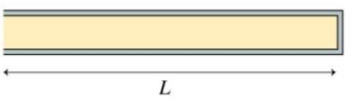
PHY132 Introduction to Physics II
Class 6 – **Outline:**

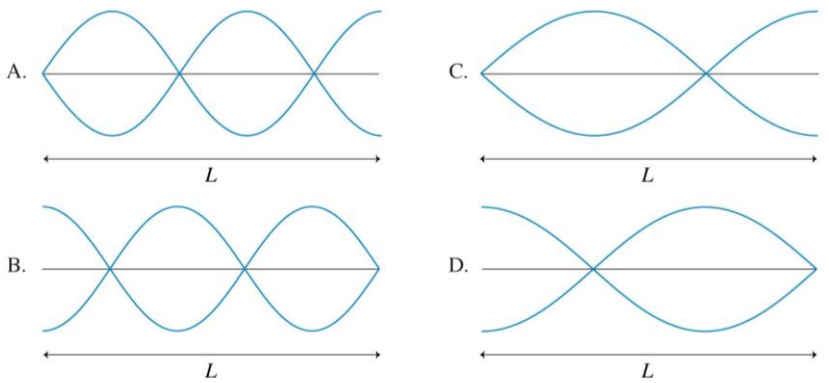
- Ch. 23, sections 23.1-23.5
- Reflection
- Refraction
- Total Internal Reflection
- Image Formation
- Colour and Dispersion

http://physics.tutorvista.com/light/index-of-refraction.html

Review Clicker Question!! Do you remember?

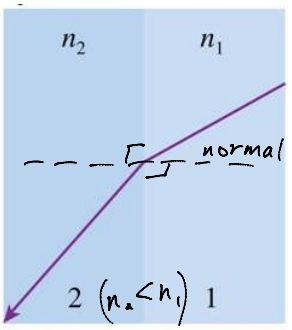
An open-closed tube of air of length L has the closed end on the right. Which is the displacement graph of the $m = 5$ standing wave in this tube?





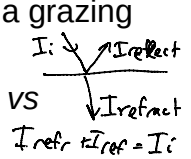
Class 6 Preclass Quiz on MasteringPhysics

- This was due this morning at 8:00am
- 636 students submitted the quiz on time
- 94% got:"Specular Reflection" is reflection by a flat, smooth object. The "law of reflection" is obeyed.
- 69% got: "Dispersion" is when the index of refraction varies slightly with wavelength.
- 59% of students got: Whenever the ray bends away from the normal, it means the waves are speeding up. That means $n_2 < n_1$.
- 65% got: there is only a critical angle (for possible total internal reflection) when $n_2 < n_1$.



Class 6 Preclass Quiz – Student Comments…

- *"curious to whether total internal reflection can work for other rays aside from the visible light spectrum."*
- **Harlow answer:** Yes! In fact, that is how X-ray telescopes work. The speed of X-rays in glass is actually slightly higher than in a vacuum, so when X-rays are incident at a grazing angle, you can make them reflect.
- *"Can you tell if a surface will have more reflection vs refraction?"*
- **Harlow answer:** Yes, but it's beyond the scope of this course (it's called "Fresnel Equations" if you want to wiki it..)



Class 6 Preclass Quiz – Student Comments…

- *"What is the difference between delta phi naught and delta phi? I know that delta phi naught is the phase difference of the sources and delta phi is the phase difference of the waves, but what does that mean conceptually?"*
- **Harlow answer:** "phase" ϕ is the argument of the sine or cosine function. $\Delta\phi$ determines interference
- So, for the wave equation, $\phi = kx - \omega t + \phi_0$. Every time ϕ changes by an integer multiple of 2π, the wave returns to the same state. If x, t are the same for both waves, then $\Delta\phi_0 = \Delta\phi$
- I think on a practicals problem sheet during the first week there was a typo, refering to ϕ_0 as the "phase". That is more properly called the "phase constant". It is one of the four constants that describe a sinusoidal wave: A, k, ω and ϕ_0.

Where to get help

- **Your classmates**: go on Piazza.com, form a study group, hang out in MP125, etc
- **Your two graduate student TAs**. Learn their email address, office hours, and office location.
- **Me**. After class + MP121B office hours are T12, F10, email [Note I am away Friday Jan.23]
- **Professor Meyertholen**, MP129A office hours are M2, F11-12
- The Physics **Drop-In Centre** in MP125, back corner MTWR 12-3, F11-2
- **Academic Success Centre** in Koffler 1st floor, inside the Career Centre

Announcement

- Test 1 is Tuesday Jan. 27th from 6:00-7:30pm.
- Room is based on your Practicals group

Group	Room
M2A	EX 200
M2B	EX 200
M3A	EX 200
M3B	EX 200

Group	Room
T2A	EX 100
T2B	EX 100
T3A	EX 100
T3B	EX 100

Group	Room
W2A	EX 300
W2B	EX 310
W3A	EX 300
W3B	EX 310
W4A	EX 310
W4B	EX 300

Group	Room
R1A	EX 200
R1B	EX 200
R2A	EX 200
R2B	EX 200
R3A	EX 200
R3B	EX 200

Group	Room
F1A	EX 100
F1B	EX 100
F2A	EX 100
F2B	EX 100

Announcement

- Test 1 is Tuesday Jan. 27th from 6:00-7:30pm.

- If you have a conflict with the regular sitting, the **alternate sitting** will be from 4:30-6:00pm on Tuesday Jan. 27th
  - To register, students should submit the Alternate Sitting Registration Form, available now in the PHY132S Portal course menu.
  - The location will be emailed no later than Jan. 26 to the people who have registered.
  - You have until Jan. 22 at 4:00pm to do it (the form will not be available after).
- There are only two sittings – you must attend one or the other!

Review: The Doppler Effect

The frequencies heard by a stationary observer when the sound source is moving at speed v_0 are

$$f_+ = \frac{f_0}{1 - v_s/v} \quad \text{(Doppler effect for an approaching source)}$$

$$f_- = \frac{f_0}{1 + v_s/v} \quad \text{(Doppler effect for a receding source)} \qquad (20.39)$$

The frequencies heard by an observer moving at speed v_0 relative to a stationary sound source emitting frequency f_0 are

$$f_+ = (1 + v_o/v) f_0 \quad \text{(observer approaching a source)}$$

$$f_- = (1 - v_o/v) f_0 \quad \text{(observer receding from a source)} \qquad (20.40)$$

Review: The Doppler Effect

- If both the source, and the observer are moving, you have to **combine** these equations.
- The general equation is:

$$f_{Doppler} = f_0 \frac{(1 - v_o/v)}{(1 + v_s/v)}$$

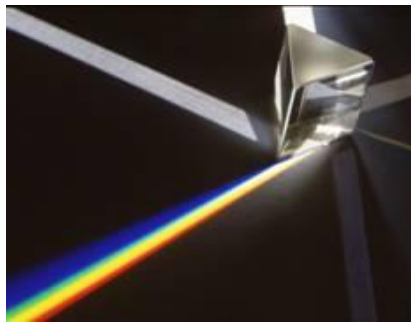
$\frac{\Delta f}{f_0} \approx \frac{\Delta v}{v}$ Don't use this

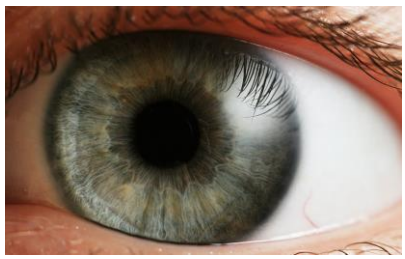
$v = 343\ m/s$ = speed of sound

- Here you must use the sign convention that v_s is **positive** if the source is **receding** and negative if the source is approaching.
- Also v_o is **positive** if the observer is **receding** from the source, and negative if the observer is approaching the source.

- What is light?

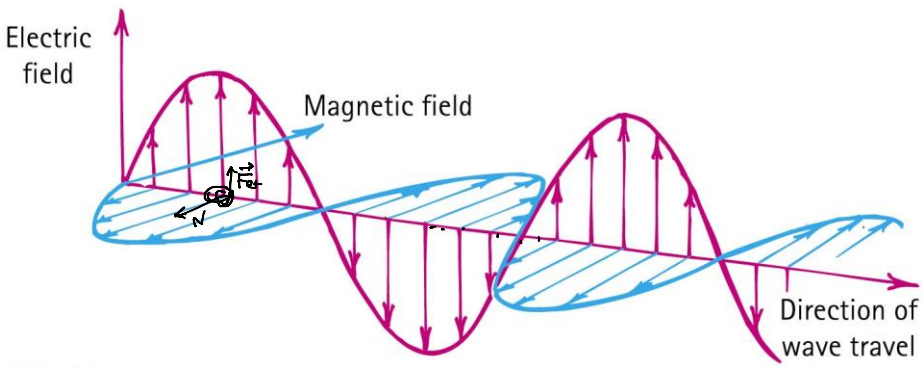
- Light is an electromagnetic wave – and is highly useful in our everyday life!





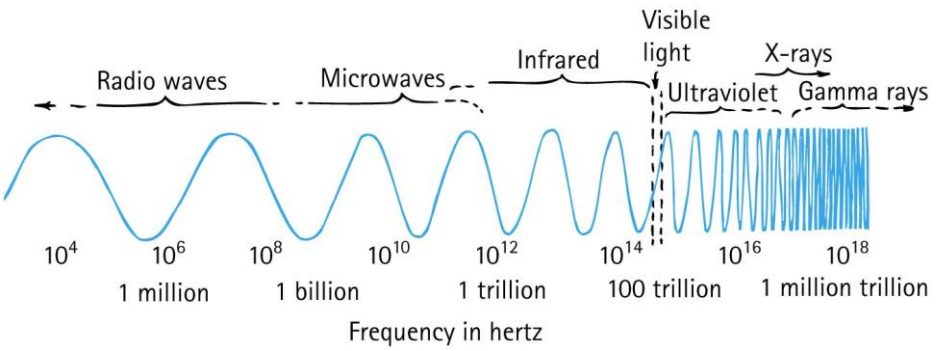
Electromagnetic Waves

The electric and magnetic fields of an electromagnetic wave are perpendicular to each other and to the direction of motion of the wave.



Electromagnetic Spectrum

- In a vacuum, all electromagnetic waves move at the same speed
- We classify electromagnetic waves according to their frequency (or wavelength)
- Light is one kind of electromagnetic wave



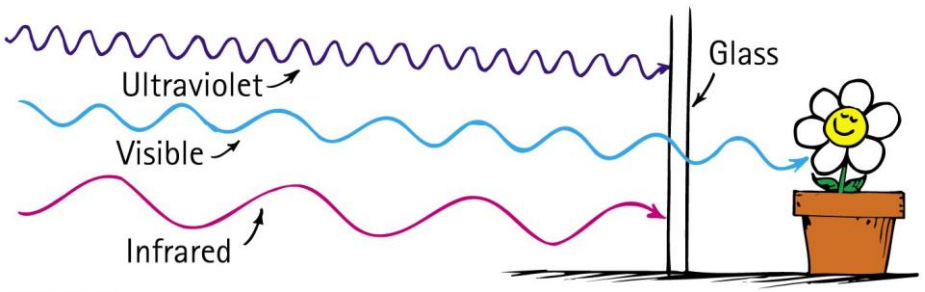
Electromagnetic Waves
CHECK YOUR NEIGHBOUR

If a certain material is “transparent” (ie, not opaque), what does this mean?

A. Electromagnetic waves of all frequencies can pass straight through it
B. Electromagnetic waves of all frequencies are reflected from its surface
C. Electromagnetic waves of all frequencies are absorbed throughout its volume
D. Electromagnetic waves of a certain frequency can pass straight through it

Transparent Materials

Glass blocks both infrared and ultraviolet, but it is transparent to visible light.



Opaque Materials

- Most things around us are **opaque**—they absorb light without re-emitting it.
- Vibrations given by light to their atoms and molecules are turned into random kinetic energy—into internal energy.
- These materials become slightly warmer.

Opaque Materials

Metals

- Light shining on metal forces free electrons in the metal into vibrations that emit their own light as reflection.

Reflection
CHECK YOUR NEIGHBOUR

Which reflects more light, a white piece of paper or a black piece of paper?

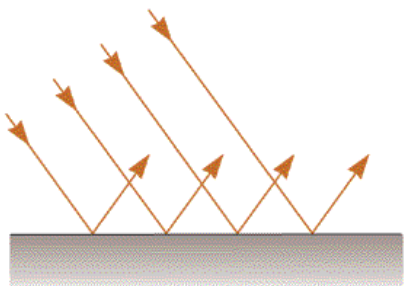
A. Black
B. White
C. About the same

Reflection
CHECK YOUR NEIGHBOUR

Which reflects more light, a white piece of paper or a mirror?

A. White Paper
B. Mirror
C. About the same

Specular Reflection

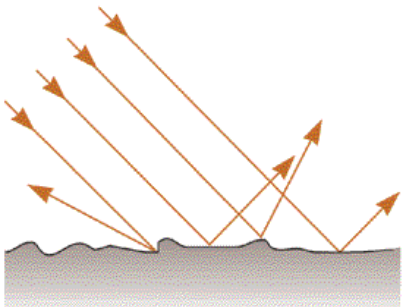


Mirrors

• The surface is *flat* at distance scales near or above the wavelength of light

• It looks “shiny”, and you can see images in it.

Diffuse Reflection

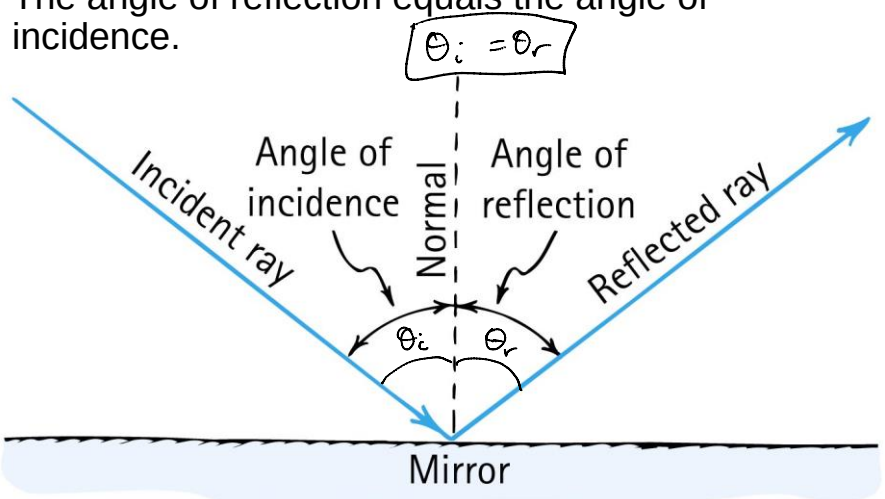


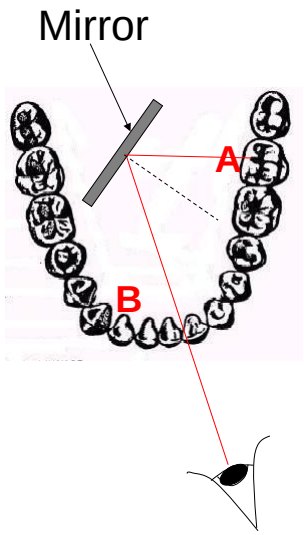
White Paper

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

Law of Specular Reflection

The angle of reflection equals the angle of incidence.



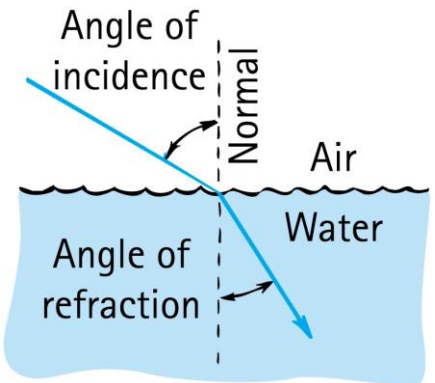


- A dentist uses a mirror to look at the back of a second molar (A).
- Next, she wishes to look at the back of a lateral incisor (B), which is 90° away.
- By what angle should she rotate her mirror?

A. 90°
B. 45°
C. 180°

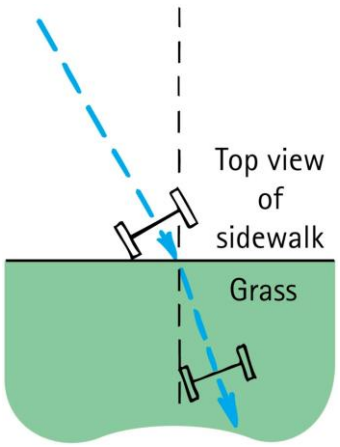
Refraction

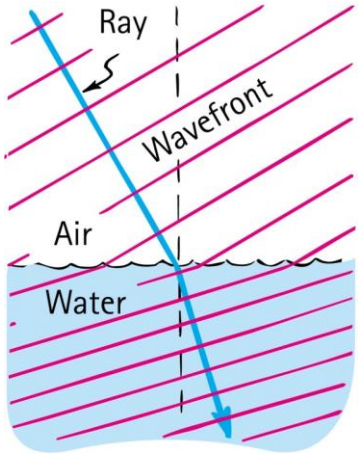
When light bends in going obliquely from one medium to another, we call this process refraction.

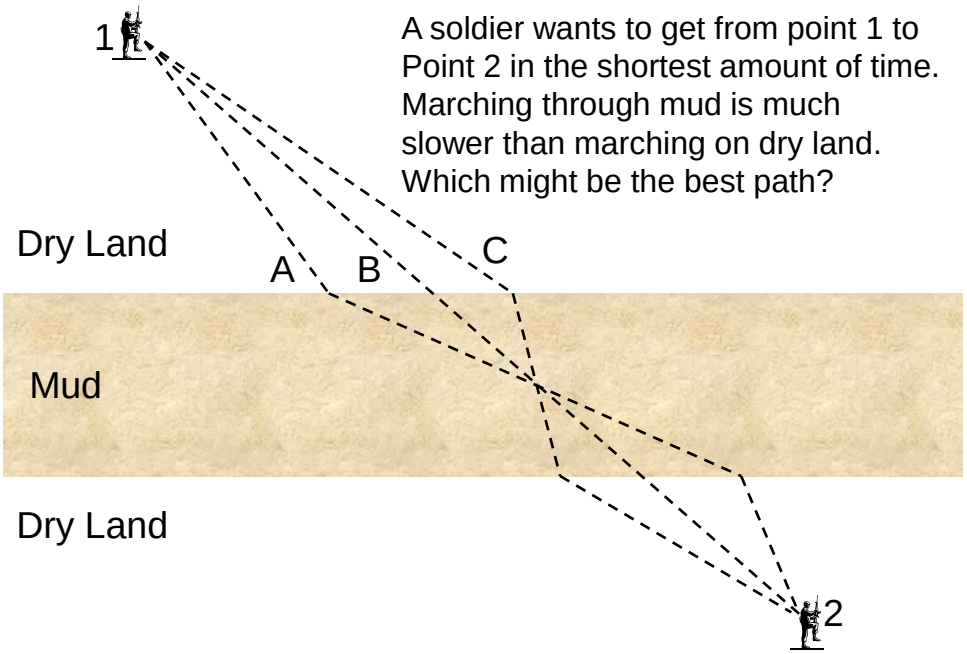


Cause of Refraction

- Bending of light when it passes from one medium to another
- Caused by change in speed of light

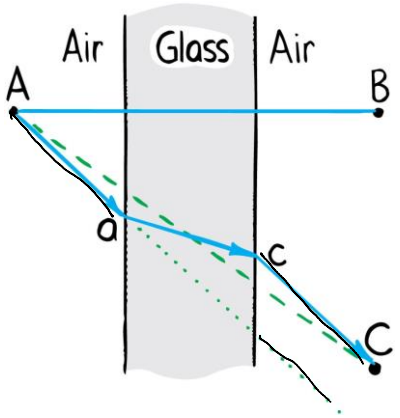






Refraction

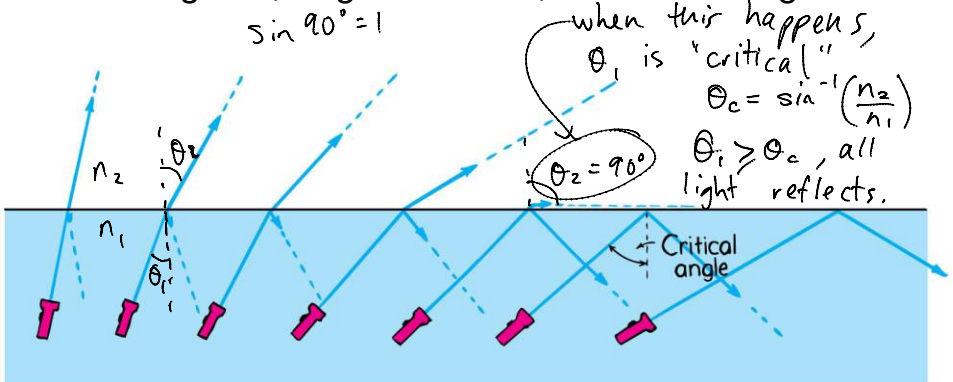
Light travels slower in glass than in air, so it minimizes the time it spends in the glass.



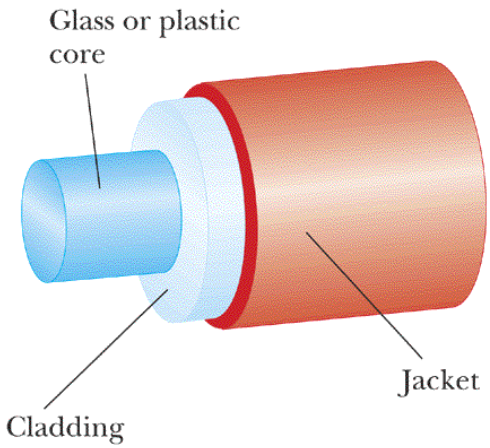
Total Internal Reflection

Law of Refraction: $n_1 \sin\theta_1 = n_2 \sin\theta_2$

- Total reflection of light traveling within a medium that strikes the boundary of another medium at an angle at, or greater than, the critical angle

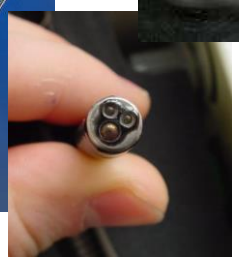


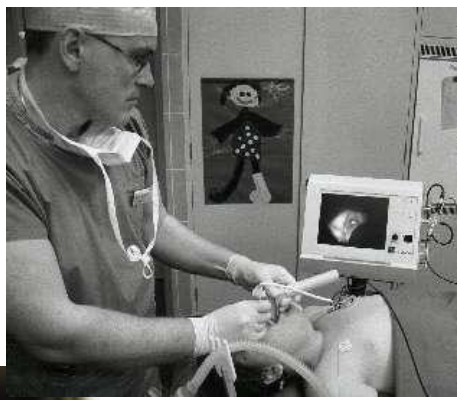
An Optical Fibre



Speed of light in cladding is *higher* than speed of light in core.

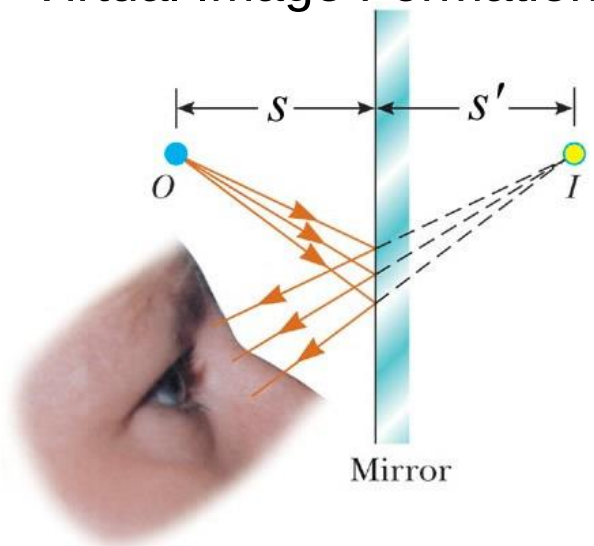
Medical Fibrescopes





Video-laryngoscopy with a flexible fiberscope

Virtual Image Formation



No light rays actually pass through or even near the image, so it is “virtual”.

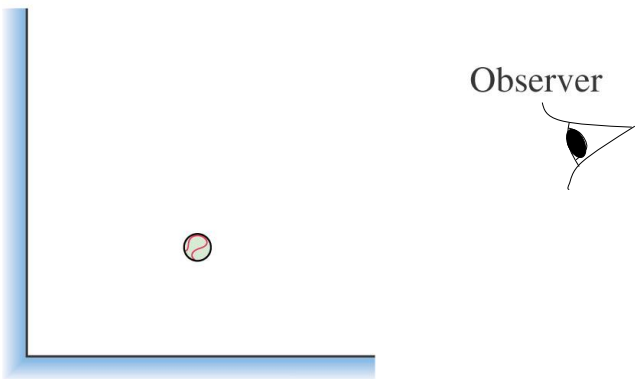
Two plane mirrors form a right angle. How many images of the ball can the observer see in the mirrors?

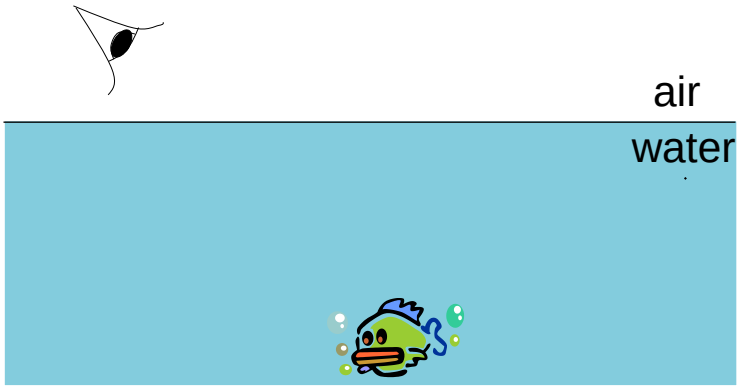
A. 1

B. 2

C. 3

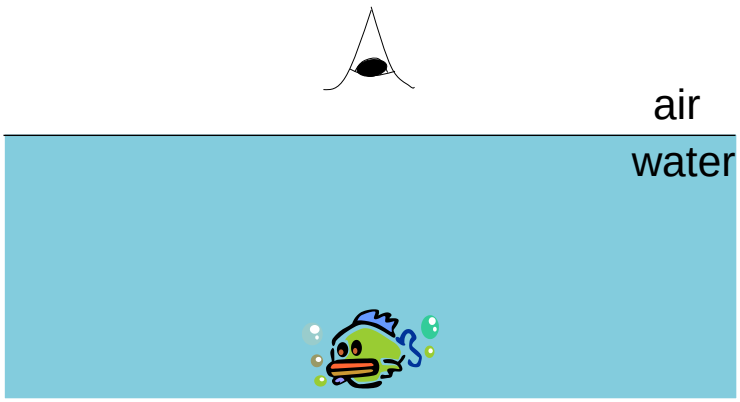
D. 4





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.

Before Class 7 on Monday

- Please read Knight Pgs. 670-686: Ch. 23, sections 23.6-23.8
- Don’t forget Problem Set 2 due on Sunday night!

- Something to think about: What is the difference between a converging and diverging lens? Which type can be used to focus sunlight onto a piece of paper and burn a hole?