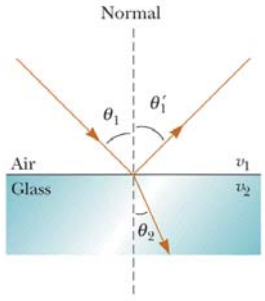
PHY138 – Waves, Lecture 7

Today's overview

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



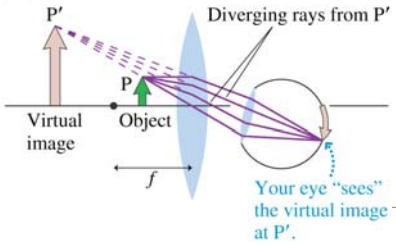
Reading Assignment

- 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 2006.
- Suggested Chapter 23 Exercises and Problems for Practice: 11, 17, 19, 27, 39, 49, 73, 81

Email question from a student: (1/2)

- "on page 736 the examples on the left hand column show lenses that are thicker in the middle than at the edges and they diverge the rays that are shone through them."



Email question from a student: (2/2)

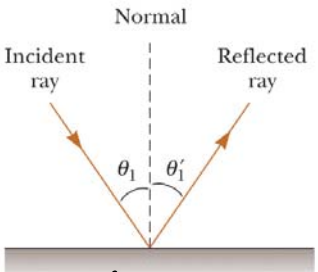
My response:

- The words "converging lens" and "diverging lens" are defined based on what the lenses do to rays that are initially ***parallel***.
- It is possible that if rays are initially diverging, they may still be diverging even after they pass through a converging lens!
- (they just will be diverging less quickly)

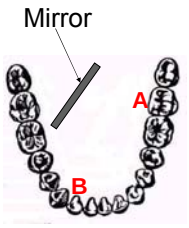
Wave Fronts and Rays

- 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



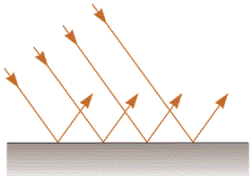
$$\theta_1' = \theta_1$$



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?

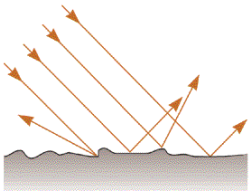
A. 90°
B. 45°
C. 180°

Specular vs. Diffuse Reflection



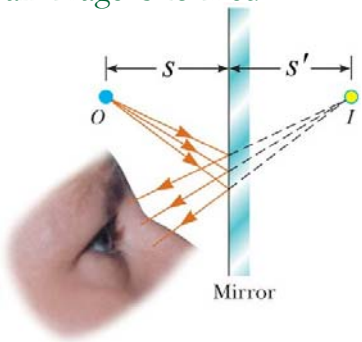
Specular Reflection
•The surface is *flat* at distance scales near or above the wavelength of light
•It looks "shiny", like a mirror.

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

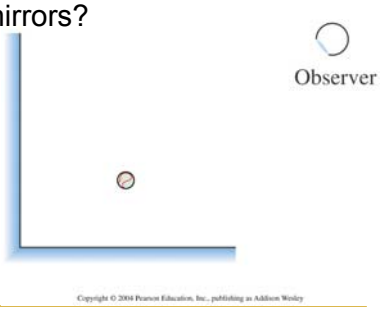


Virtual Image in a flat mirror

- 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

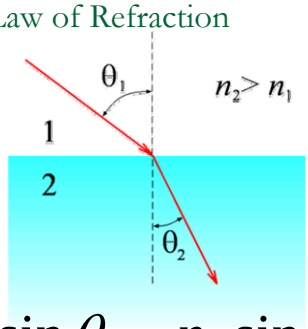


Index of Refraction

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

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

Snell's Law of Refraction



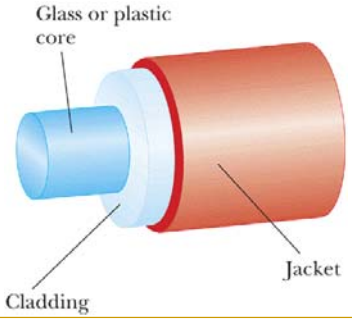
$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

Total Internal Reflection

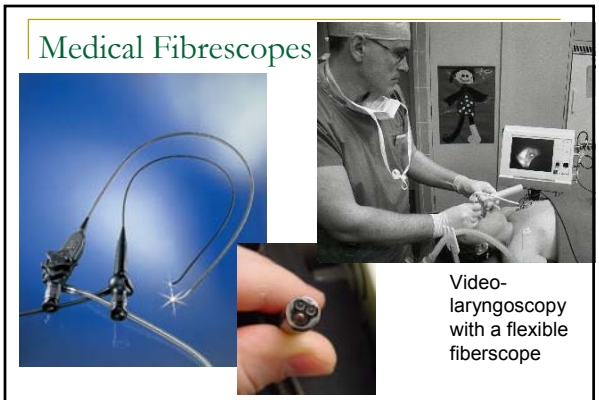
- Occurs when $n_2 < n_1$
- θ_c = critical angle.
- When $\theta_1 \geq \theta_c$, no light is transmitted through the boundary; 100% reflection

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

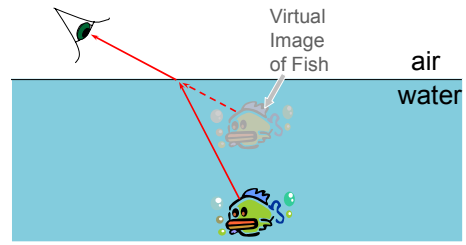
An Optical Fibre



Medical Fibrescopes



Video-laryngoscopy with a flexible fiberscope

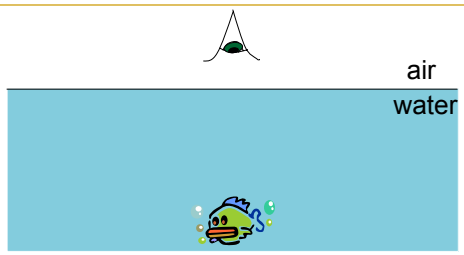


A fish swims below the surface of the water. An observer sees the fish at:

A. a greater depth than it really is.

B. its true depth.

C. a smaller depth than it really is.



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

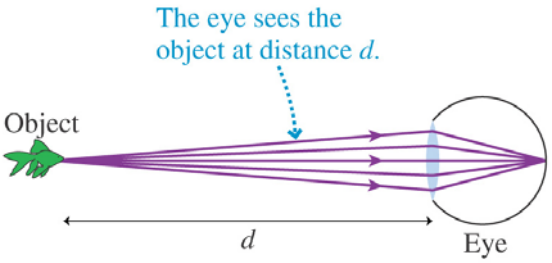
A. a greater depth than it really is.

B. its true depth.

C. a smaller depth than it really is.

Depth perception

A fish out of water



Apparent Depth

A fish in the aquarium