Geometric Optics, Pt. II: Lenses and Mirrors

Knight Secs. 34.5-34.7

Physics 2C, Spring 2025

Agenda Today (May 27 & 29, 2025)

- Converging vs. Diverging Lenses
- Converging Lenses
  - How to draw; Principal Rays
  - Lens Equation; Magnification Equation
  - Real vs. Virtual Images
- Repeat above for Diverging Lenses
- Lensmaker's Equation

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Converging vs. Diverging Lenses

Converging lenses are thicker in the middle relative to the edges;

Diverging lenses are thicker at the edges relative to the middle:

FIGURE 34.27 Parallel light rays pass through a converging lens and a diverging lens.

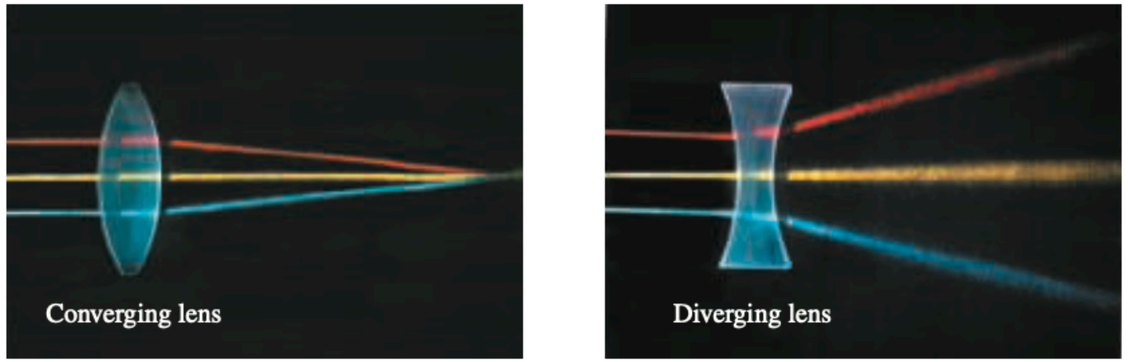
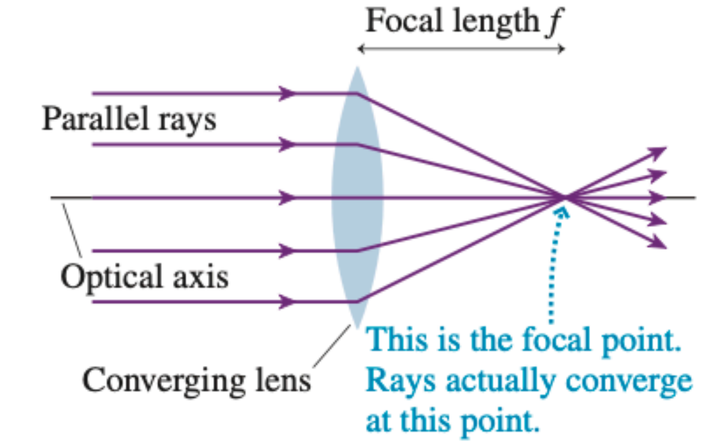
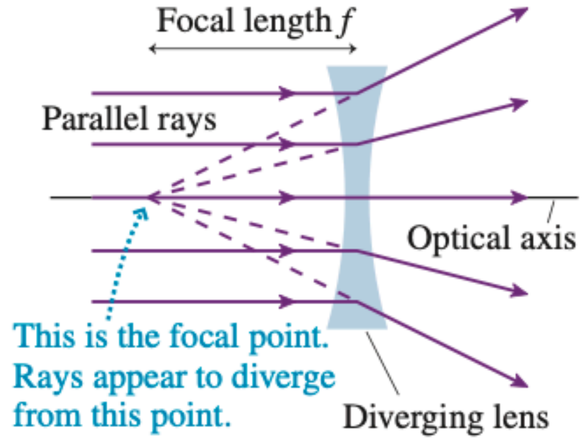


FIGURE 34.28 The focal lengths of converging and diverging lenses.

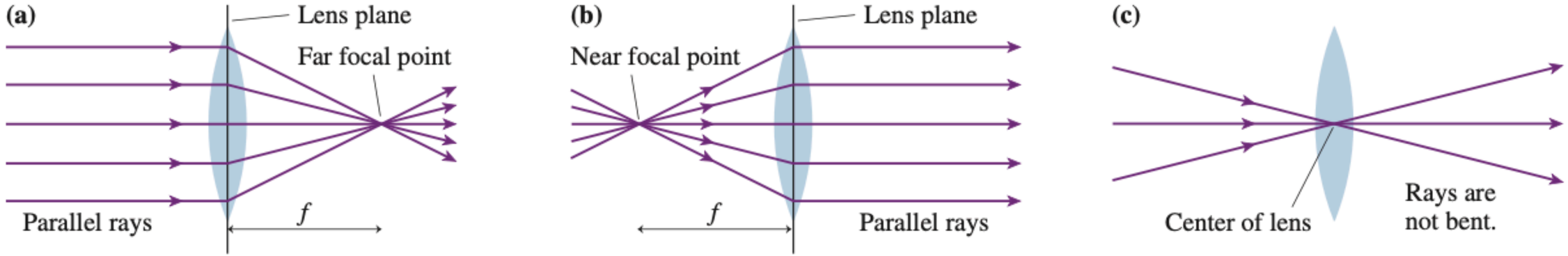




Principal Rays for Converging Lenses

To draw the path of light rays, it's easiest to focus on three main ones:

FIGURE 34.29 Three important sets of rays passing through a thin converging 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.

Real vs. Virtual Images, Converging Lenses

A converging lens can produce either a real or a virtual image:

Real image: light actually converges here;
Virtual image: light *appears* to come from here, but doesn't actually

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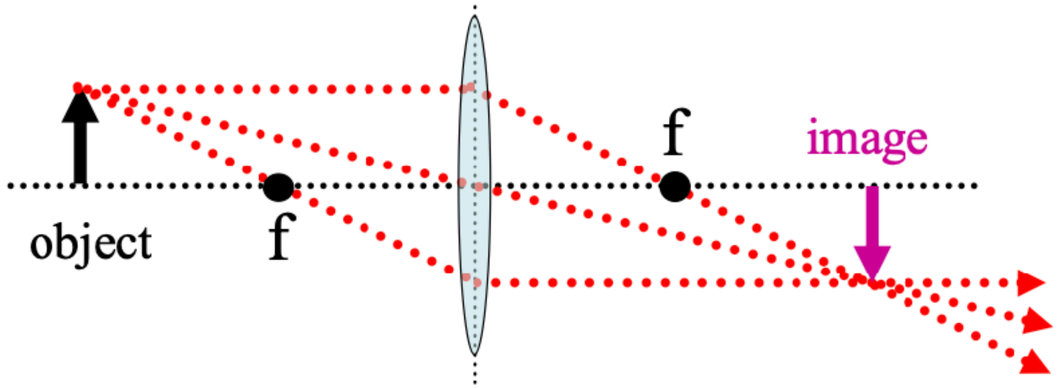
Clicker/Poll Question

A lens is used to make an image three light rays are drawn out of the infinite number coming from the arrowhead. The image given in this sketch could be seen:



A. By placing a screen at the image point.
B. Without a screen by looking back at the lens.
C. By both techniques (A) and (B).
D. Only if the lens is big enough.
E. None of the above answers is 100% correct.

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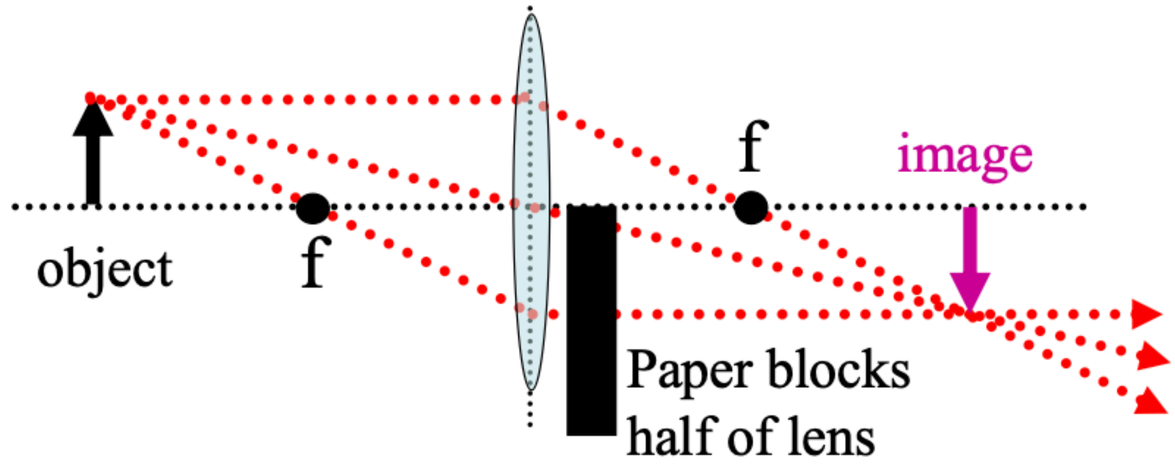
Clicker/Poll Question

Jennifer blocks half the lens as shown with a piece of paper.
What happens to the image?



A. It disappears.
B. Only half of it is still seen.
C. It looks the same but gets slightly dimmer.
D. It gets fuzzy.
E. It depends on what part of the lens is blocked.

Clicker/Poll Question

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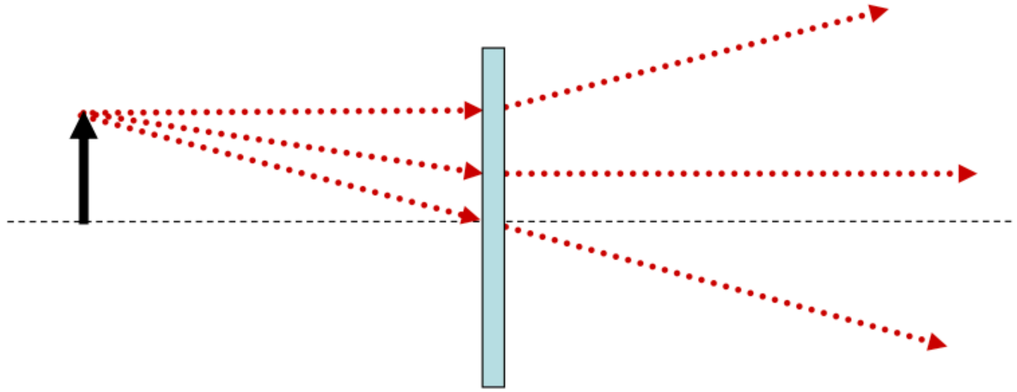
The figure below shows three principal rays for a converging lens. Which of the following best describes the image?



A. The image is real.
B. The image is virtual.
C. There is no image.
D. There are multiple images; impossible to say.

The Lens Equation; Magnification

- The Lens Equation $\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$ gives the location of the image ($s' > 0$ to the right)
- The magnification $m = -\frac{s'}{s}$ tells you how big the image is and its orientation.

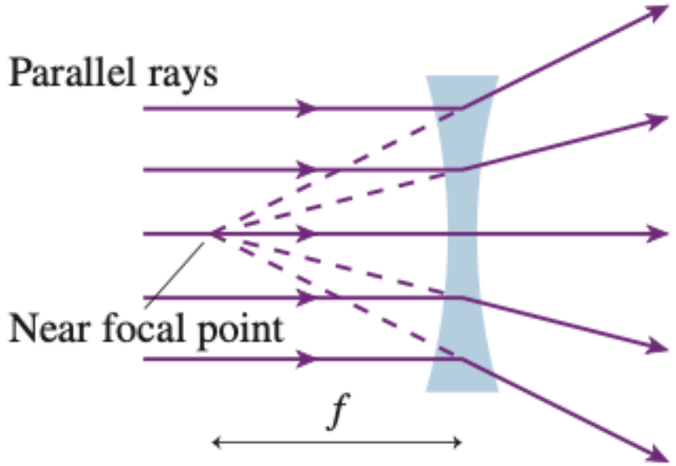
Example

An object is placed 20cm from a converging lens of focal length +10cm.
(a) Draw this setup. (b) Where is the image? What's its magnification?

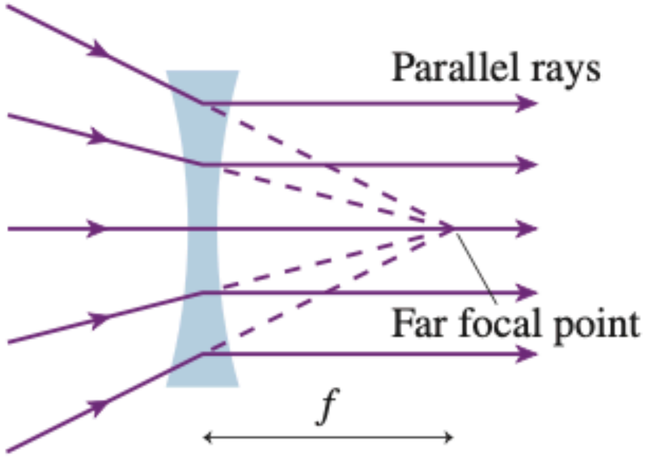
Principal Rays for Diverging Lenses

To draw the path of light rays, it's easiest to focus on three main ones:

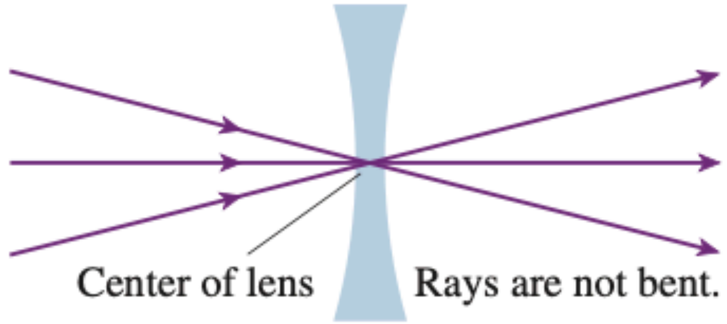
FIGURE 34.36 Three important sets of rays passing through a thin diverging lens.



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.

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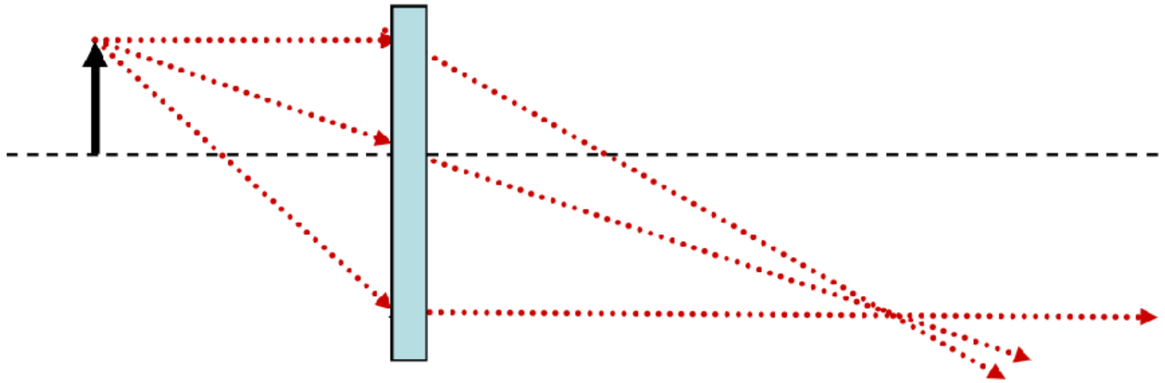
Clicker/Poll Question

A lens has been hidden behind a blue curtain but you've been given three light (red) rays used to construct an image. Your task is to determine the type of lens and the type of image.



A. Convex (converging) lens, real image.
B. Convex (converging) lens, virtual image.
C. Concave (diverging) lens, real image.
D. Concave (diverging) lens, virtual image.

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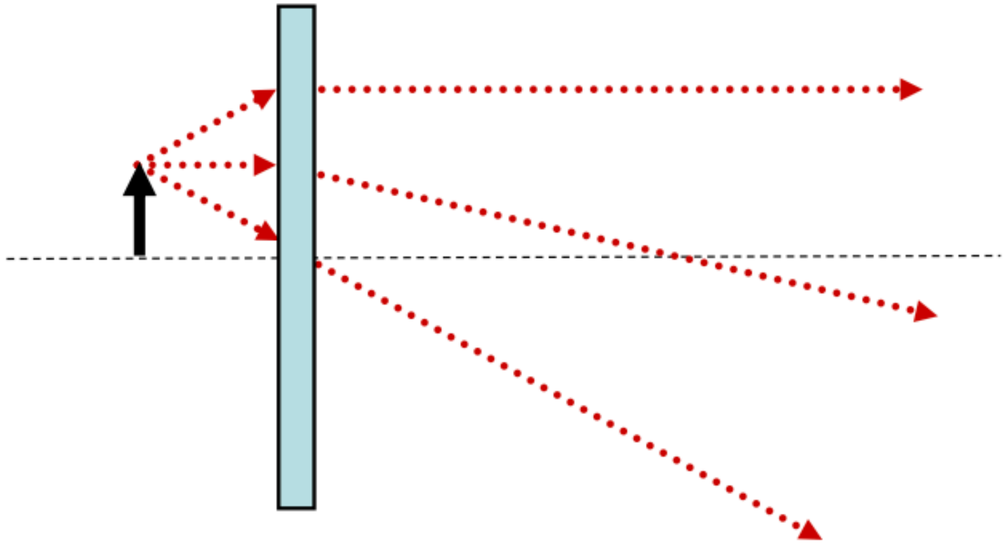
Clicker/Poll Question

For the figure to the right, determine the lens and type of image.



A. Convex (converging) lens, real image.
B. Convex (converging) lens, virtual image.
C. Concave (diverging) lens, real image.
D. Concave (diverging) lens, virtual image.

Try it yourself…

An object is placed 20cm from a lens and has a magnification of +0.50. (a) Draw this setup. (b) What is the focal length of the lens is it converging or diverging?

Concave and Convex Mirrors

Mirror Equations

Mirrors have a similar equation known as the mirror equation:

Clicker/Poll Question

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You see an upright, magnified image of your face when you look into a magnifying cosmetic mirror. Which of the following best explains the mirror and its focal length relative to your distance to the mirror?

A. Convex (diverging) mirror, $|f| > s$.
B. Convex (diverging) mirror, $|f| < s$.
C. Concave (converging) lens, $|f| > s$.
D. Concave (converging) lens, $|f| < s$.

Keep it going…

For the previous clicker, assume m=2.0 and s=10cm. What is f?

Lensmaker's Equation

Given the shape of the two sides of the lens, and the lens material's index of refraction, we can conpute the value of f.

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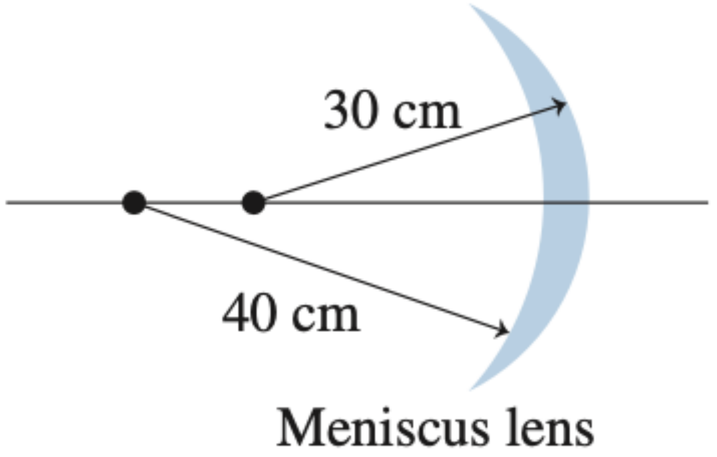
Clicker/Poll Question

A meniscus lens made of glass with n=1.5 is overall diverging. The radii of curvature have magnitudes 50 cm and 25 cm. What is the focal length of this lens?

A. -1.00m
B. +1.00m
C. -0.50m
D. +2.00m
E. -2.00m

Example

Find the focal length f of the following lens:



Example

A meniscus lens, made of glass with $n = 1.5$, is overall diverging. The radii of curvature have magnitudes 50 cm and 25 cm. What is the focal length of this lens?

Another Example

The illumination lights in an operating room use a concave mirror to focus an image of a bright lamp onto the surgical site. One such light uses a mirror with a 30 cm radius of curvature. If the mirror is 1.2 m from the patient, how far should the lamp be from the mirror?

Clicker/Poll Question

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A photographer focuses her camera on an object. Suppose the object moves closer to the camera. To refocus, should the camera lens move closer to or farther from the detector?

A. Closer to
B. Farther from