction by moving **away** from the normal i.e. angle of refraction (air) r > i angle of incidence (water)

There is a certain angle of incidence when the angle of refraction ray is 90^{o}, i.e. along the water surface. In this case we say that the angle of incidence is equal to the **critical angle.**

Any ray of light that strikes the barrier at an angle of incidence greater than the critical angle, cannot be move into the air. It is reflected back into the water. This phenomenon is known as **total internal refraction.**

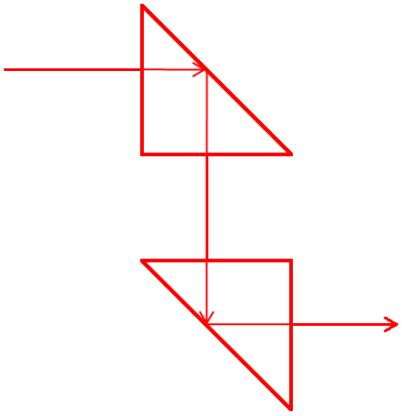
The conditions for total internal refraction to take place:

1. Light ray must move from greater optical density to a medium with lower optical density
2. Angle of incidence must be greater than the critical angle

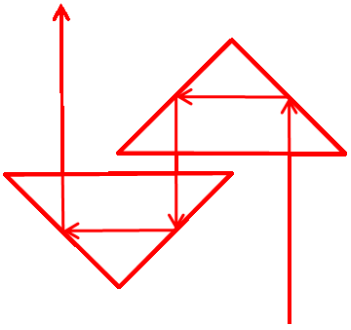
Application of Total Internal Refraction

The principle of Total Internal Reflection applies to:

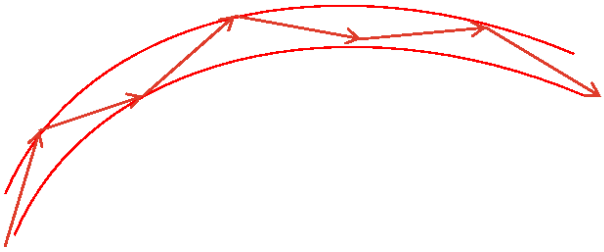
1. The Periscope



2. Binoculars



3. Fibre Optics



Uses of Fibre Optics: Telecommunications

Applications are widespread, ranging from global networks to desktop computers. These involve the transmission of voice, data, or video over distances of less than a metre to hundreds of kilometres, using one of a few standard fibre designs in one of several cable designs.

Optical fibres carry telephone service across their nationwide networks.

Optical fibre is used extensively for the transmission of data. Multinational firms need secure reliable systems to transfer data and financial information between buildings to computers and to transfer data around the world.

Cable television companies also use fibre for delivery of digital video and data services.

Test Yourself

Question 1

Which optical instrument depends on total internal reflection?

A binoculars

B microscope

C reading glasses

D telescope

Question 2

Substance A has a refractive index of 1,31 and substance B has a refractive index of 1,65. These substances form a boundary through which a beam of light can travel. Under which conditions could total internal reflection take place?

A When a beam of light inside substance A strikes the boundary with substances B

B When a beam of light inside substance A strikes the boundary at an angle of 90^{o}

C When a beam of light inside substance B strikes the boundary with substances A

D When a beam of light inside substance B strikes the boundary at an angle of 80^{o}

Question 3

A prism has a critical angle of 48^{o}. When light passes from the prism towards air, what would happen if the angle of incidence is equal to 45^{o}?

A total internal reflection

B refraction with an angle of refraction equal to 90º

C reflection with an angle of reflection equal to 45^{o}

D refraction with an angle of refraction greater than 45º

Question 4

When a ray of light moves from air into a perspex block which has a refractive index of 1,5, the ray of light will

A continue to move at the same speed

B slow down

C speed up

D always change direction

Question 5

When a ray of light moves from glass (n = 1,5) into water (n =1,33), at an angle of incidence of 30º, the ray of light will

A slow down and bend towards the normal

B slow down and bend away from the normal

C speed up and bend towards the normal

D speed up and bend away from the normal

Question 6

A ray of light moves from water (n =1,33) into air. The angle of refraction is 90º.The name given to the angle formed between the ray of light and the normal inside the water is:

A The critical angle

B The angle of incidence

C The angle of reflection

D The angle of refraction

Question 7

A ray of light moves from air into a drop of sugar water solution. The sugar water has a refractive index of 1,49. Which of the following statements is true when the light leaves the sugar water and emerges into air?

A the 2nd angle of refraction is equal to the 1st angle of incidence

B the 2nd angle of refraction is greater than the 2nd angle of incidence

C the 2nd angle of refraction is less than the 2nd angle of incidence

D the 2nd angle of refraction is equal to the 1st angle of refraction

Question 8

When a ray of light moves from air to glass (n= 1,5) to water (n= 1,33), the speed of light undergoes the following changes

A slows down in glass and speeds up in water

B slows down in glass and slows down more in water

C speeds up in glass and slows down in water

D no change in glass but speeds up in water

Improve your Skills

Question 1

A rectangular glass prism has a critical angle of 42°. Draw a sketch to show what happens when light move inside the glass towards the air and strikes the boundary with:

a.) an angle of incidence i = 35°

b.) an angle of incidence i = 42°

c.) an angle of incidence i = 60°

Question 2

Draw diagrams to show how you can use prisms to turn light through:

a.) 90°

b.) 180°

c.) Which glass triangular prism should be used if the critical angle of glass is 42°?

Question 3

Water has a refractive index of 1,33 at 20° C.

a.) What is the critical angle of water?

b.) Explain what a scuba diver who see if she looked:

i. directly up at the surface of the water from a depth of 2m

ii. looked towards the surface of the water more than 20m away from her position 2m below the surface