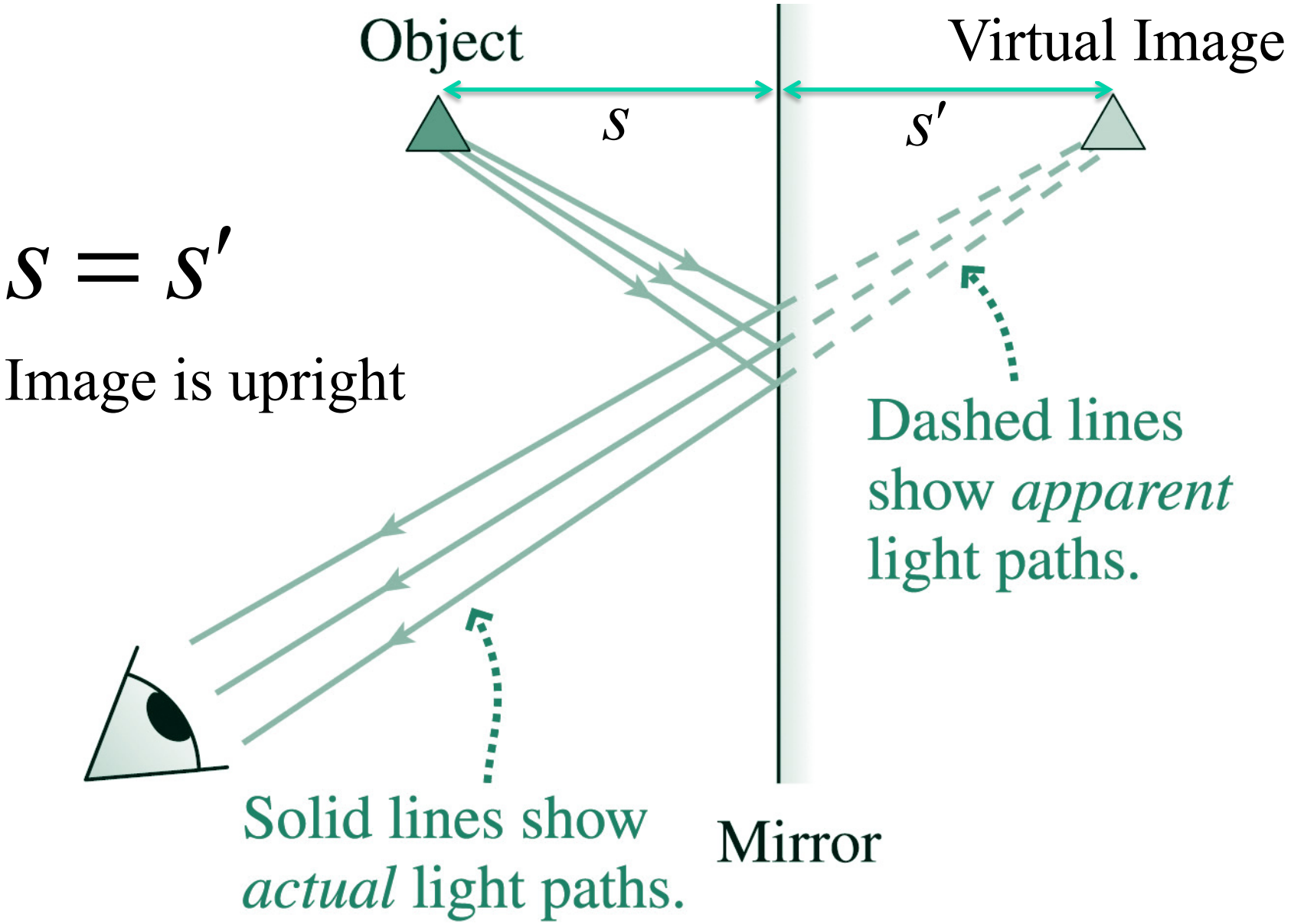
Chapter 31: Images/Optical Instruments
Tuesday November 29th

- **V. IMPORTANT: Final exam will be in HCB103/316**
  - **HCB316, last names A to J; HCB103, last names K to Z**
- **Mini-exam 6 on Thu. (Chs. 30/31, LONCAPA 21-23)**
- **Check your exam scores online**
- **Still 42 unregistered *i*Clickers; send email if unsure.**

- Review: images, mirrors and lenses (Ch. 31)
- The human eye
- Vision correction
- Microscopes and telescopes (if time)

Reading: up to page 560 in the text book (Ch. 31)

Images with Mirrors

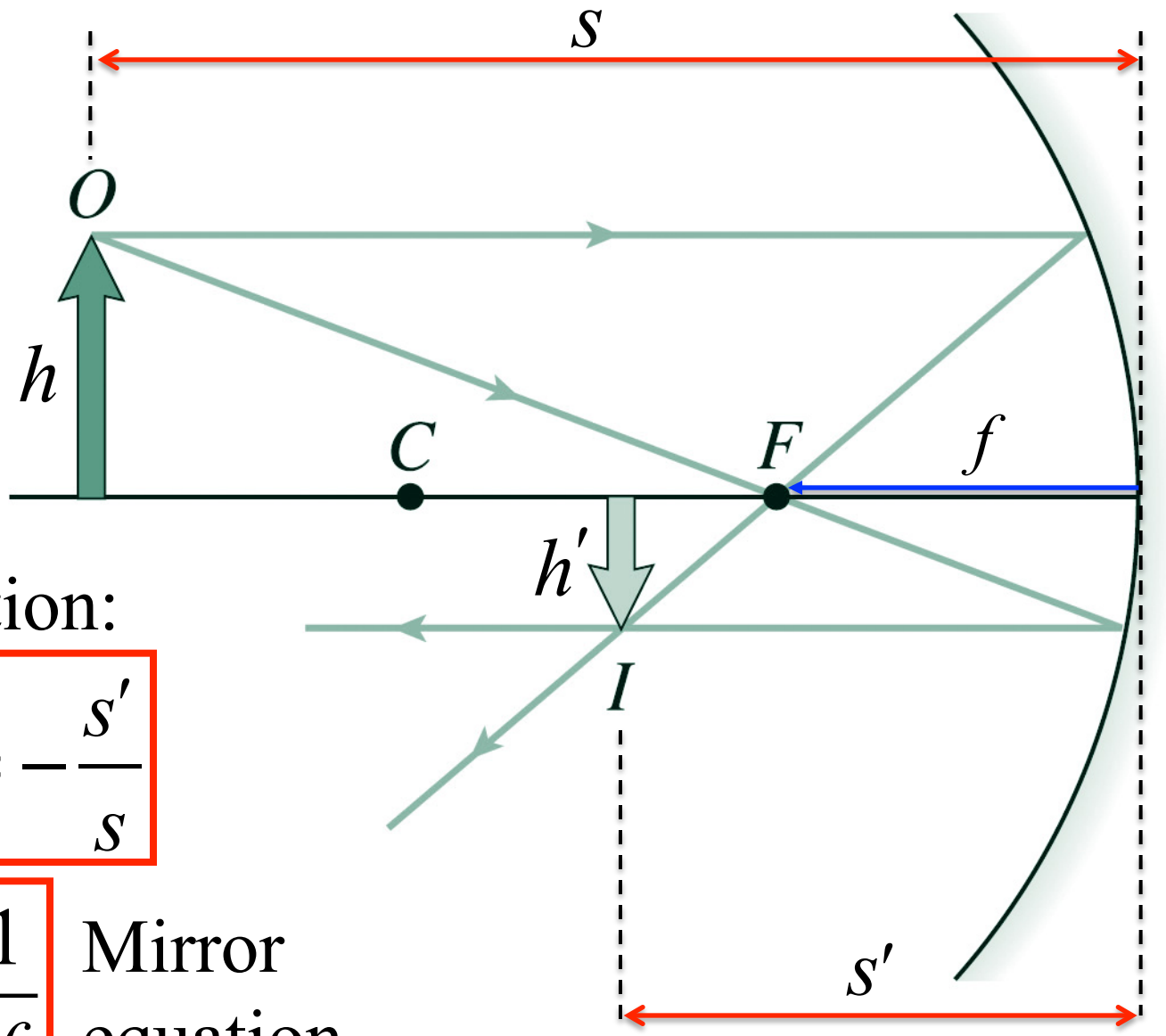


$s = s'$

Image is upright

Ray Tracing with Mirrors

$C = 2f$ for spherical mirror



Magnification:

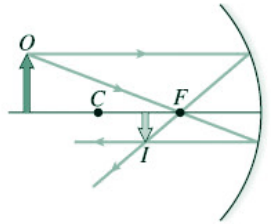
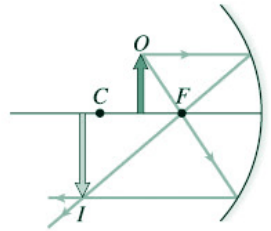
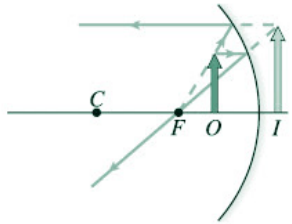
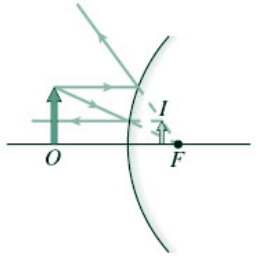
$$M = \frac{h'}{h} = -\frac{s'}{s}$$

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

Mirror equation

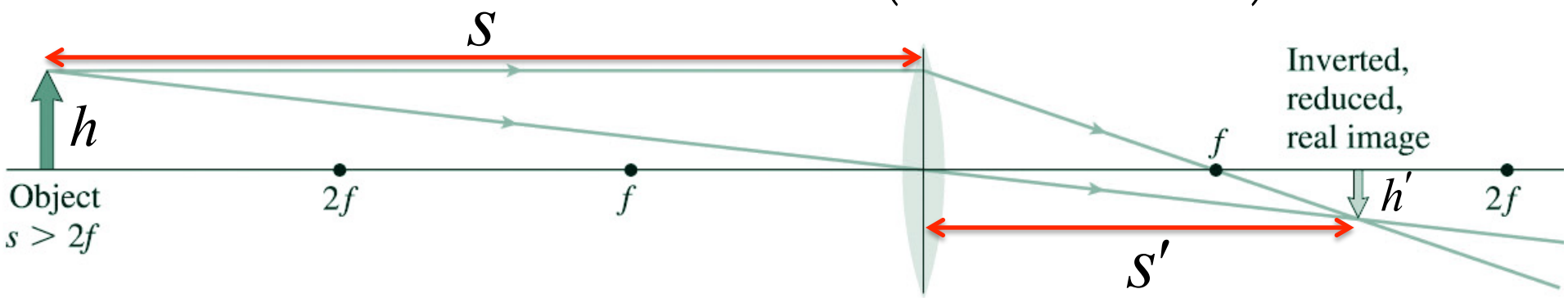
Summary for curved mirrors

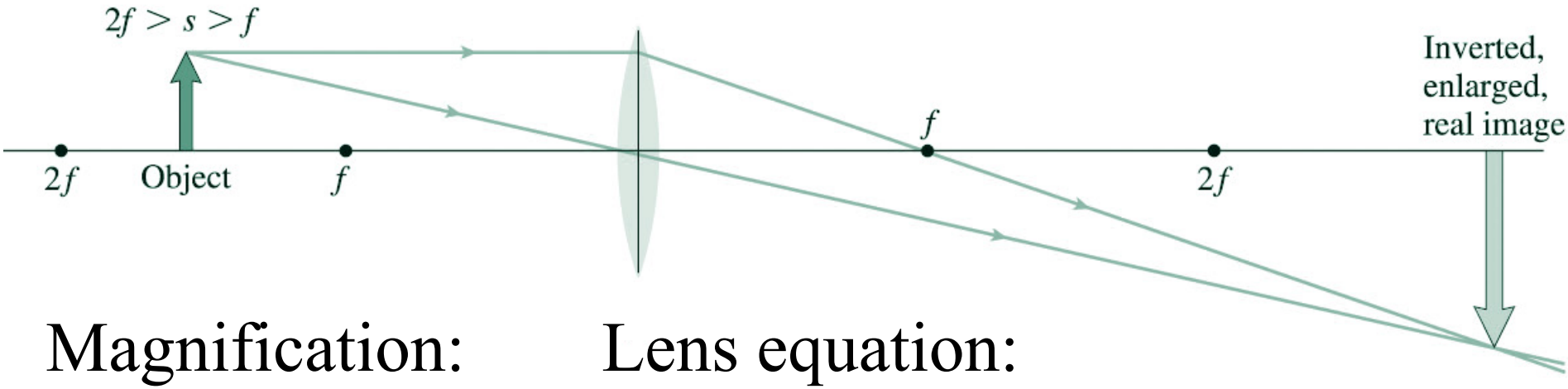
Table 31.1 Image Formation with Mirrors: Sign Conventions

Focal Length, f	Object Distance, s	Image Distance, s'	Type of Image	Ray Diagram
+ (concave)	+ (in front of mirror) $s > 2f$	+ (in front of mirror) $s' < 2f$	Real, inverted, reduced	
+ (concave)	+ (in front of mirror) $2f > s > f$	+ (in front of mirror) $s' > 2f$	Real, inverted, enlarged	
+ (concave)	+ (in front of mirror) $s < f$	− (behind mirror)	Virtual, upright, enlarged	
− (convex)	+ (in front of mirror)	− (behind mirror)	Virtual, upright, reduced	

Ray Tracing with Convex Lenses

Real image other side of lens $\left(f > 0,\ s' > 0\right)$





Magnification:

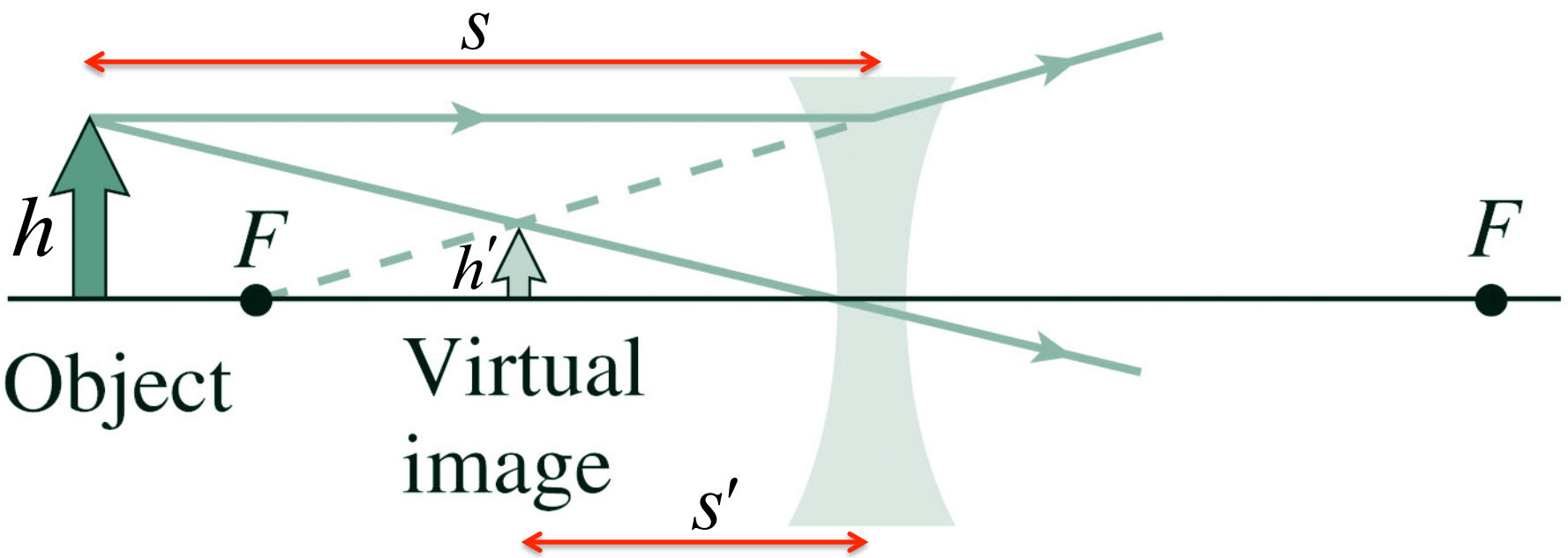
$$M = \frac{h'}{h} = -\frac{s'}{s}$$

Lens equation:

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

Ray Tracing with Concave Lenses

Virtual image same side of lens $\left(f < 0,\ s' < 0\right)$



Magnification:

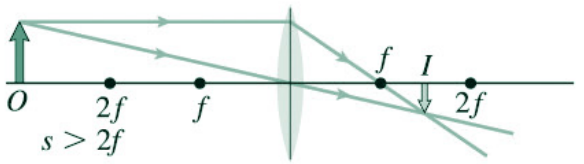
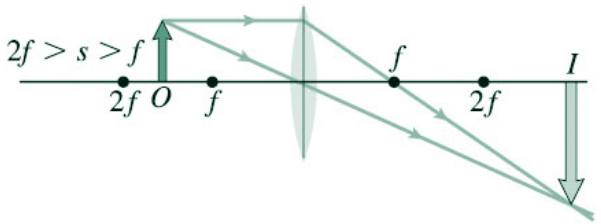
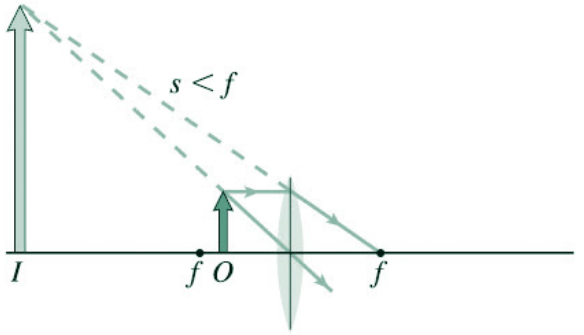
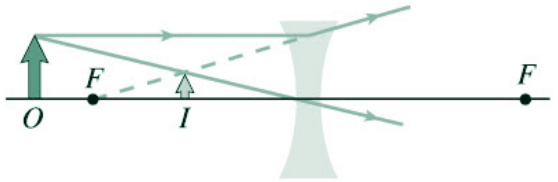
$$M = \frac{h'}{h} = -\frac{s'}{s}$$

Lens equation:

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

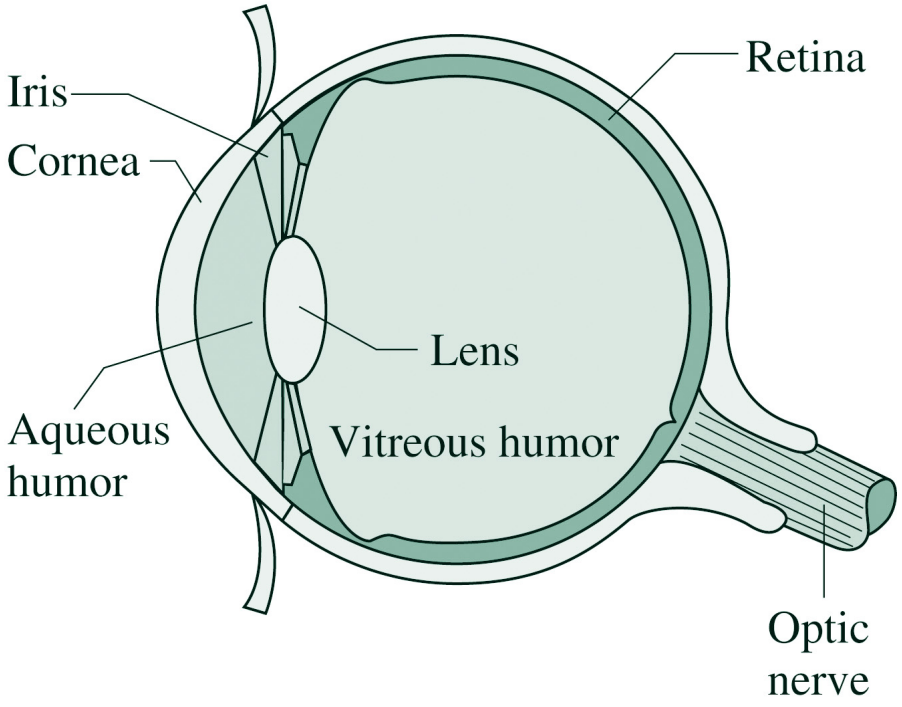
Summary for Lenses

Table 31.2 Image Formation with Lenses: Sign Conventions

Focal Length, f	Object Distance, s	Image Distance, s'	Type of Image	Ray Diagram
+ (convex)	+ $s > 2f$	+ (opposite side of lens) $2f > s' > f$	Real, inverted, reduced	
+ (convex)	+ $2f > s > f$	+ (opposite side of lens) $s' > 2f$	Real, inverted, enlarged	
+ (convex)	+ $s < f$	− (same side of lens)	Virtual, upright, enlarged	
− (concave)	+	− (same side of lens)	Virtual, upright, reduced	

The Human Eye

- The human eye is a complex optical instrument.
  - Refraction in the cornea, in the fluids of the eye ("humors"), and in the lens should form an image on the retina.
  - Most of the refraction occurs in the cornea.
  - The lens changes shape to adjust for different object distances.
  - Special cells in the retina respond to light by sending electrochemical signals to the brain through the optic nerve.



Myopia (nearsightedness)

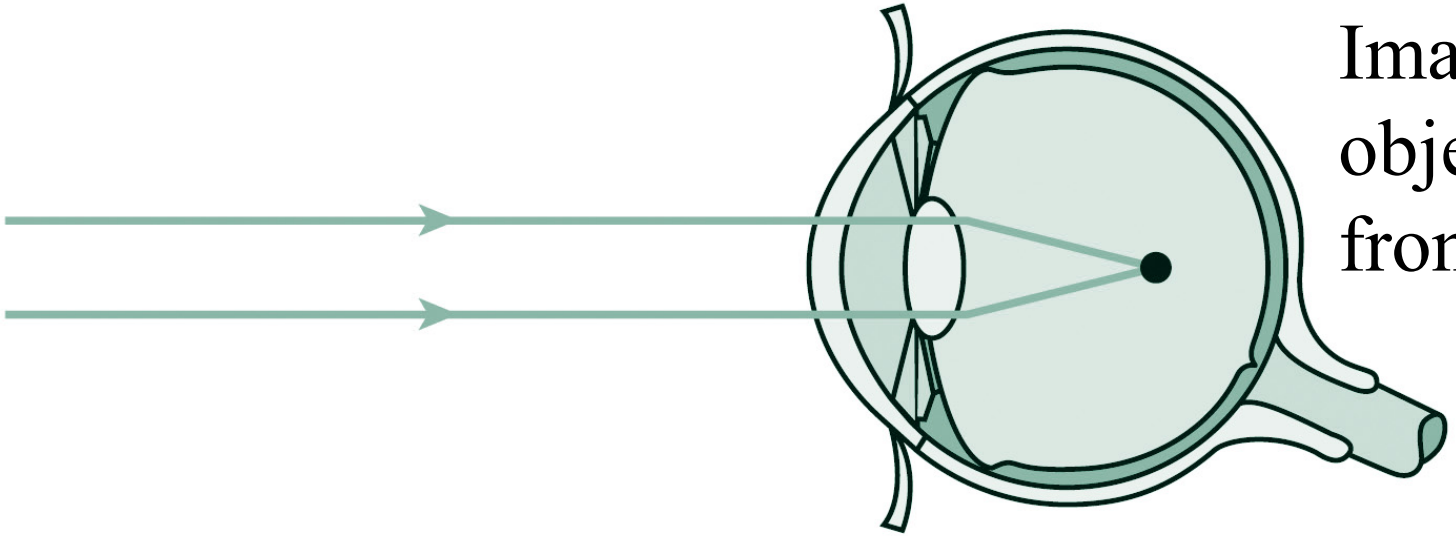
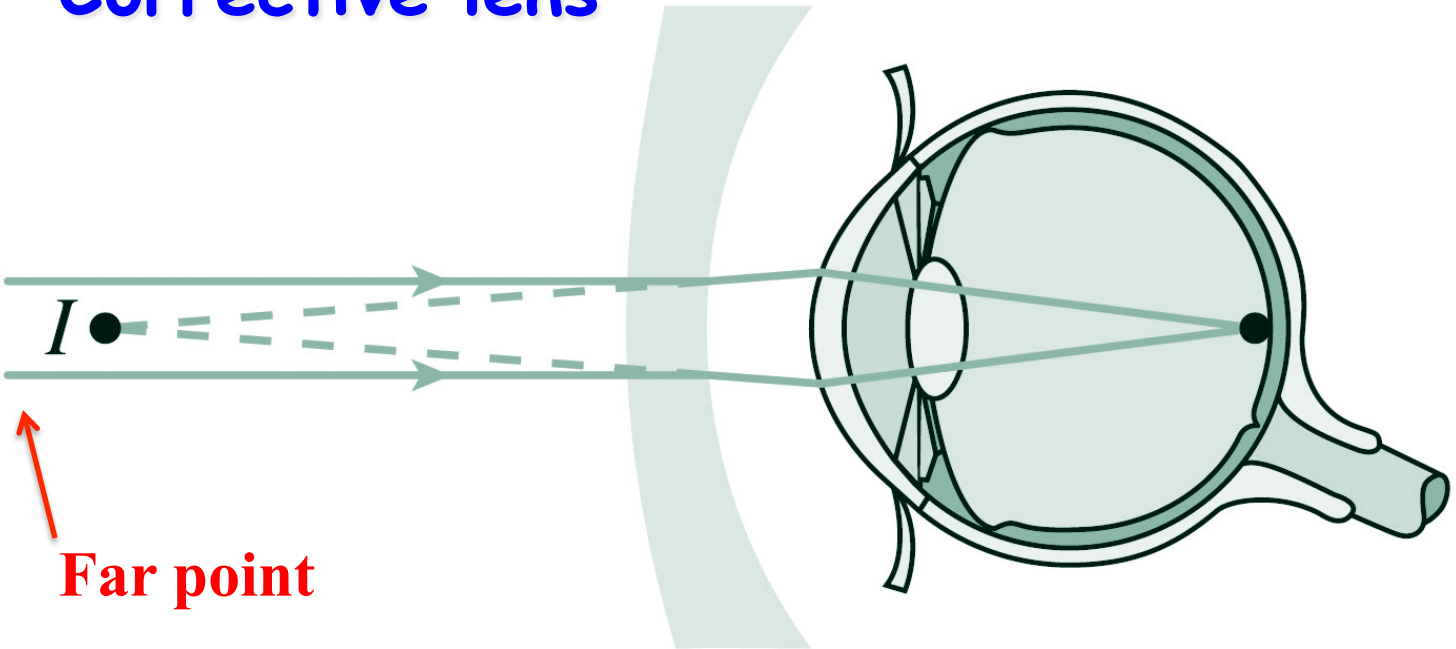


Image of distant object forms in front of retina

Corrective lens



A diverging lens corrects the problem by creating a virtual image closer to the eye

Hyperopia (farsightedness)

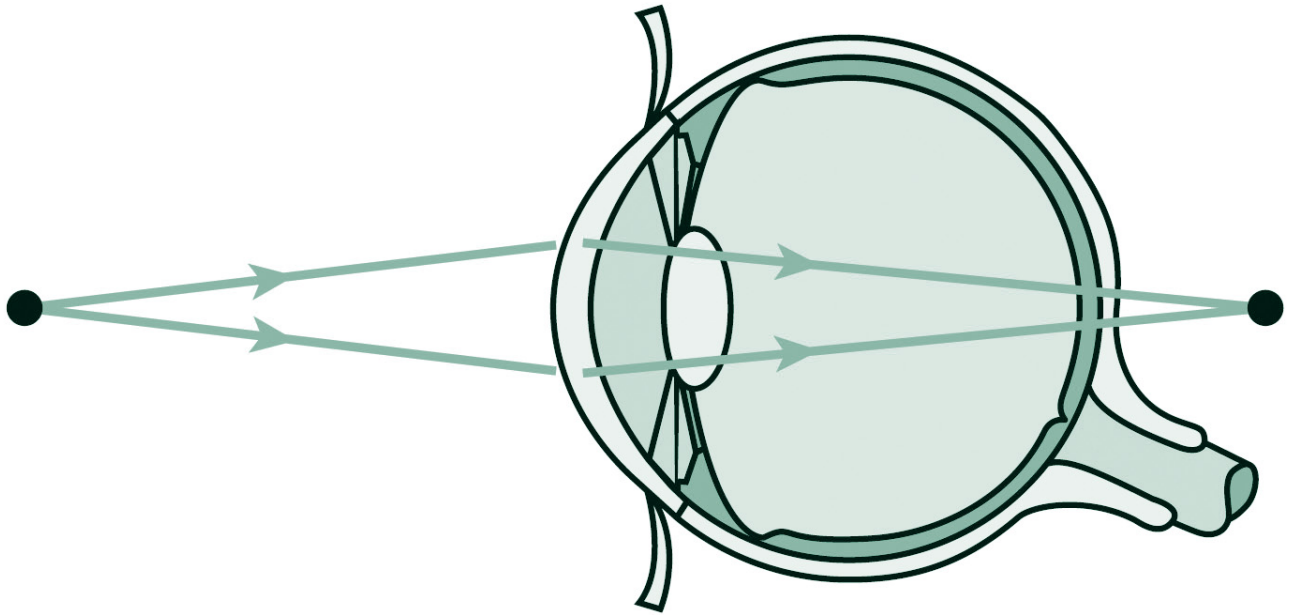
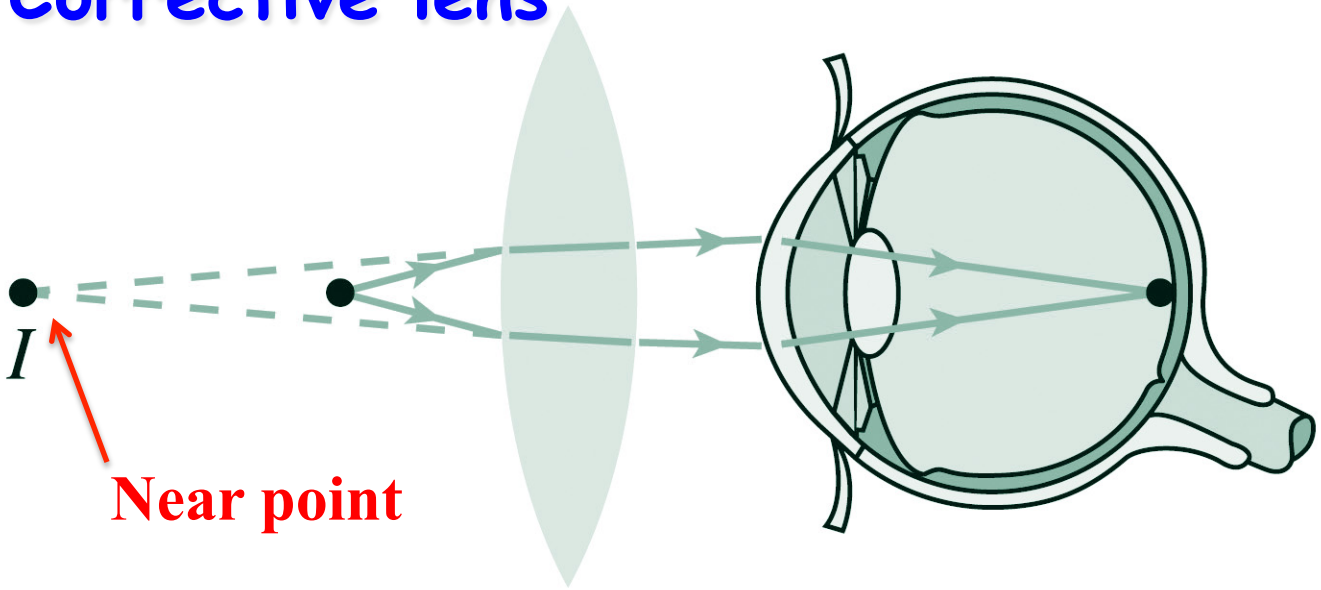


Image of nearby object forms behind the retina

Corrective lens



A converging lens corrects the problem by creating a virtual image further from the eye

Power of Lenses

- Everyone has a near point.
- Normal eyes can't focus objects much closer than 25cm.
- This distance tends to increase with age, requiring corrective (converging) reading glasses.

Corrective Power, P:

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

- Measured in **diopters** – inverse of focal length in meters.
- A 1-diopter lens has a 1 m focal length, a 2-diopter lens has $f = 0.5$ m.
- Note: $f < 0$ for diverging lens, so P can be both positive and negative.