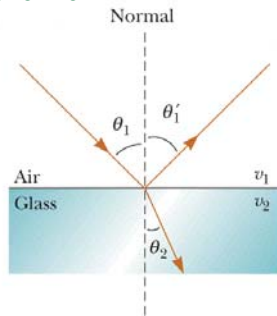


PHY138 – Waves, Lecture 7

Today's overview

- The Ray Model of Light
- Reflection
- Refraction
- Total Internal Reflection
- Medical Fibrescopes
- Apparent Depth



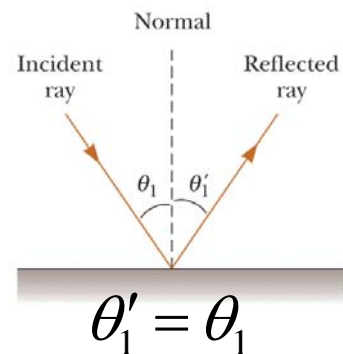
Reading Assignment

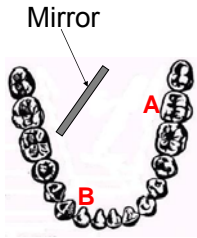
- This week's reading assignment from the text by Knight is: **Chapter 23**, Sections 23.1-23.7
- Test 2 will cover up to and including Section 23.7, Thin Lenses and Refraction Theory, plus lab materials from this semester.
- A masteringphysics Problem Set is due Friday by 5:00 PM. It is the *last* problem set of 2007.
- Suggested Chapter 23 Exercises and Problems for Practice: 11, 17, 19, 27, 39, 49, 73, 81

Wave Fronts and Rays

- Wave fronts connect points of equal phase on an extended wave.
- Rays show the propagation direction of waves, and are always perpendicular to wave fronts.
- Rays travel in straight lines
- At a boundary they can *reflect* (bounce off) and *refract* (penetrate) the different medium.
- Ray angles are measured relative to surface normal.

The Law of Reflection

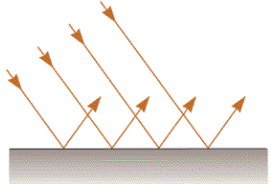




A dentist uses a mirror to look at the back of a second molar (A). Next, she wishes to look at the back of a lateral incisor (B), which is 90° away. By what angle should she rotate her mirror?

A. 90°
 B. 45°
 C. 180°

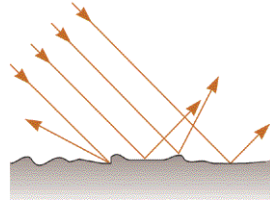
Specular vs. Diffuse Reflection



Specular Reflection

- The surface is *flat* at distance scales near or above the wavelength of light
- It looks “shiny”, like a mirror.

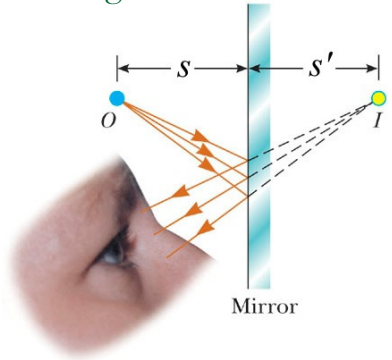
Specular vs. Diffuse Reflection



Diffuse Reflection

- The surface is *rough* at distance scales near or above the wavelength of light
- Almost *all* surfaces reflect in this way!

How an image is formed

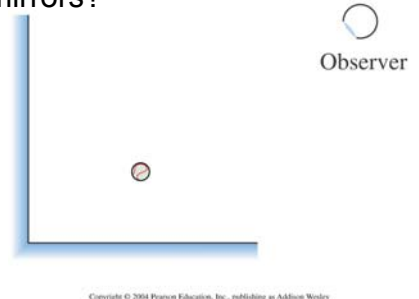


Virtual Image in a flat mirror

- Light rays emerging from an object obey the law of reflection for the specular surface of a mirror
- Our mind imagines that the rays emerge from points beyond the mirror.
- This thing beyond the mirror is called an image. No light rays actually pass through the image, so it is “virtual”.
- It is convenient to describe the size and location of the image as if it were an actual thing.

Two plane mirrors form a right angle. How many images of the ball can you see in the mirrors?

- A. 1
- B. 2
- C. 3
- D. 4



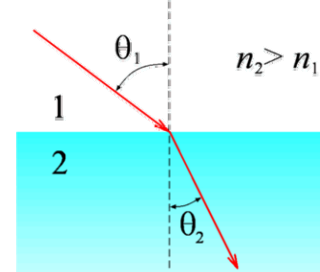
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Index of Refraction

$$v_{medium} = \frac{c}{n}$$

- v_{medium} is the speed of light in a transparent medium.
- c is the speed of light in a vacuum ($c=3.00 \times 10^8$ m/s)
- n is a dimensionless constant: $n \geq 1$
- $n=1$ in a vacuum

Snell's Law of Refraction



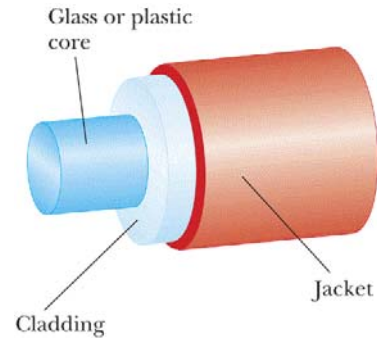
$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

Total Internal Reflection

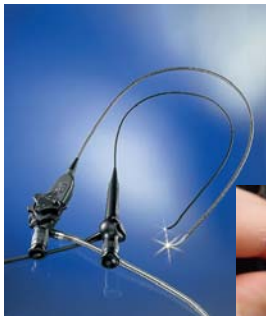
- Occurs when $n_2 < n_1$
- θ_c = critical angle.
- When $\theta_i \geq \theta_c$, no light is transmitted through the boundary; 100% reflection

$$\sin \theta_c = \frac{n_2}{n_1}$$

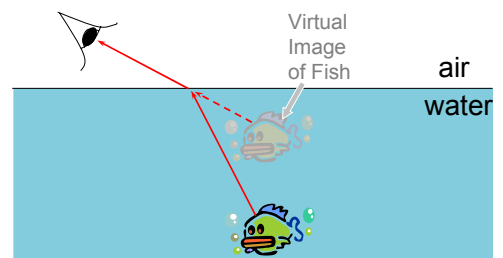
An Optical Fibre



Medical Fibrescopes



Video-laryngoscopy with a flexible fiberscope



A fish swims below the surface of the water.

An observer sees the fish at:

A. a greater depth than it really is.

B. its true depth.

C. a smaller depth than it really is.

A diagram showing a fish swimming directly below the surface of the water. An observer's eye is positioned above the water surface. The region above the surface is labeled 'air' and the region below is labeled 'water'. The fish is shown as a colorful cartoon character.

A fish swims *directly* below the surface of the water. An observer sees the fish at:

- A. a greater depth than it really is.
- B. its true depth.
- C. a smaller depth than it really is.

Depth perception

A fish out of water

The eye sees the object at distance d .

Object

Eye

d

A ray diagram showing a green fish-like object on the left and an eye on the right. Purple rays originate from the object and travel towards the eye. A dashed blue arrow points from the text 'The eye sees the object at distance d ' to the rays. A horizontal double-headed arrow below the object and eye is labeled d .

Apparent Depth

A fish in the aquarium

The eye sees the image at distance d' .

Object

Image

Actual rays

Refraction

d'

Diverging rays appear to come from this point. This is a virtual image.

A ray diagram showing a green fish-like object (labeled 'Object') and a virtual image (labeled 'Image') inside a blue rectangular area representing an aquarium. Purple rays originate from the object and travel towards the right. At the boundary of the aquarium, the rays bend away from the normal, labeled 'Refraction'. The rays then travel to an eye on the right. A dashed blue arrow points from the text 'The eye sees the image at distance d' ' to the rays. A horizontal double-headed arrow below the object and eye is labeled d' . A dashed blue arrow points from the text 'Diverging rays appear to come from this point. This is a virtual image.' to the virtual image location.