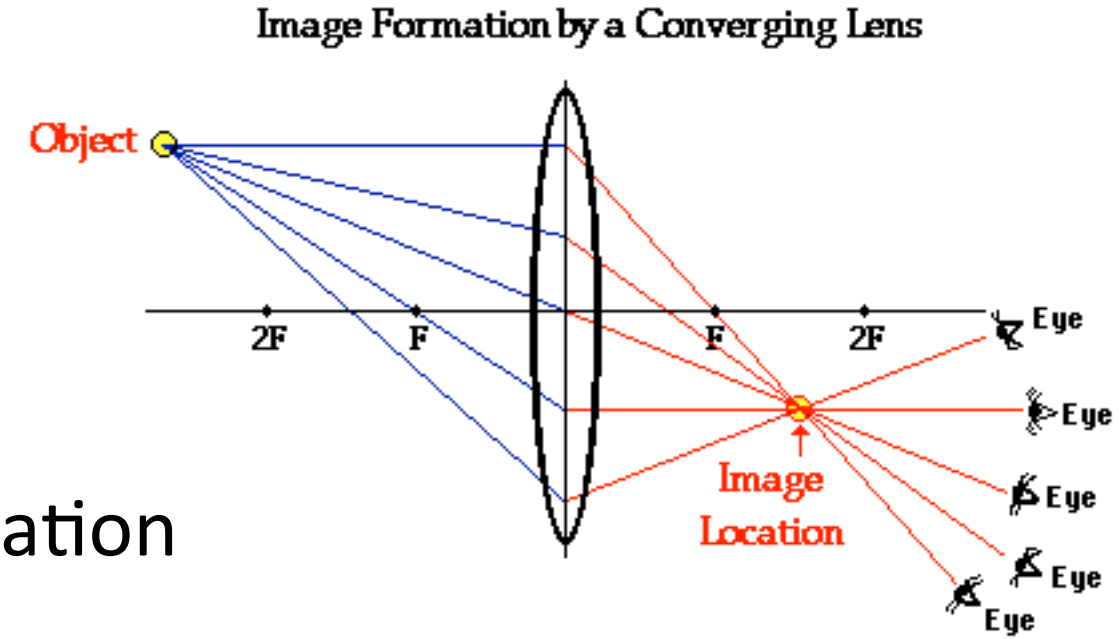
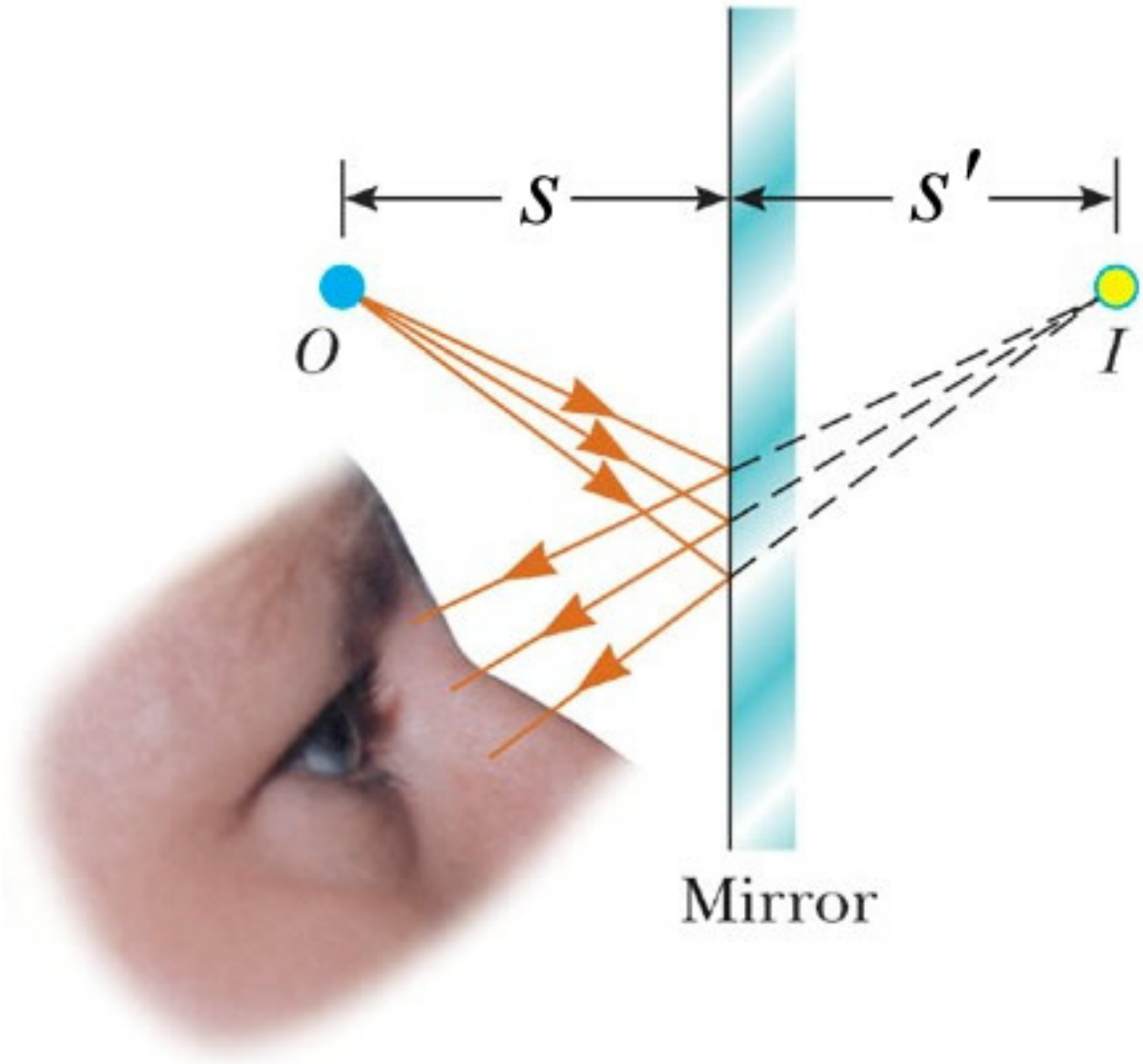
PHY385-H1F Introductory Optics

Class 9 – Outline: Sections 5.1, 5.2

- Geometrical Optics Introduction
- Refraction at a Curved Surface
- Thin Lens Equation
- Focal Point
- Focal Plane
- Images
- Magnification
- Lenses in Combination

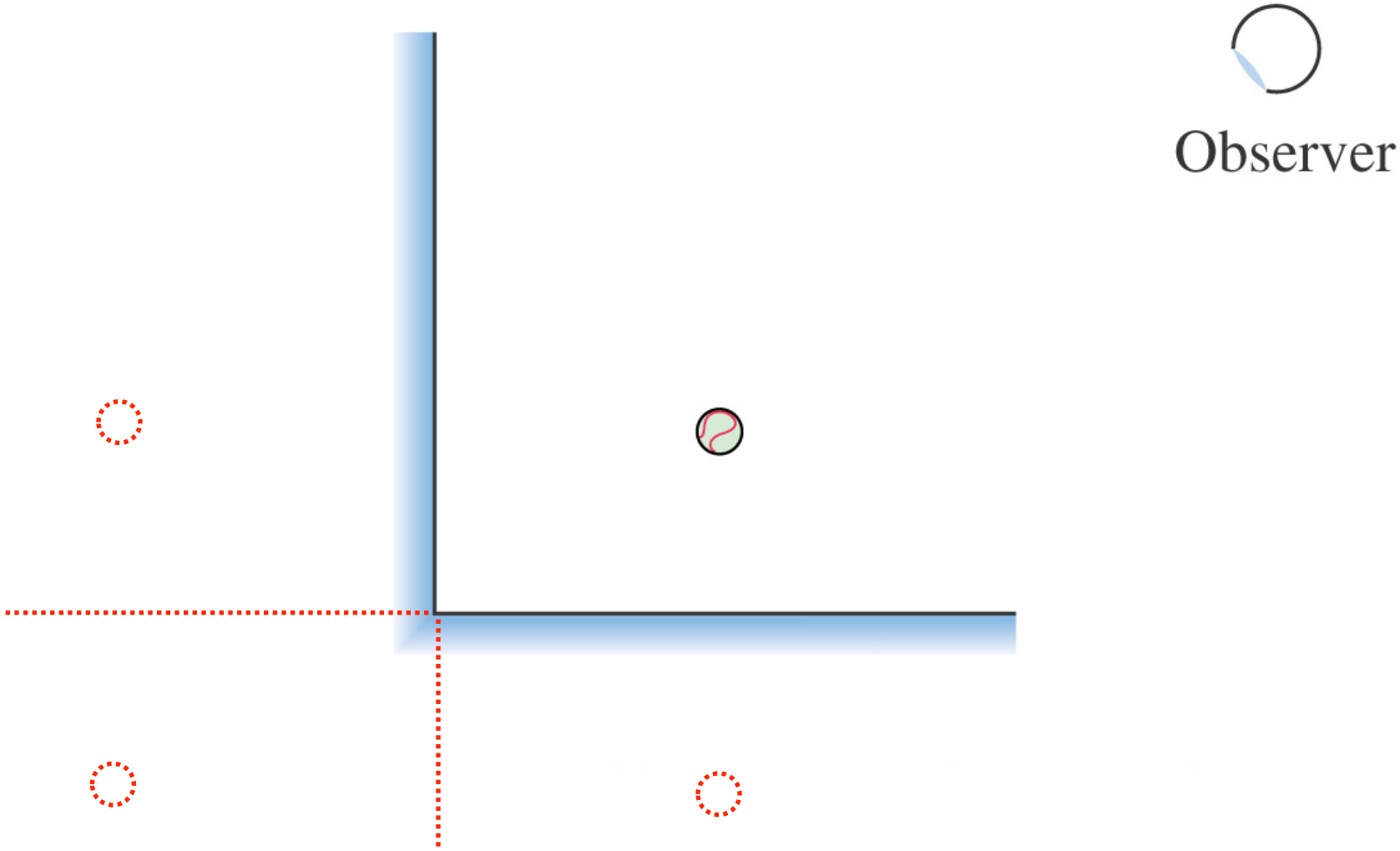


How an image is formed

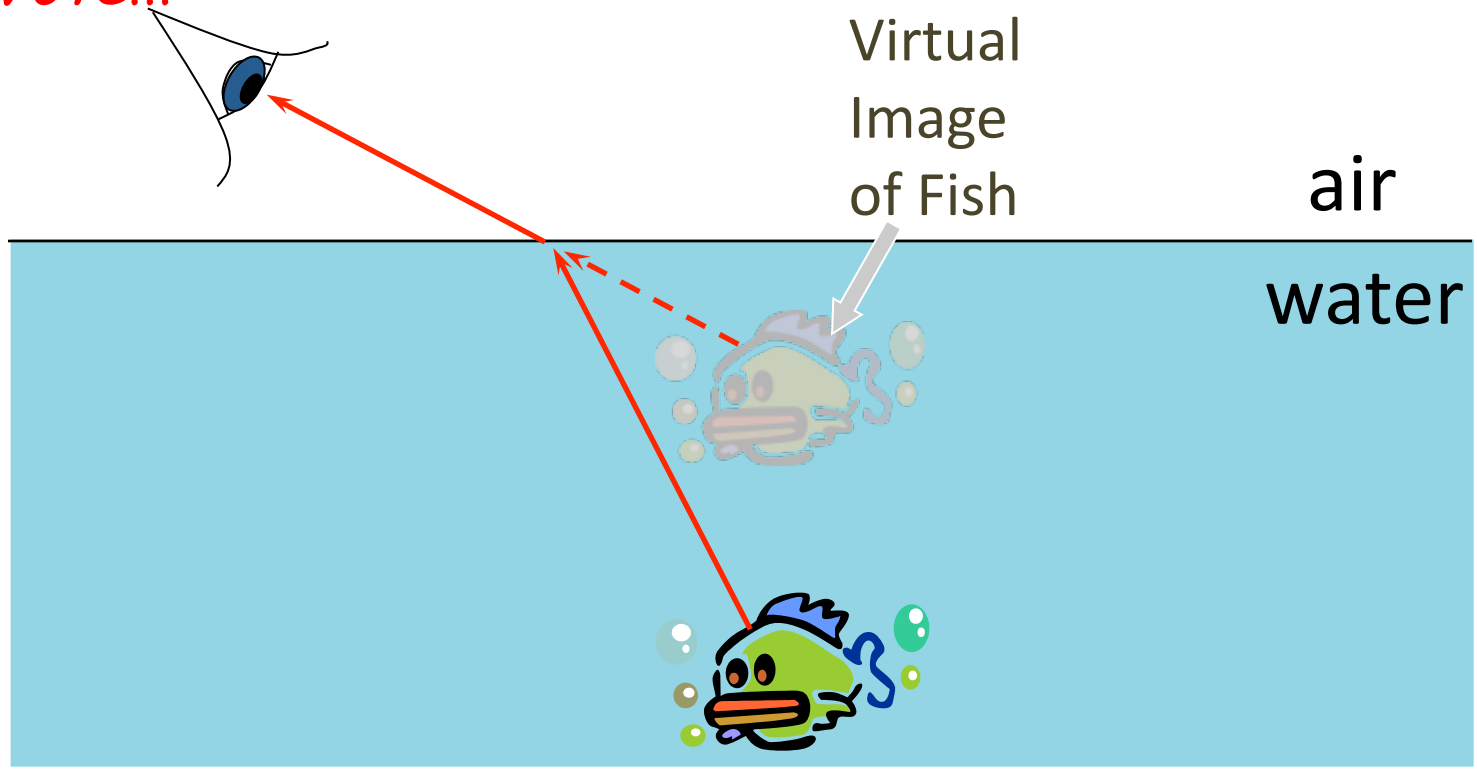


Finger Vote!!!

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



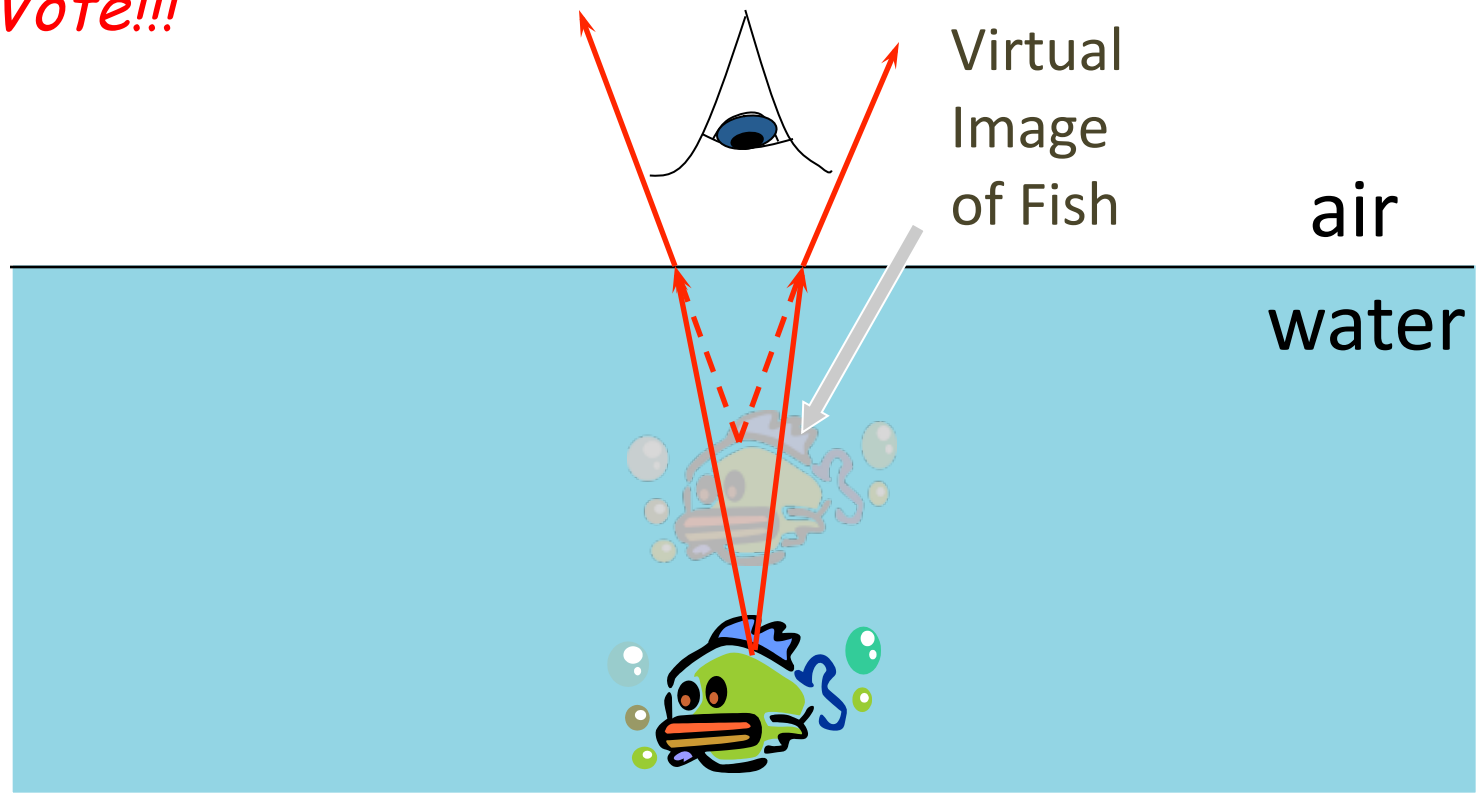
Finger Vote!!!



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

1. a greater depth than it really is.
2. its true depth.
3. a smaller depth than it really is.

Finger Vote!!!



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

1. a greater depth than it really is.
2. its true depth.
3. a smaller depth than it really is.

Image Formation from a Plane Surface

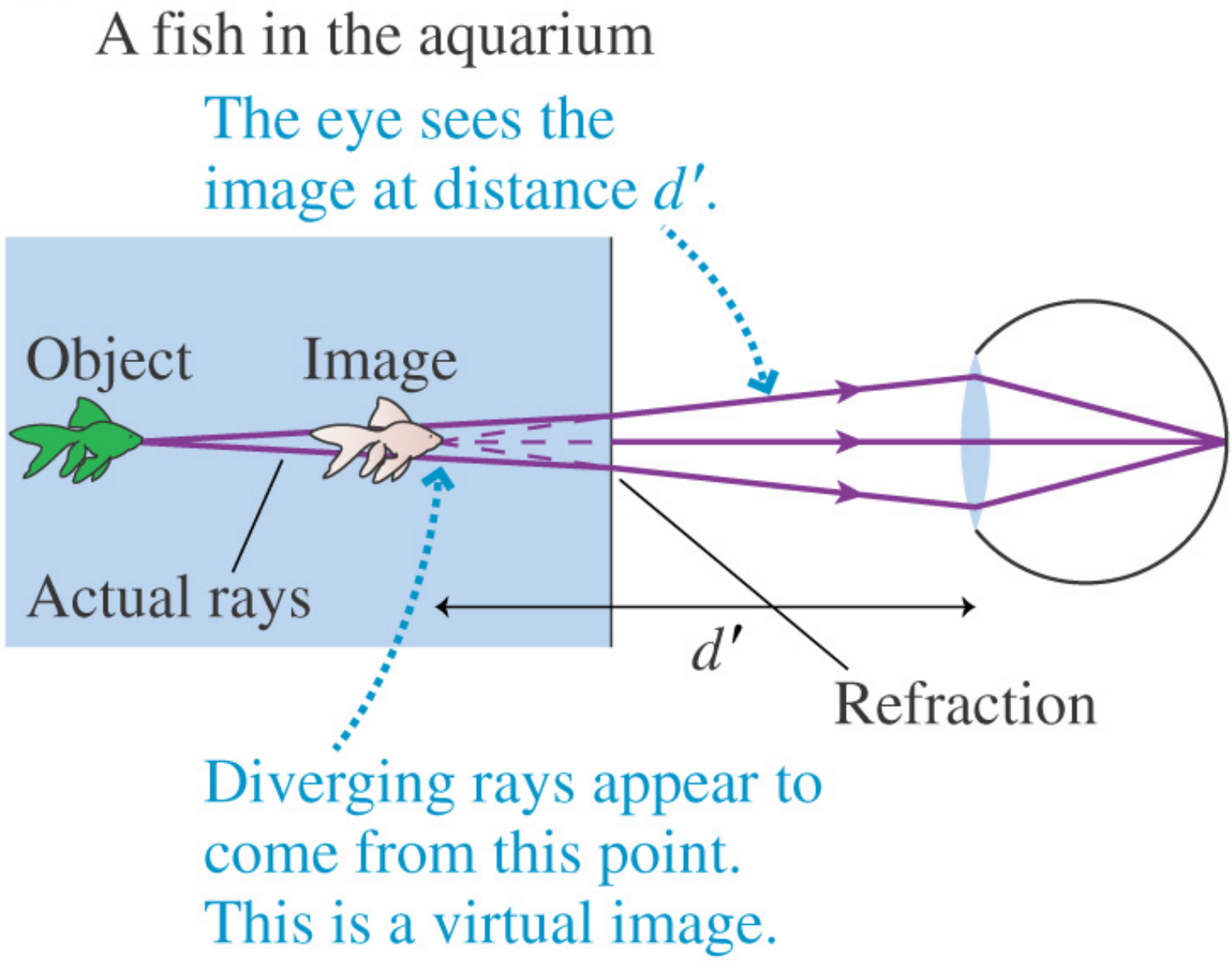
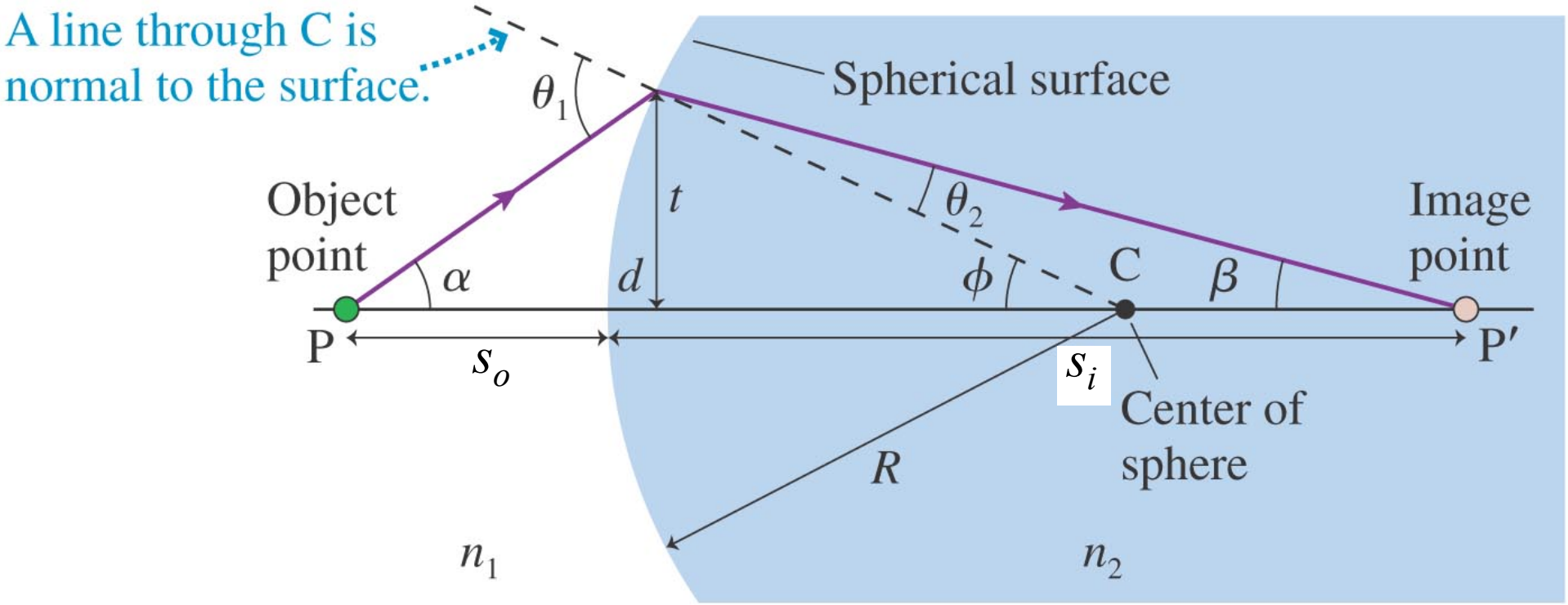


Image formation at a spherical interface



$$\frac{n_1}{s_o} + \frac{n_2}{s_i} = \frac{n_2 - n_1}{R}$$

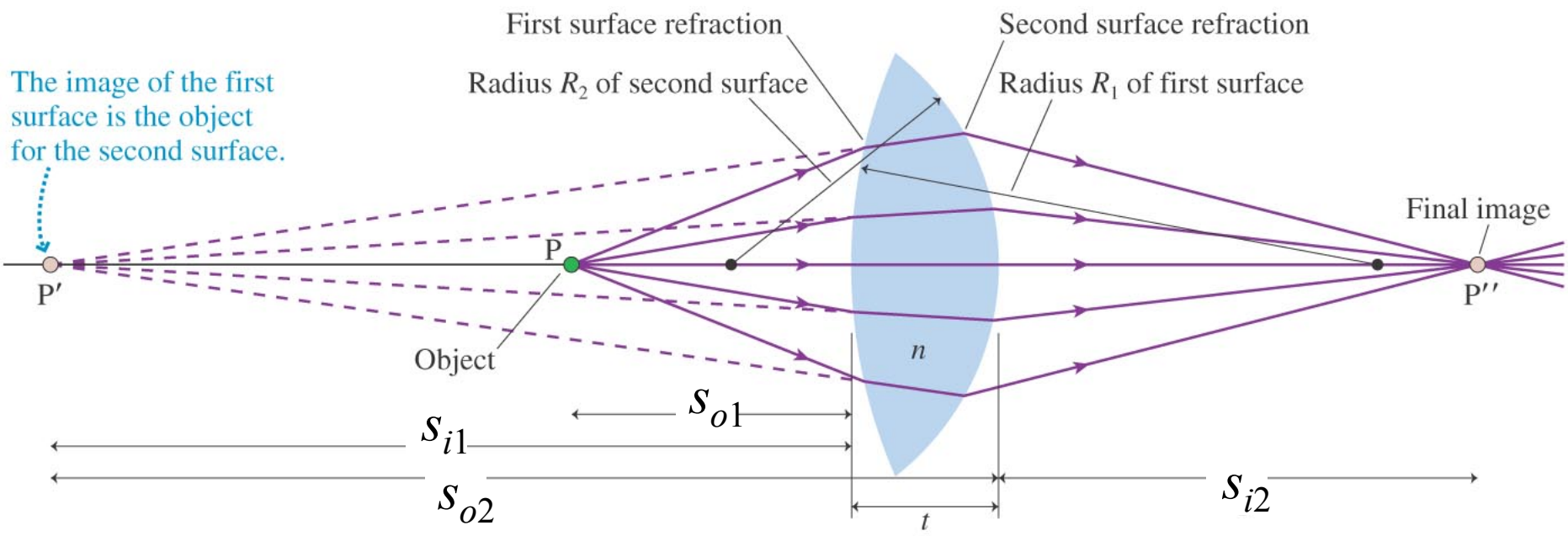
R is positive means surface is convex toward the object

R is negative means surface is concave toward object

s_o is positive means object is to the left of interface

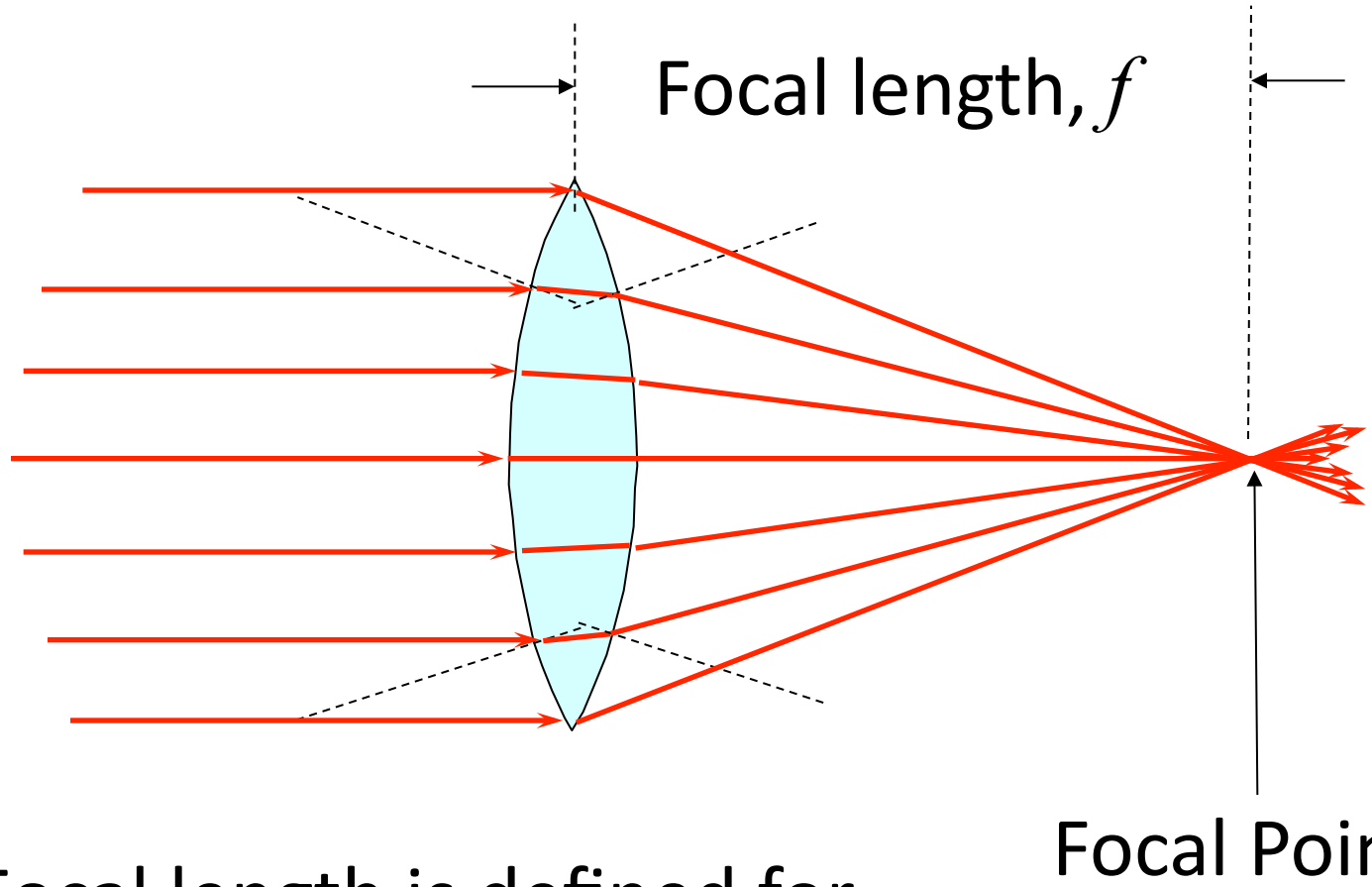
s_i is positive means image is real, to the right of interface

Lensmaker's Formula



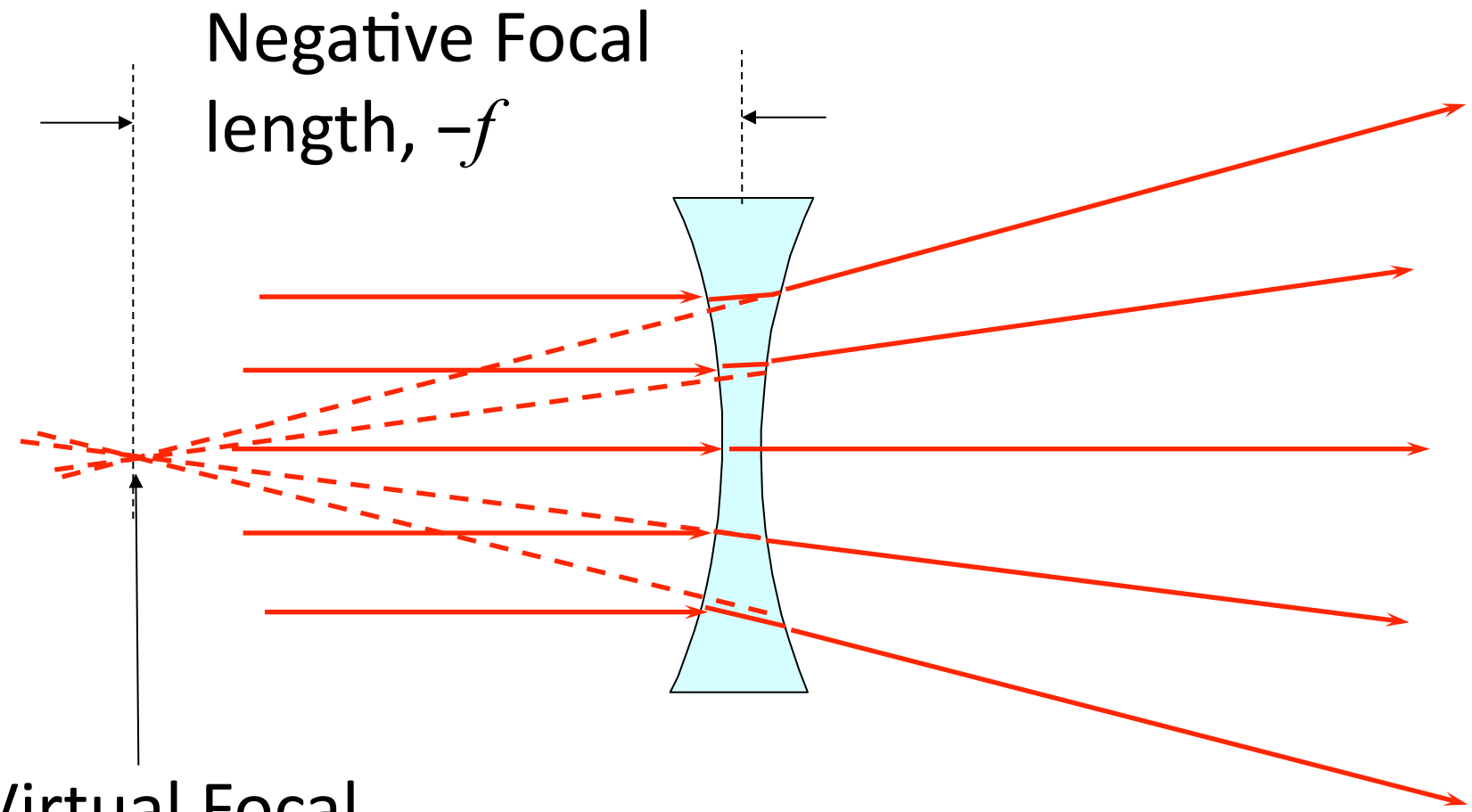
$$\frac{1}{s_{o1}} + \frac{1}{s_{i2}} = (n_l - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Converging Lens

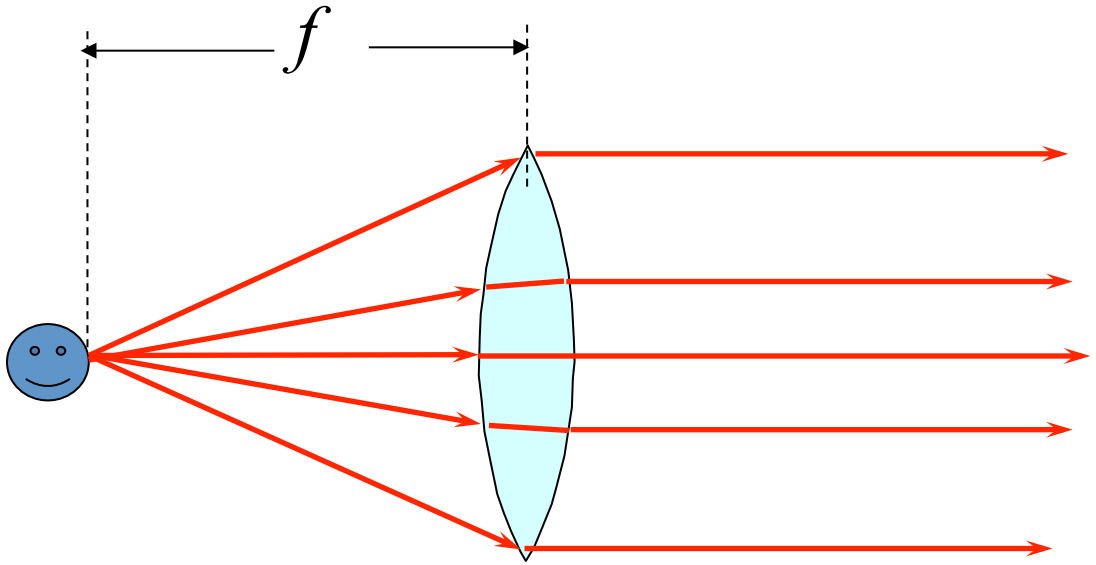


NOTE: Focal length is defined for initially *parallel* rays.

Diverging Lens



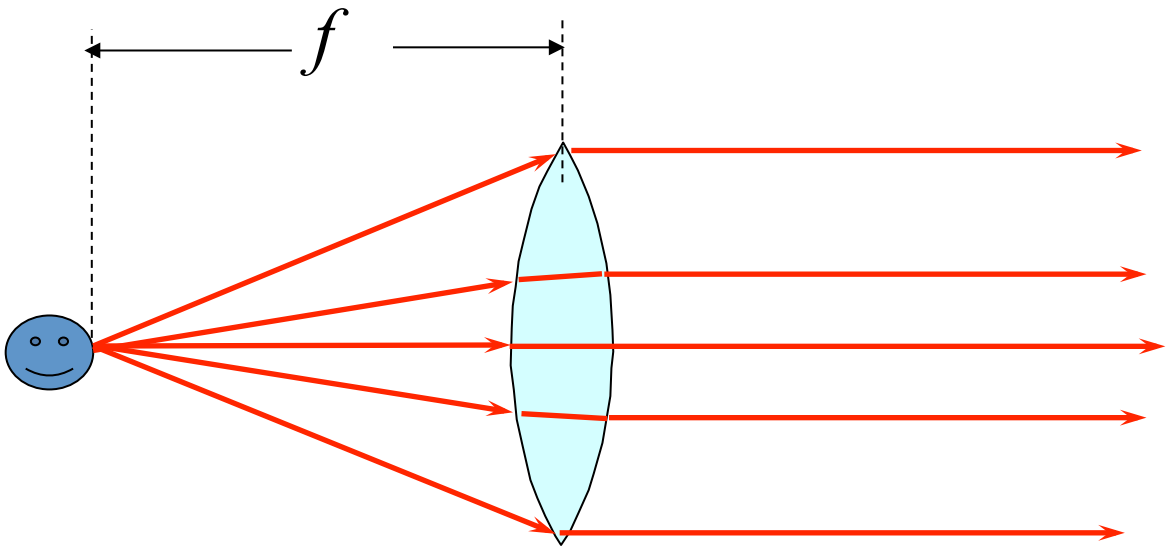
Finger Vote!!!



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

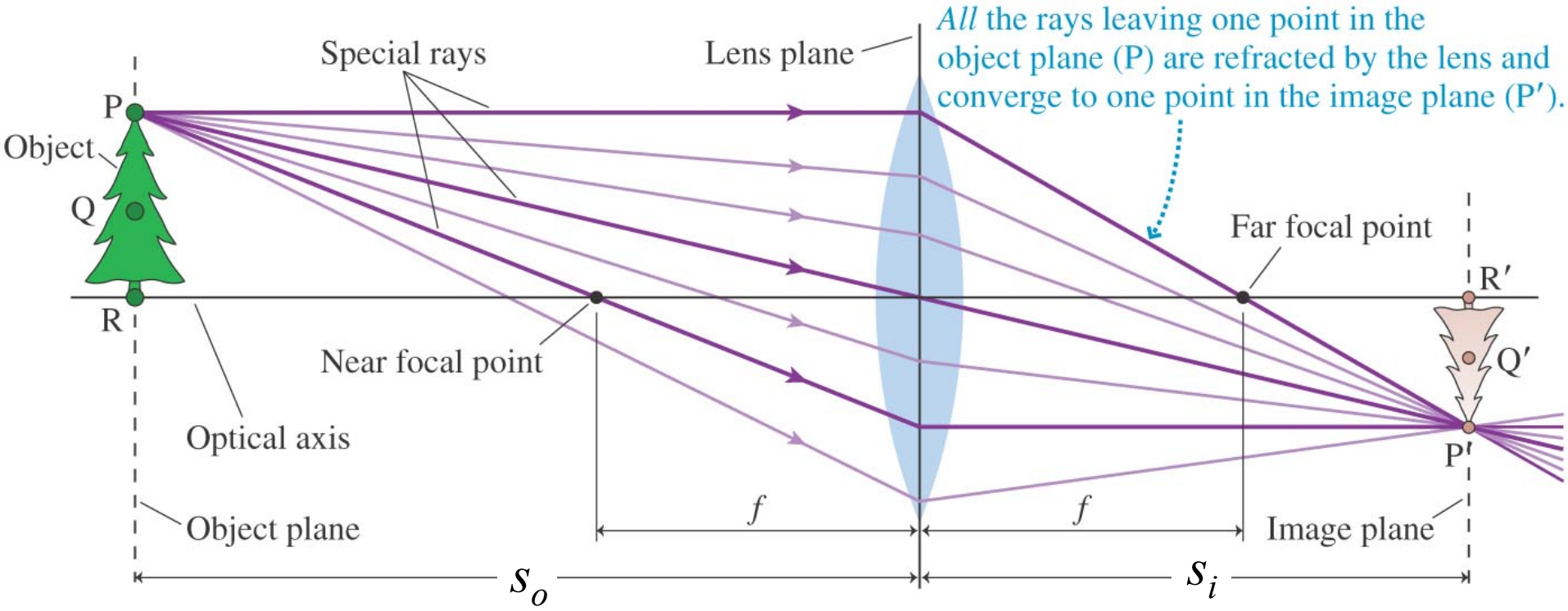
1. They will remain parallel.
2. They will diverge (spread out).
3. They will converge (toward a focus).

Finger Vote!!!



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?

1. They will remain parallel.
2. They will diverge (spread out).
3. They will converge (toward a focus).



The Thin Lens Equation: $$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$$

f is positive for a converging lens

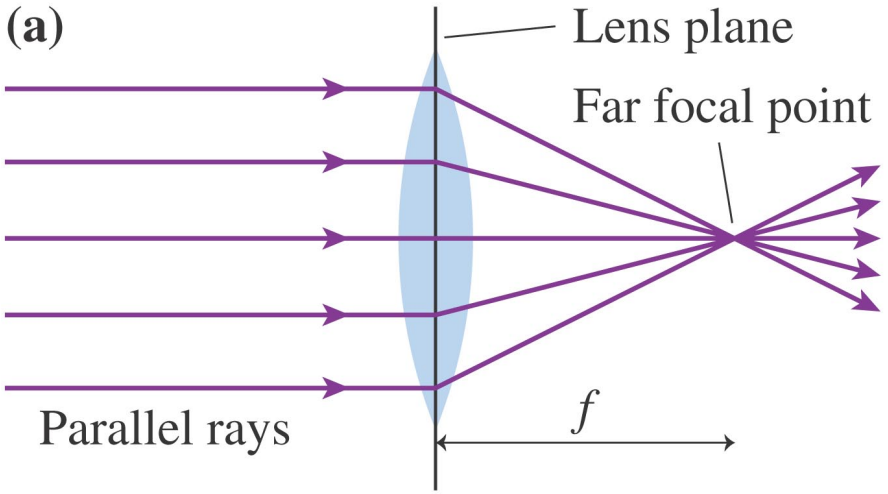
f is negative for a diverging lens

s_o is positive means object is real, to the left of lens

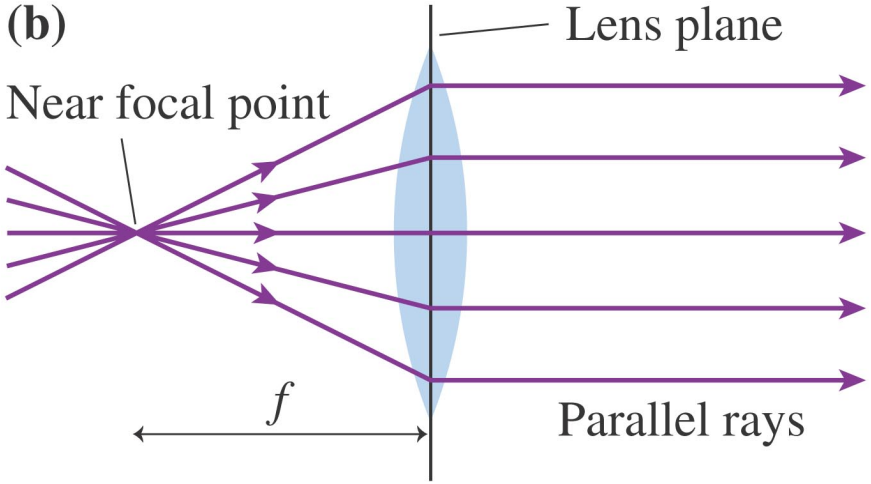
s_i is positive means image is real, to the right of lens

s_i is negative means image is virtual, to the left of lens

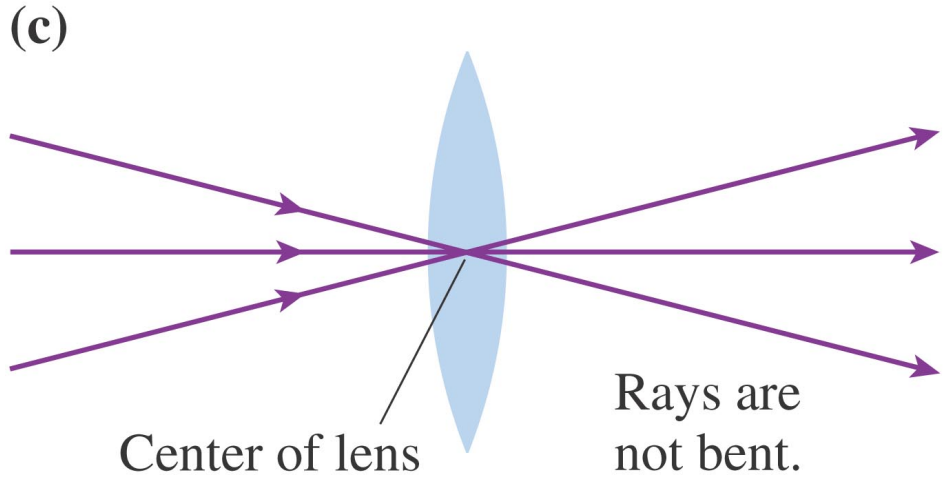
Ray Tracing
With a converging thin lens



Any ray initially parallel to the optical axis will refract through the focal point on the far side of the lens.

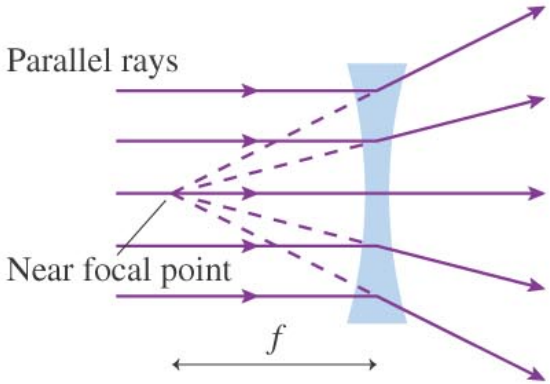


Any ray passing through the near focal point emerges from the lens parallel to the optical axis.

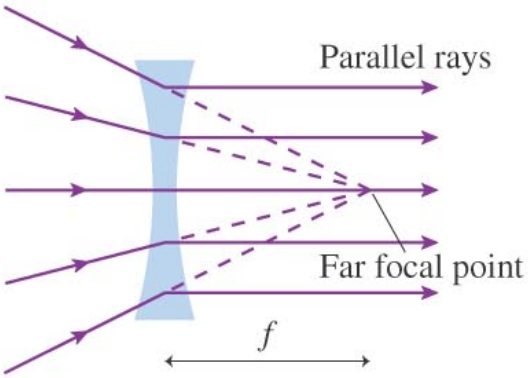


Any ray directed at the center of the lens passes through in a straight line.

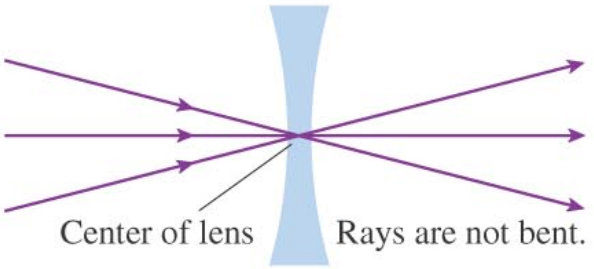
Ray Tracing
With a diverging thin lens



Any ray initially parallel to the optical axis diverges along a line through the near focal point.



Any ray directed along a line toward the far focal point emerges from the lens parallel to the optical axis.



Any ray directed at the center of the lens passes through in a straight line.

Thin Lens Combinations