

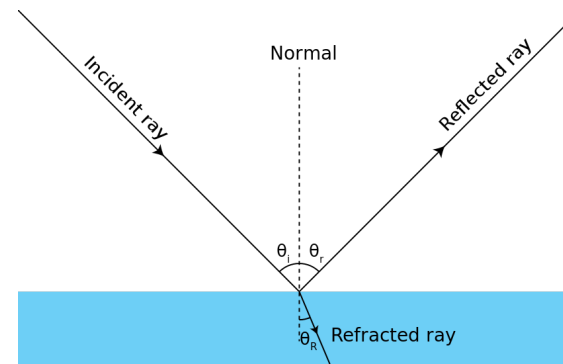
The Wave Nature of Light

Lesson Topics Include:

- Waves
- Light
- Describing Waves
- Universal Wave Equation
- Properties of Waves
- Types of Reflection
- Prisms and White Light
- Index of Refraction
- Snell's Law
- Critical Angle



$$v = f\lambda$$



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Waves

- A wave is a disturbance that moves along a medium from one end to the other
- Waves move from one location to another in a given time → therefore, waves have a speed
- _____



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Describing waves

- Speed – v – how fast the disturbance propagates (m/s)
- Frequency – f – rate of oscillation (cycles per second, Hz)
- _____

Speed of light

The speed of light in a vacuum is a universal constant in all reference frames

- Fixed at 299,792,458 m/s
- Speed of light is represented by $c = 3.00 \times 10^8$ m/s
- Nothing can travel faster than the speed of light and anything with mass cannot reach the speed of light
- _____

The Universal Wave Equation

$$\textit{speed} = \frac{\text{distance}}{\text{time}} \quad v = \frac{\lambda}{T} \quad \left(\textit{but}, f = \frac{1}{T} \right)$$

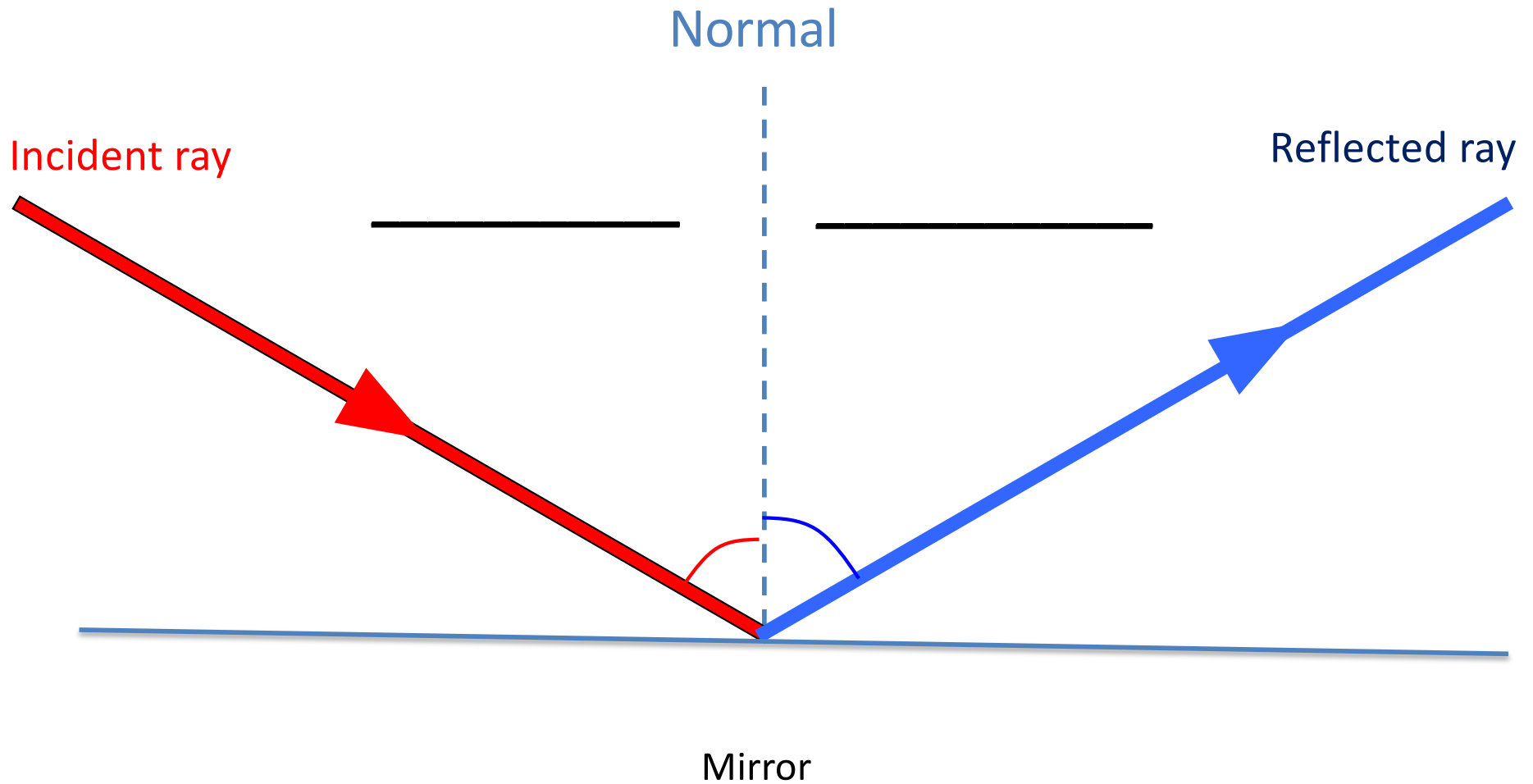
$$v = f\lambda$$

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Reflection Observed



Reflection From a Mirror



Types of Reflection

- Clear (Specular) Reflection

— _____

- Diffuse Reflection

— _____



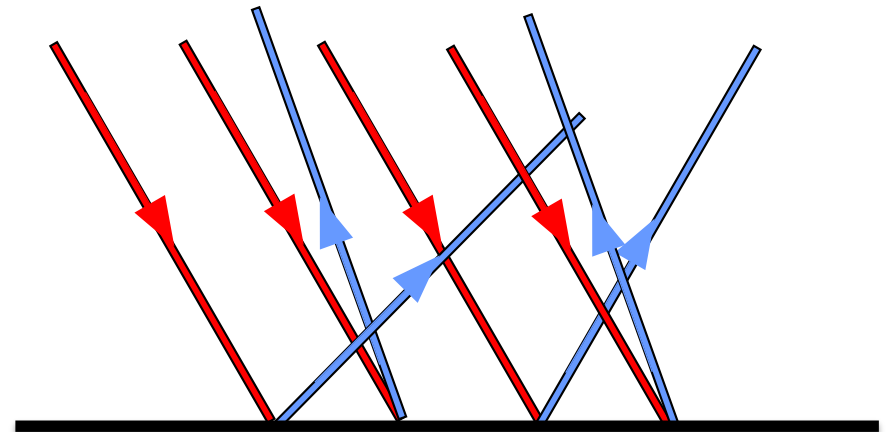
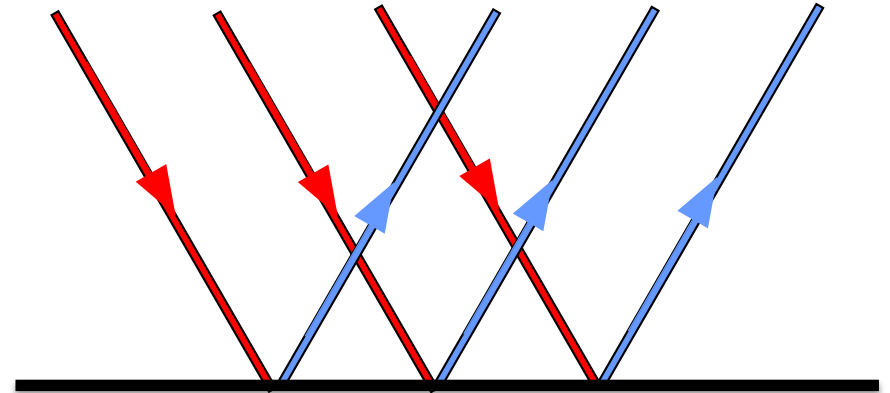
Clear Reflection



Diffuse Reflection

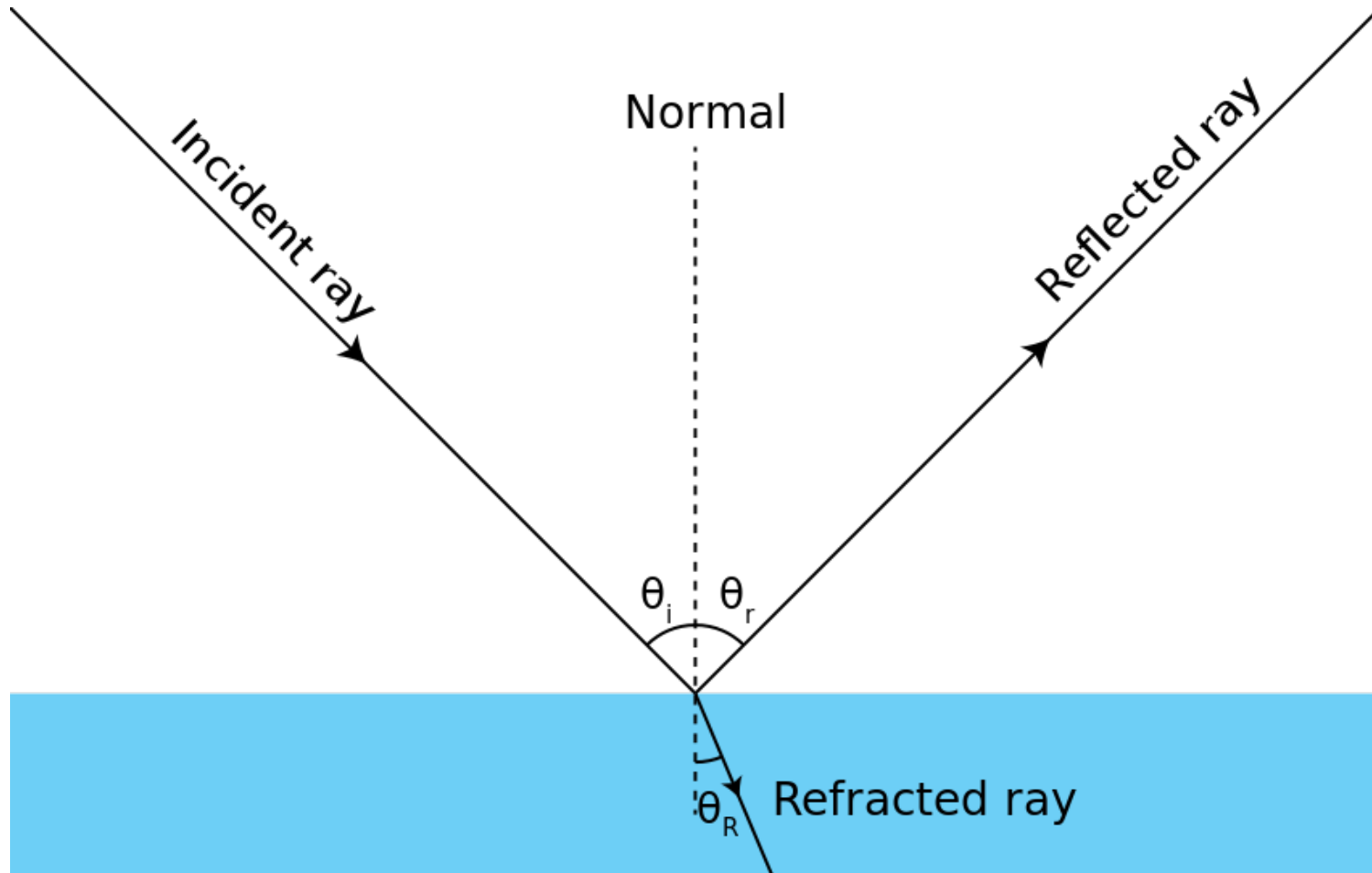
Clear vs. Diffuse Reflection

- Smooth, shiny surfaces have a clear reflection
- Rough, dull surfaces have a diffuse reflection
- Diffuse reflections occur when light is scattered in different directions



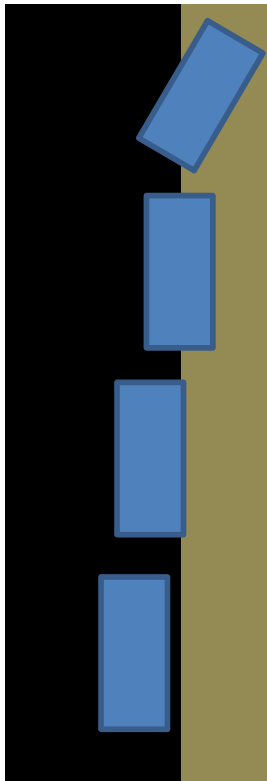
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Unlike Reflection, in Refraction



The angle of incidence (θ_1) $\neq$ the angle of refraction θ_R

Example: The Dangers of Driving on the Shoulder

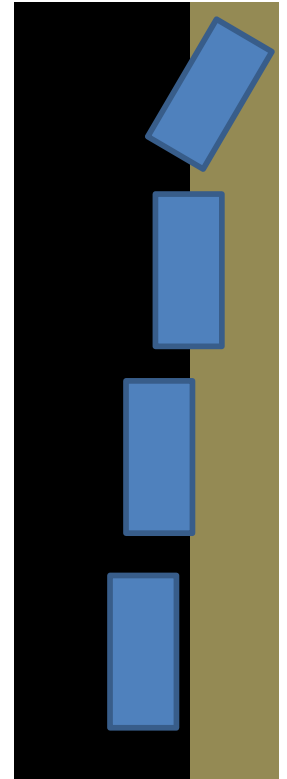


- When the right wheels touch the grass, they begin to slow down
- At the same time, the left wheels are still moving at their initial pace
- This difference in speed causes the cart to turn right

Example: The Dangers of Driving on the Shoulder

- _____

- This causes the wave to turn or bend



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Rules of Refraction

1. The incident ray, refracted ray, and normal all lie on the same plane.

2. _____

3. _____

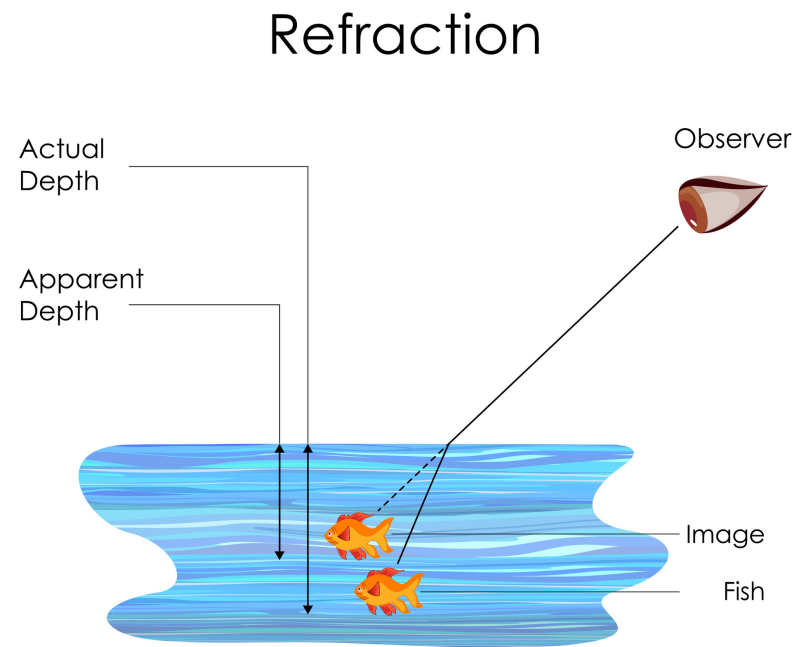
The Bent Pencil

- A pencil in a glass of water appears bent when viewed from the side
- Light from the part of the pencil below the surface of the water must change mediums from water to glass to air before reaching the eye
- Light from the exposed part of the pencil goes from air to glass to air
- _____



Apparent Depth

- _____
- Due to refraction, the apparent depth (distance to image) is different from the actual depth (distance to object)
- We think light rays travel in straight lines, so we assume the fish is higher because that is where the light rays appear to come from
- _____



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Index of refraction

Index of Refraction $\rightarrow$ $n = \frac{c}{v}$

c $\leftarrow$ Speed of light in a vacuum

v $\leftarrow$ Speed of light in the material

Snell's Law

The changes in speed of light between transparent materials forms a useful relationship called Snell's Law.

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{V_1}{V_2} = \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$$

$$n = \frac{\sin\theta_i}{\sin\theta_R}$$

Check Your Understanding

A 5.0 Hz water wave, traveling at 31 cm/s in deep water, enters shallow water. The angle between the incident wave front in the deep water and the boundary between the deep and shallow regions is 50° . The speed of the wave in the shallow water is 0.972 km/h. Find

- a) the angle of refraction in the shallow water
- b) the wavelength in shallow water

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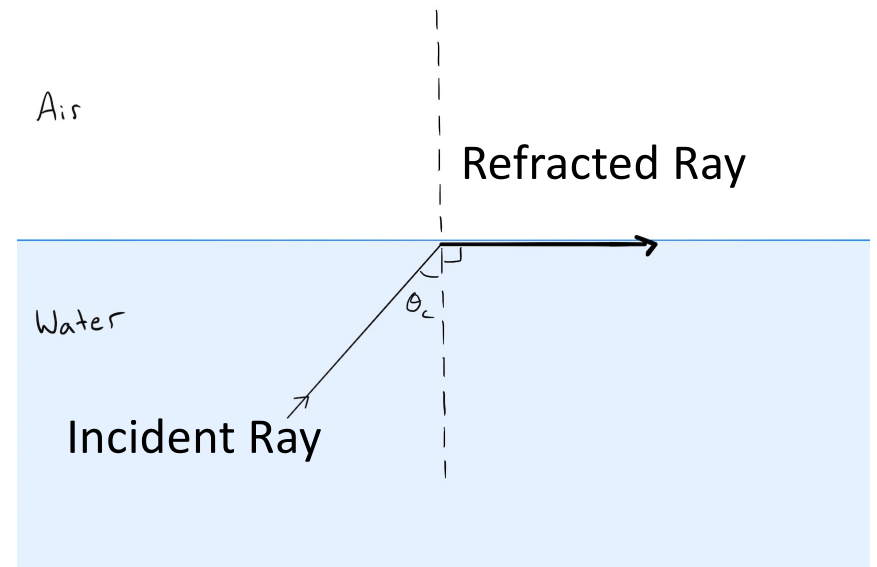
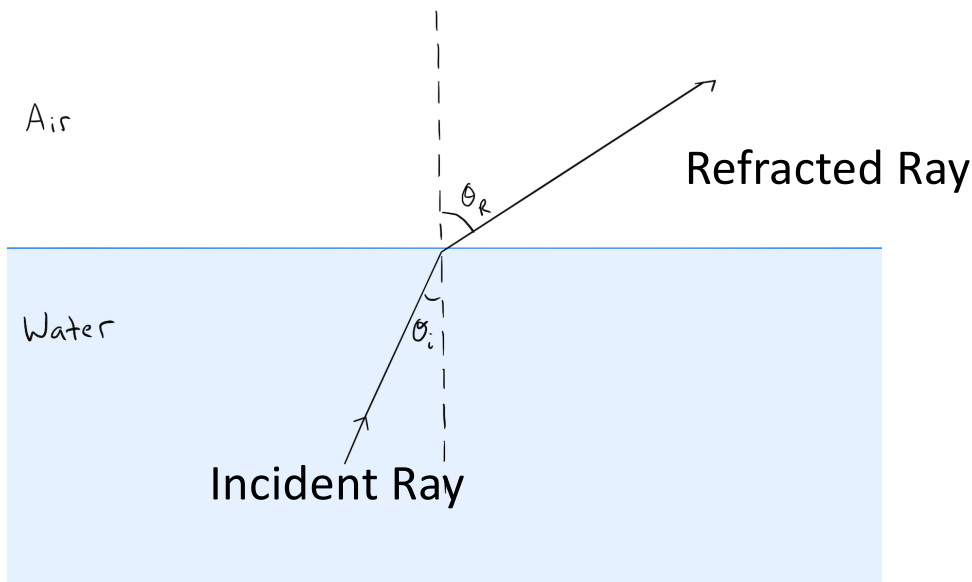
Total Internal Reflection

- Light bends AWAY from the normal when it speeds up at the boundary of two media
 - i.e moves from acrylic (plastic) to air
- As the angle of incidence increases so does the angle of refraction
 - _____

Total Internal Reflection

- When light rays pass from one medium to another, they are refracted (bent)
- Critical Angle:

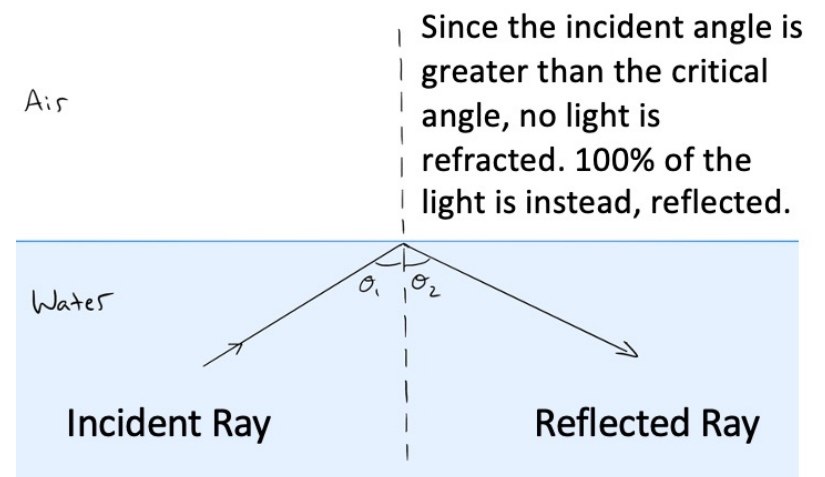
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Total Internal Reflection

- If the angle of incidence is increased

- When this occurs, the refracted ray disappears and only a reflected ray is visible
 - “total internal reflection”



Check Your Understanding

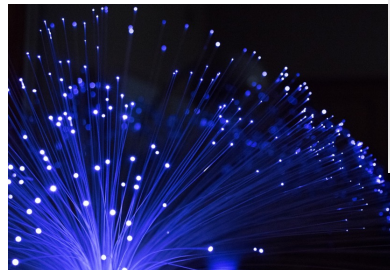
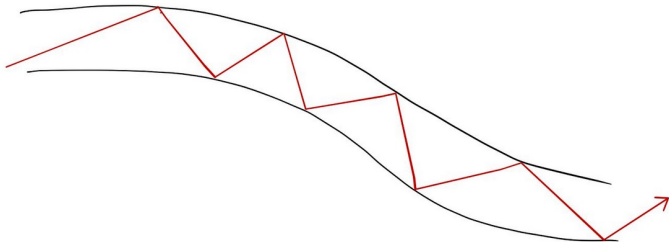
Example: Calculate the critical angle for the crown glass ($n = 1.52$) – air ($n = 1.00$) boundary

Example: Calculate the critical angle for the diamond ($n = 2.42$) – air ($n = 1.00$) boundary

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Fiber Optics

- _____
- The critical angle of the tube must be small so that the light entering the cable will most likely have a greater incident angle
- If the incident angle is greater, the light will internally reflect and be passed down the cable to its destination



Fiber Optics

Uses of fibre optics;

- _____
- Instrument panels of cars
- Medicine (i.e. Endoscope)
 - Two bundles of fibre optics.
One lights the body while the other carries the reflected light back so the image can be seen on a screen

