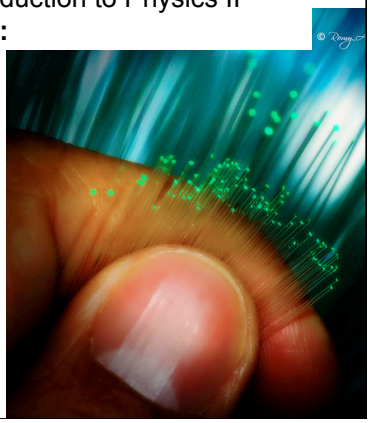
PHY132H1F Introduction to Physics II
Class 5 – **Outline:**

- Reflection and Refraction
- Fibre-Optics
- Colour and Dispersion
- Thin Lens Equation
- Image Formation



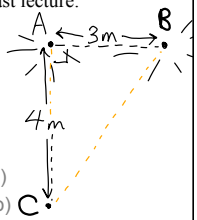
Quick reading quiz..

A virtual image is

A. the cause of optical illusions.
B. a point from which rays appear to diverge.
C. an image that only seems to exist.
D. the image that is left in space after you remove a viewing screen.
E. an image that only can be viewed with a web-browser.

Recall *In Class Discussion Question 5* from last lecture:

Two speakers, A and B, are "in phase" and emit a pure note with a wavelength 2 m. The speakers are side-by-side, 3 m apart. Point C is 4 m directly in front of speaker A.

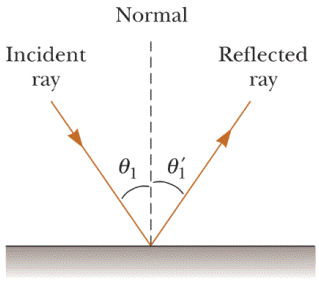


At point C, there will be

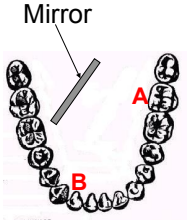
A. Perfect constructive interference (A_C=2A)
B. Perfect destructive interference (A_C=zero)
C. Intermediate interference (0 < A_C < 2A)

The answer I was looking for was B, since the waves are perfectly out of phase (phase difference = pi). However, these are point sources so the intensity drops as 1/r2, meaning the amplitude from B will be less than the amplitude from A. So they will not exactly cancel – the correct answer is C!

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?

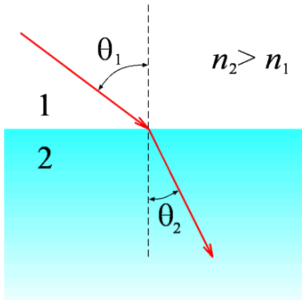
A. 90°
B. 45°
C. 180°

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



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

TABLE 23.1 Indices of refraction

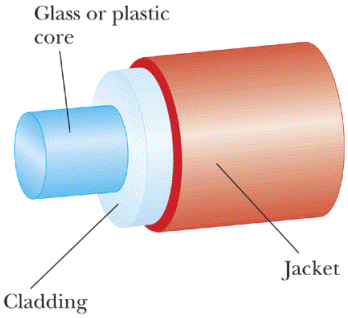
Medium	*n*
Vacuum	1.00 exactly
Air (actual)	1.0003
Air (accepted)	1.00
Water	1.33
Ethyl alcohol	1.36
Oil	1.46
Glass (typical)	1.50
Polystyrene plastic	1.59
Cubic zirconia	2.18
Diamond	2.41
Silicon (infrared)	3.50

Total Internal Reflection

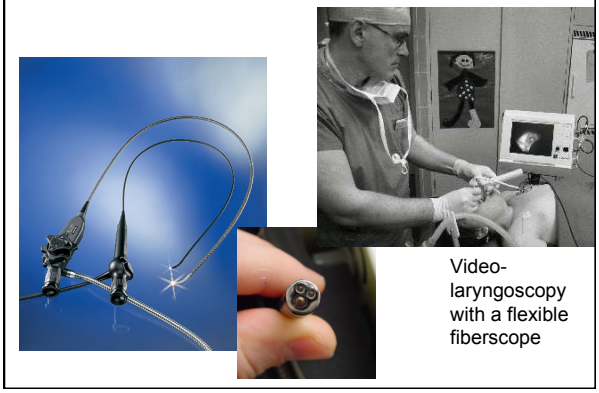
- Occurs when $n_2 < n_1$
- θ_c = critical angle.
- When $\theta_1 \geq \theta_c$, no light is transmitted through the boundary; 100% reflection

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

An Optical Fibre



Medical Fibrescopes



Video-laryngoscopy with a flexible fiberscope

Color

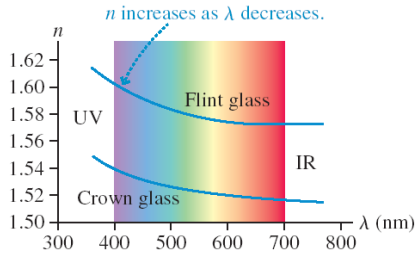
Different colors are associated with light of different wavelengths. The longest wavelengths are perceived as red light and the shortest as violet light. Table 23.2 is a brief summary of the *visible spectrum* of light.

TABLE 23.2 A brief summary of the visible spectrum of light

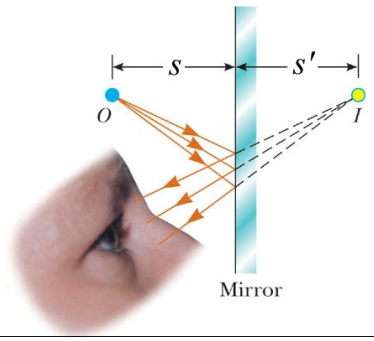
Color	Approximate wavelength
Deepest red	700 nm
Red	650 nm
Green	550 nm
Blue	450 nm
Deepest violet	400 nm

Dispersion

The slight variation of index of refraction with wavelength is known as **dispersion**. Shown is the dispersion curves of two common glasses. Notice that ***n* is larger when the wavelength is shorter**, thus violet light refracts more than red light.



How a virtual image is formed from a flat mirror

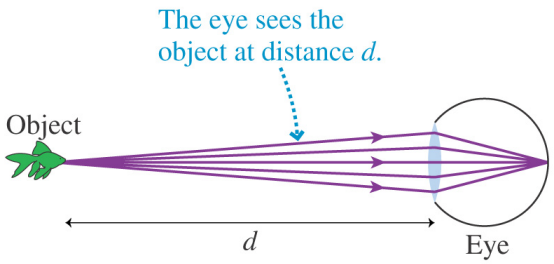


Virtual Image in a flat mirror

- 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.

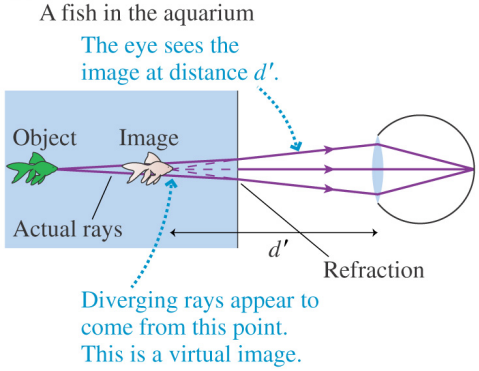
Depth perception

A fish out of water



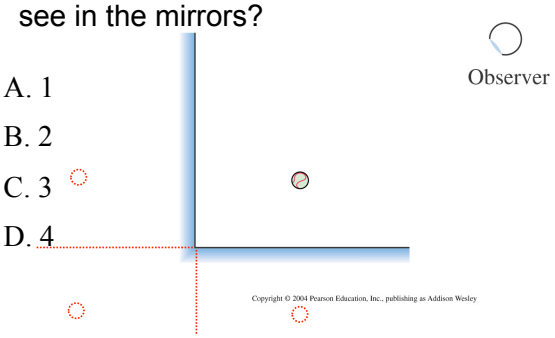
Apparent Depth

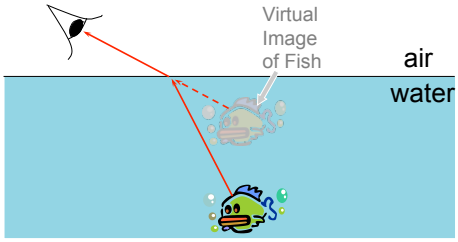
A fish in the aquarium



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

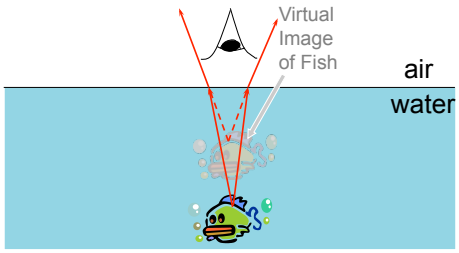
A. 1
B. 2
C. 3
D. 4





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.



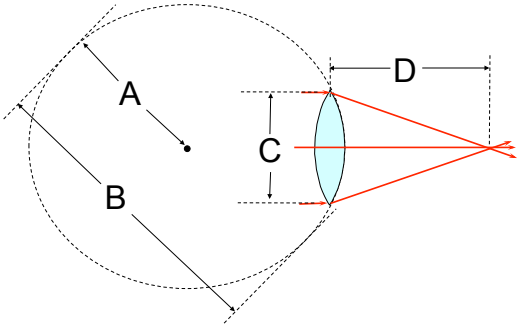
A fish swims *directly* below the surface of the water. An observer sees the fish at:

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

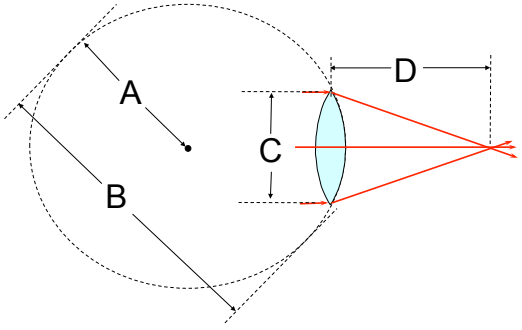
Lenses

- Formed by two curved boundaries between transparent media.
- Lenses often have spherical surfaces (lens-maker's equation). The curved surfaces are parts of large spheres of radius R_1 or R_2.
- ***Every*** lens shaped like a circle has a diameter, D, and focal length, f.
- The ratio of (f / D) is called "f-number". For example, an "f/6" lens has a focal length of 6 times its diameter.

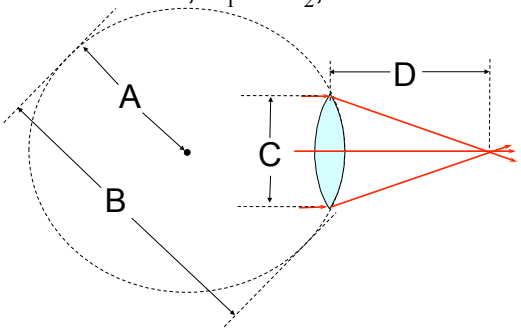
Which quantity is the Diameter, D, of the Lens?



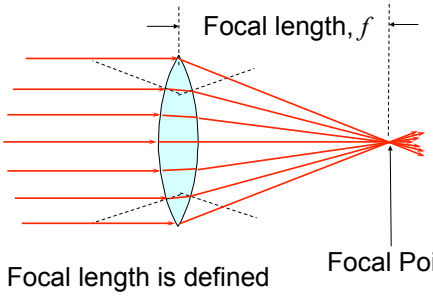
Which quantity is the Focal Length, f, of the Lens?



Which quantity is the Radius of curvature, R_1 or R_2, of the Lens?

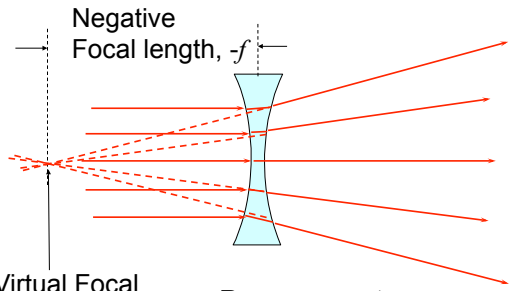


Converging Lens



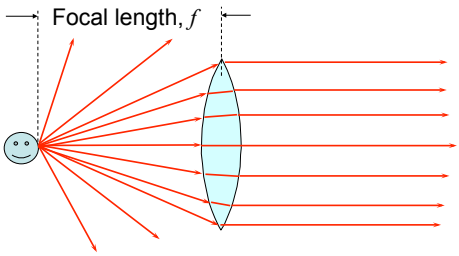
NOTE: Focal length is defined for initially parallel rays.

Diverging Lens

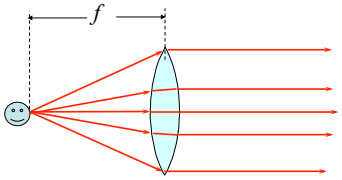


Rays appear to emerge from Virtual Focal Point

Diverging rays through a Converging Lens

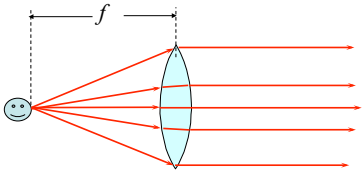


This follows from the principle of reversibility.



What will happen to the rays emerging to the right of the lens if the face is moved a little closer to the lens?

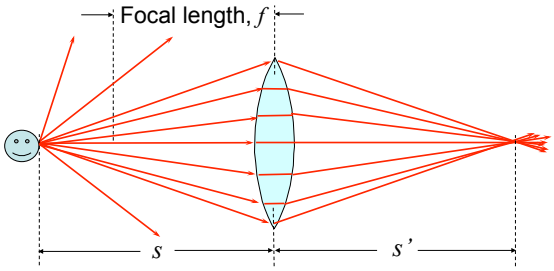
A. They will remain parallel.
B. They will diverge (spread out).
C. They will converge (toward a focus).



What will happen to the rays emerging to the right of the lens if the face is moved a little further away from the lens?

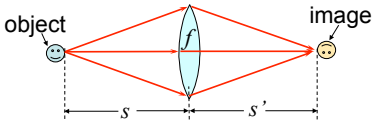
A. They will remain parallel.
B. They will diverge (spread out).
C. They will converge (toward a focus).

Diverging rays through a Converging Lens



Thin Lens Equation: $\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}$

Thin Lens Equation: sign conventions



$$\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}$$

s is positive for objects to the left of lens, negative for objects to the right of lens (virtual objects).

s' is positive for images to the right of lens, negative for images to the left of lens (virtual images).

f is positive for converging lenses, negative for diverging lenses.

Magnification

$$|M| \equiv \frac{h'}{h} \qquad M = -\frac{s'}{s}$$

- The absolute magnitude of the magnification $|M|$ is defined to be the ratio of image height to object height.
- A positive value of M indicates that the image is upright relative to the object. A negative value of M indicates the image is inverted relative to the object.
- Note that when s and s' are both positive, M is negative.

Before Next Class:

- Please read Chapter 24. But you can skip section 24.5 (we won't be covering this on the tests or exam)
- Try the suggested end-of-chapter problems for Chapter 23

See you Wednesday!