Optics of Lenses

Lecture 32

What is the position of the real image

1. 52 cm
2. 112 cm
3. 232 cm

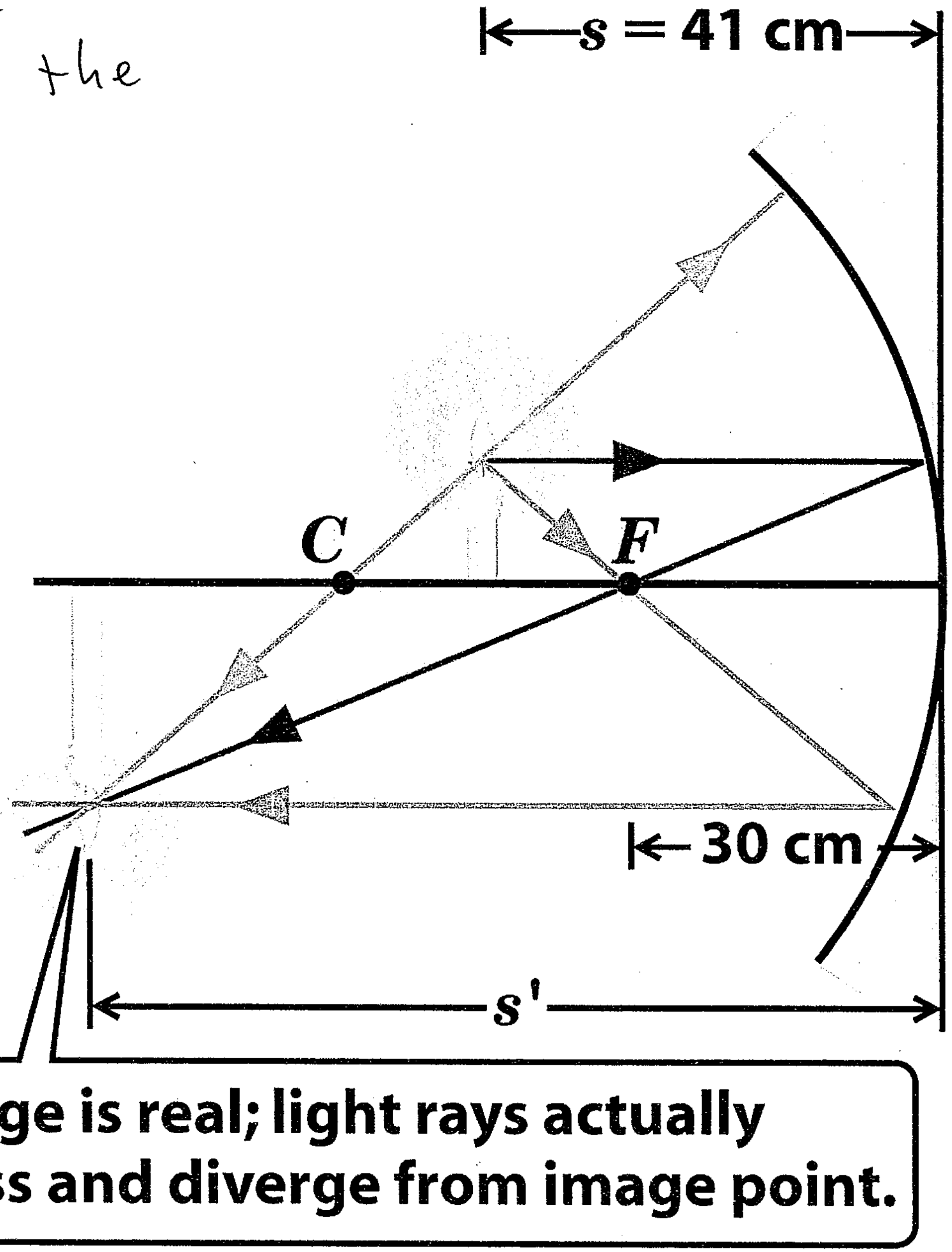


Figure 34-41a Physics for Engineers and Scientists 3/e

In This [redacted] picture [redacted].

Which of these objects are closer to you?

a. The upright ‘5’ on the right.

b. The inverted ‘5’ on the left

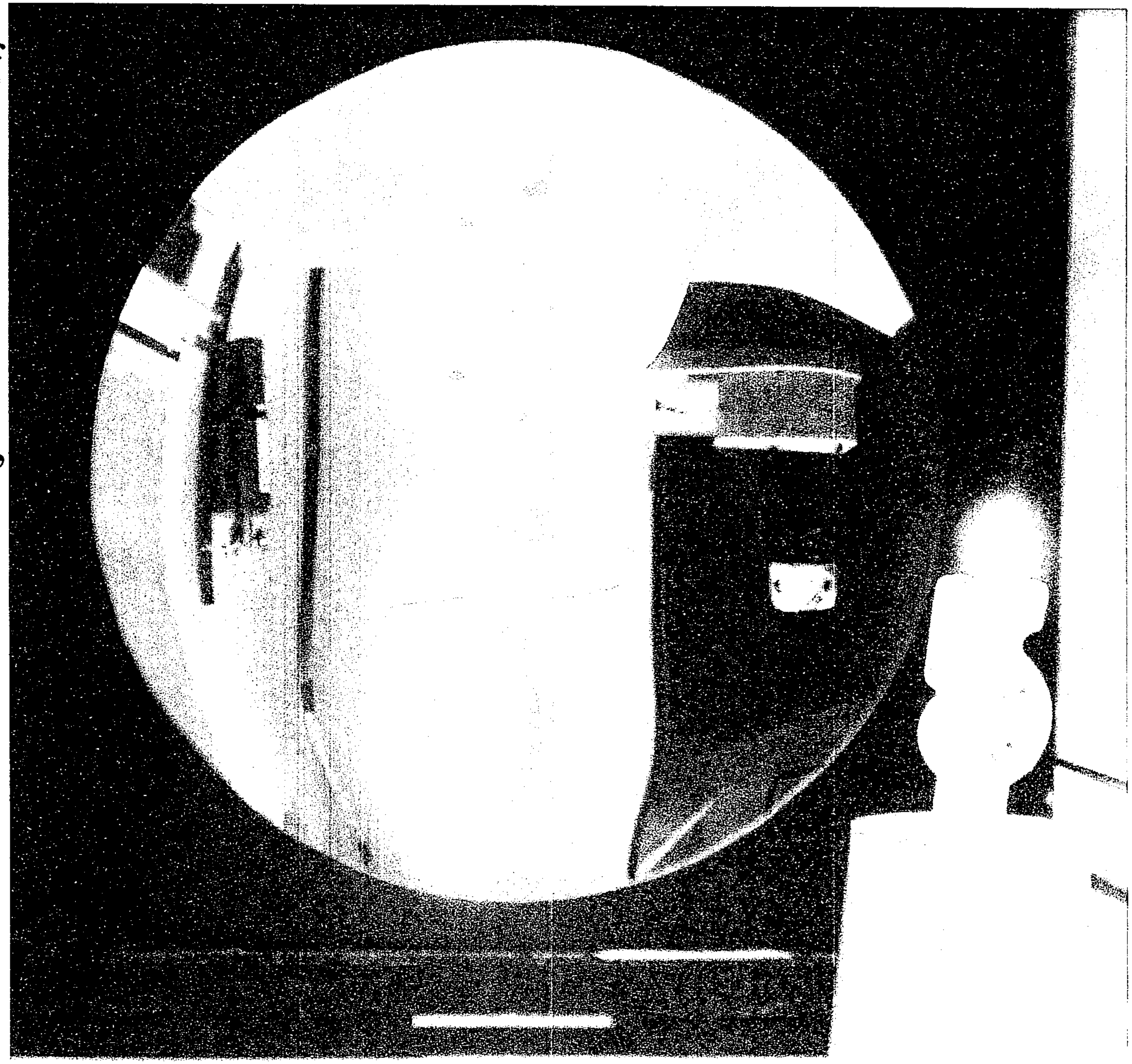


Figure 34-41b Physics for Engineers and Scientists 3/e
Courtesy of John Markert

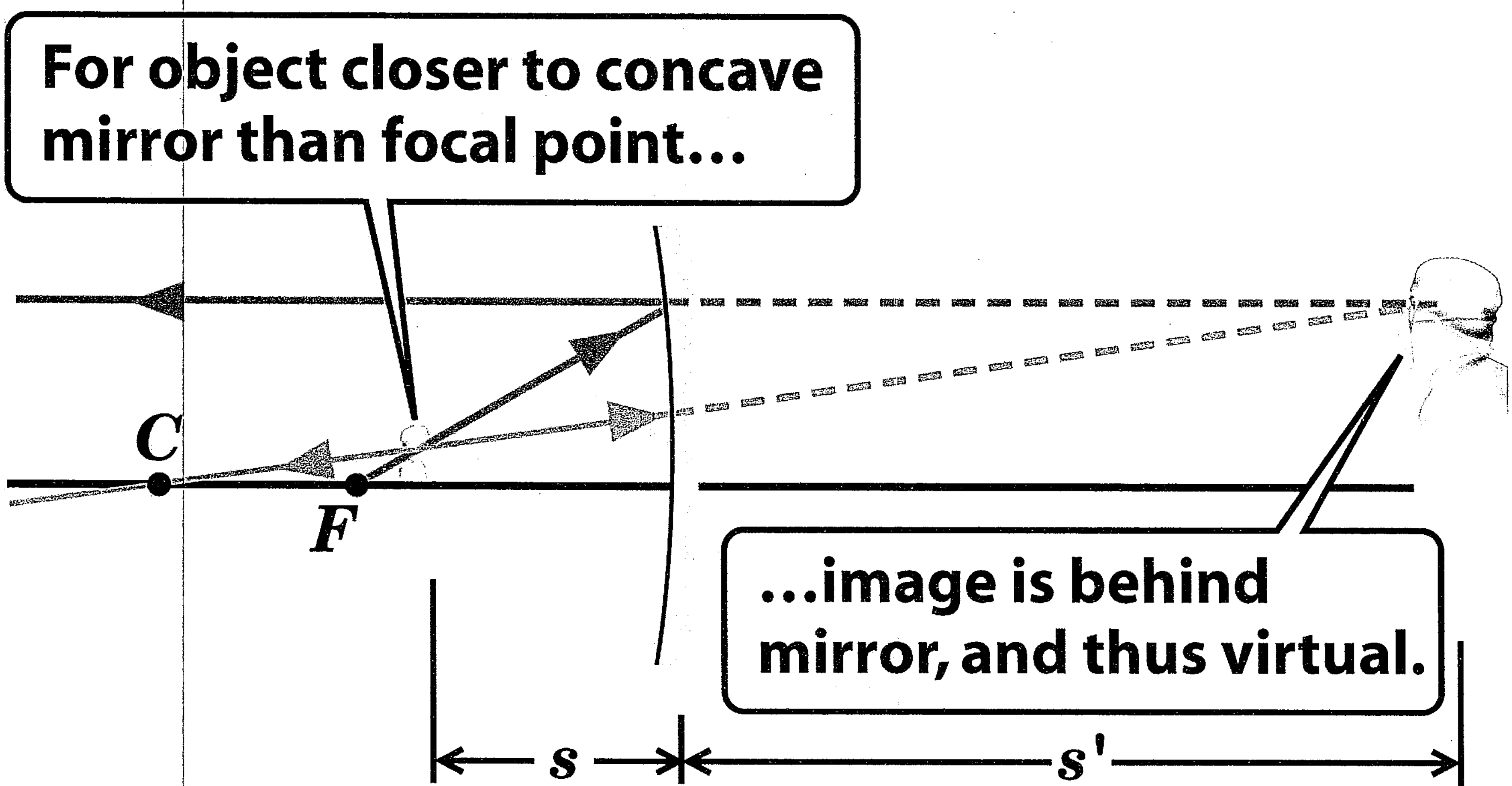


Figure 34-42 Physics for Engineers and Scientists 3/e

Focusing Lens ($f > 0$)

focal length $\equiv f$

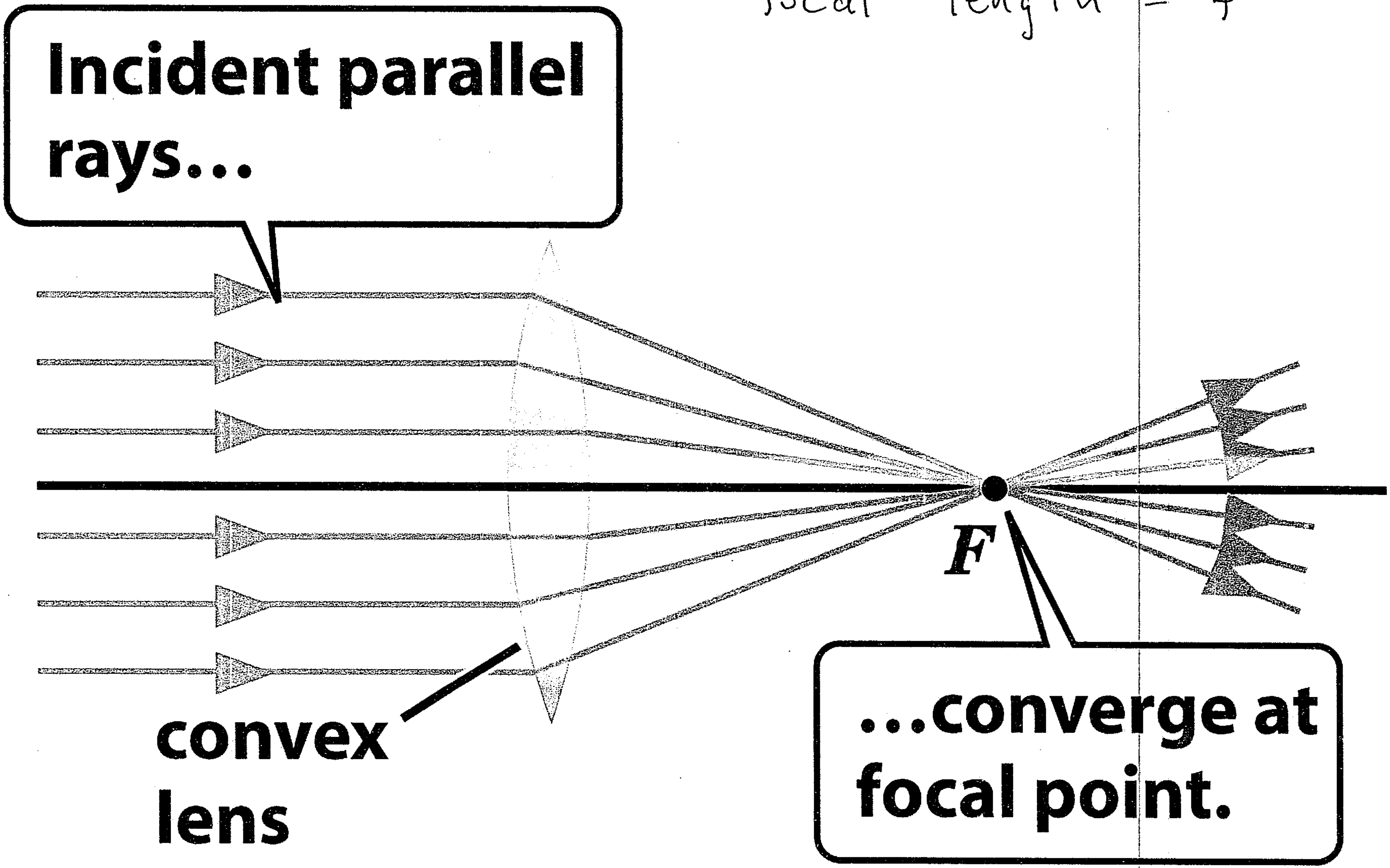


Figure 34-43a Physics for Engineers and Scientists 3/e

De focusing lens ($f < 0$)

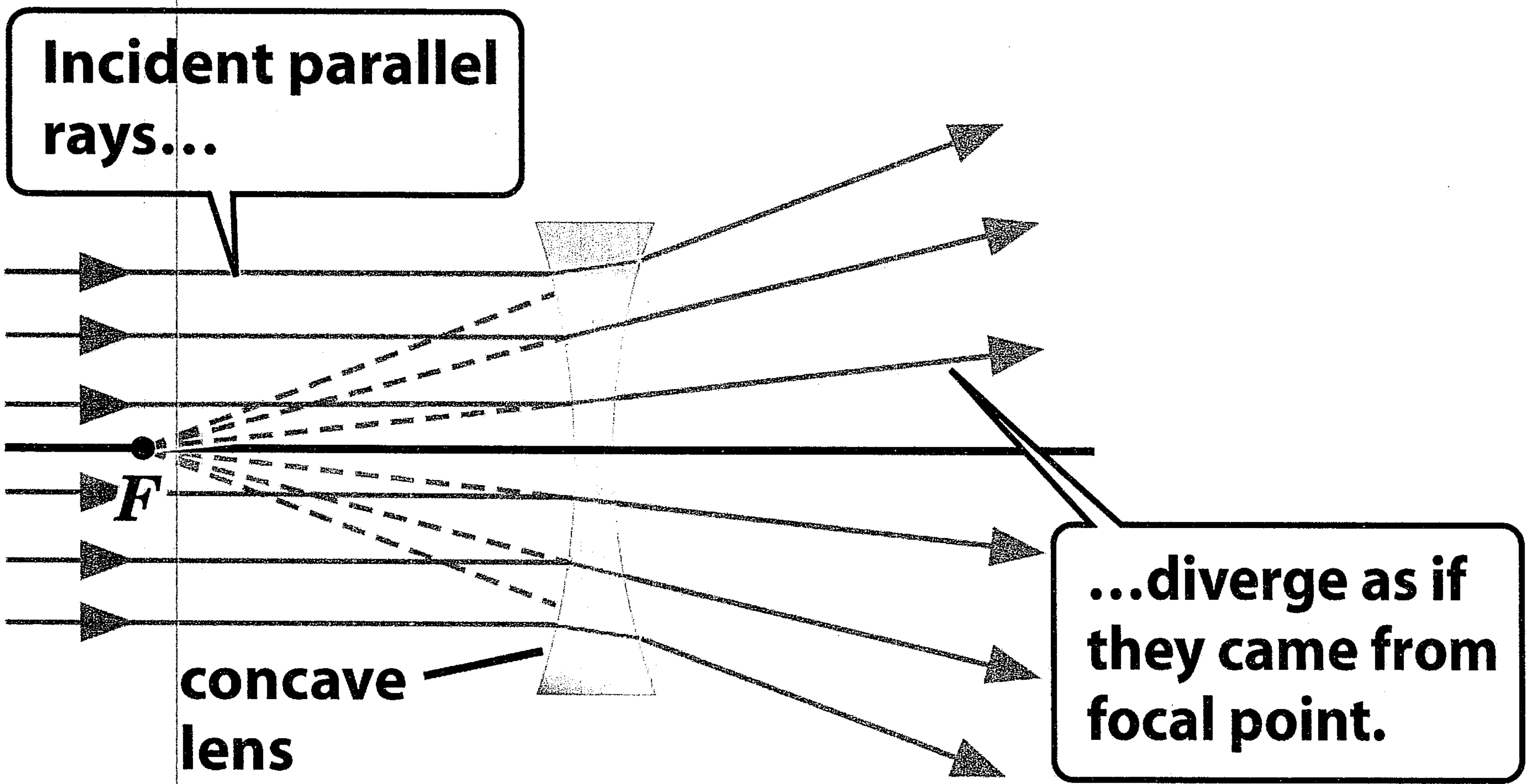
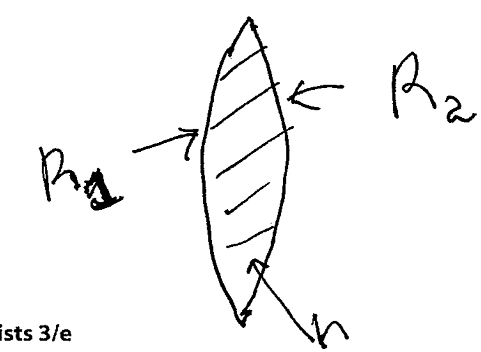


Figure 34-44a Physics for Engineers and Scientists 3/e

LENS MAKER'S FORMULA

$$\frac{1}{f} = (n - 1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$



n_{medium}

$$\frac{1}{f} = (n - n_{medium})\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

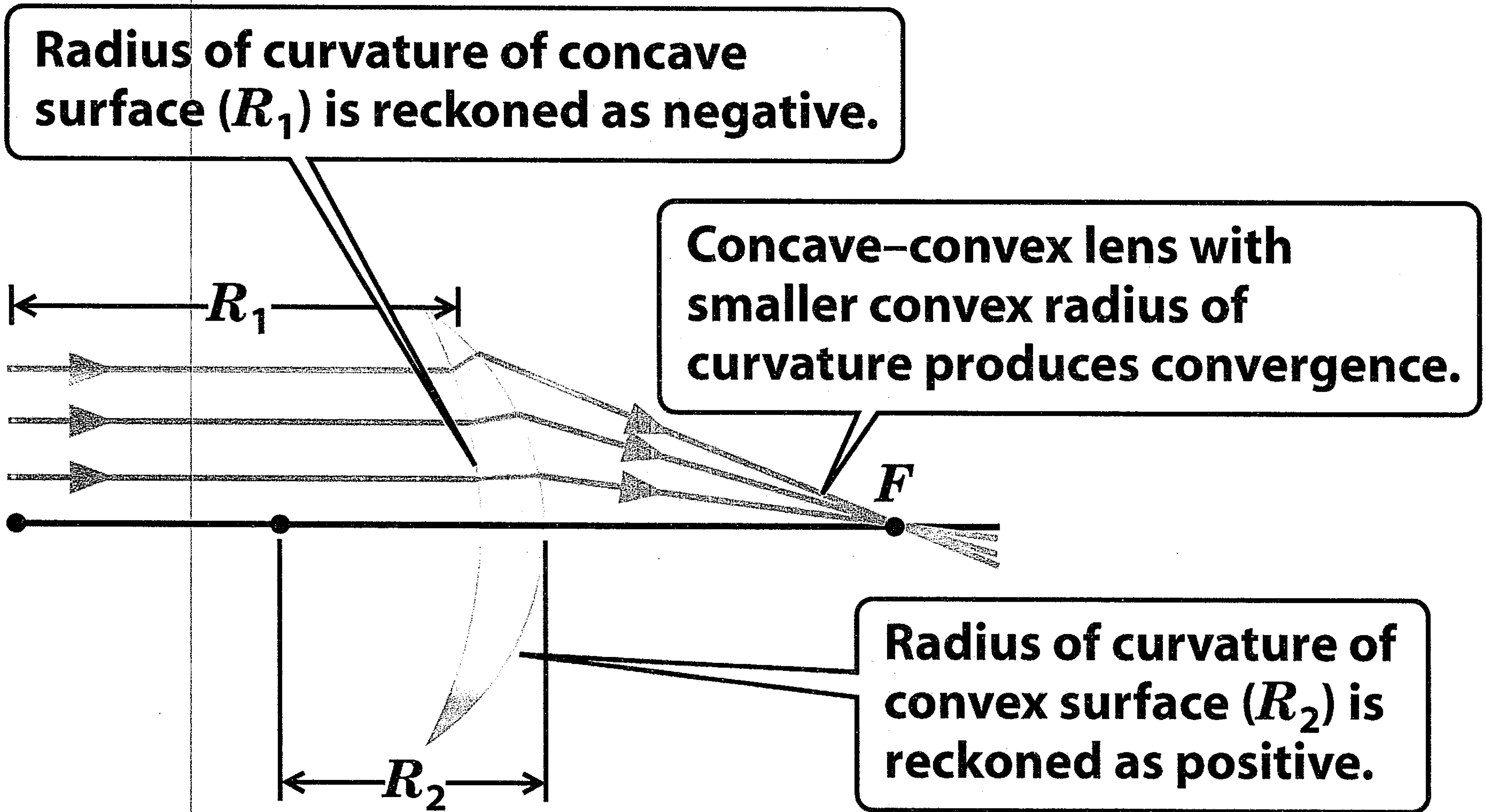


Figure 34-45a Physics for Engineers and Scientists 3/e

$f = (n-1)\left(\frac{-1}{|R_1|} + \frac{1}{R_2}\right)$

$f = (n-1)\,(|R_1| - |R_2|)/|R_1||R_2|$

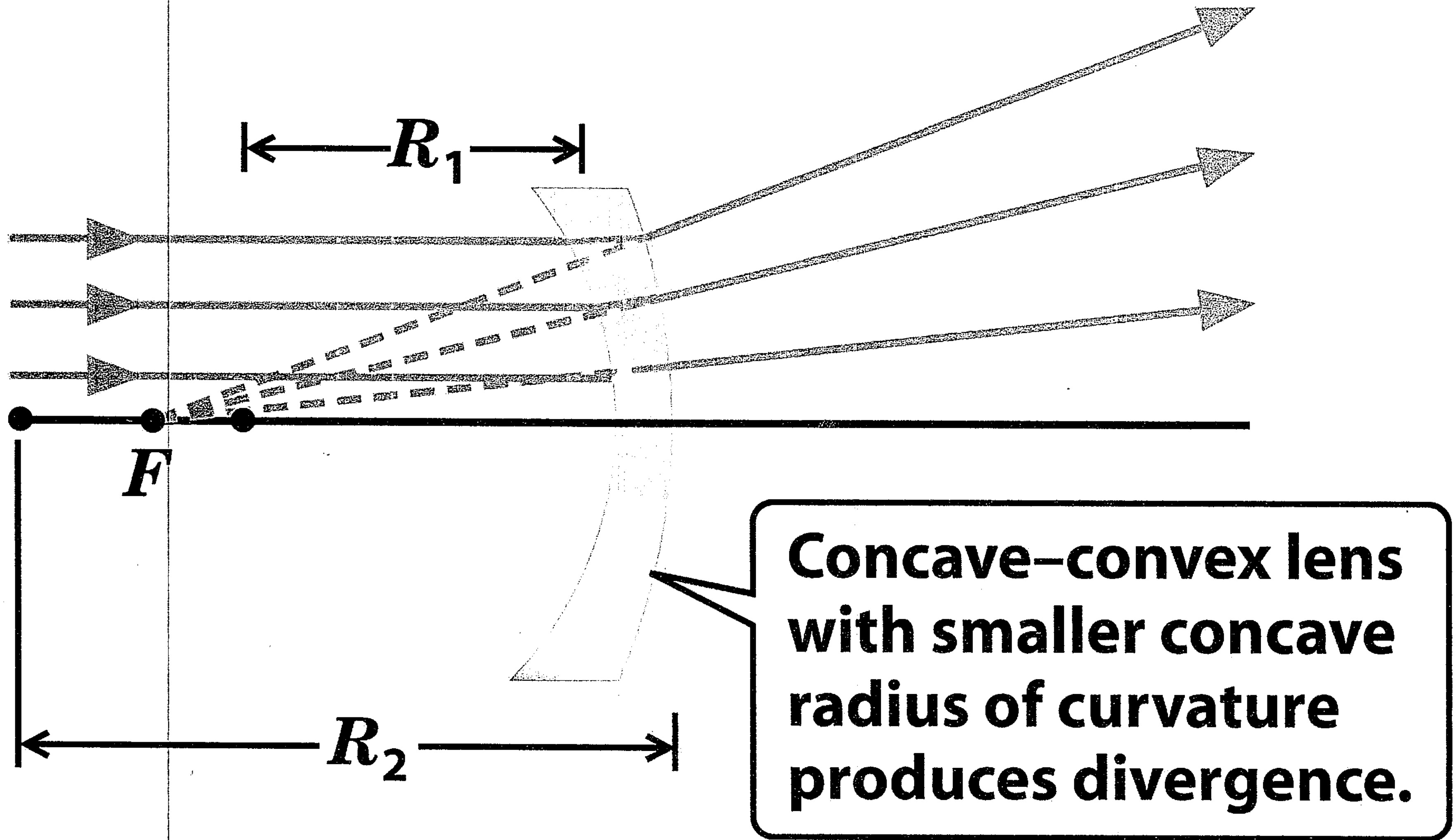


Figure 34-45b Physics for Engineers and Scientists 3/e

8

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

Linear Magnification

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

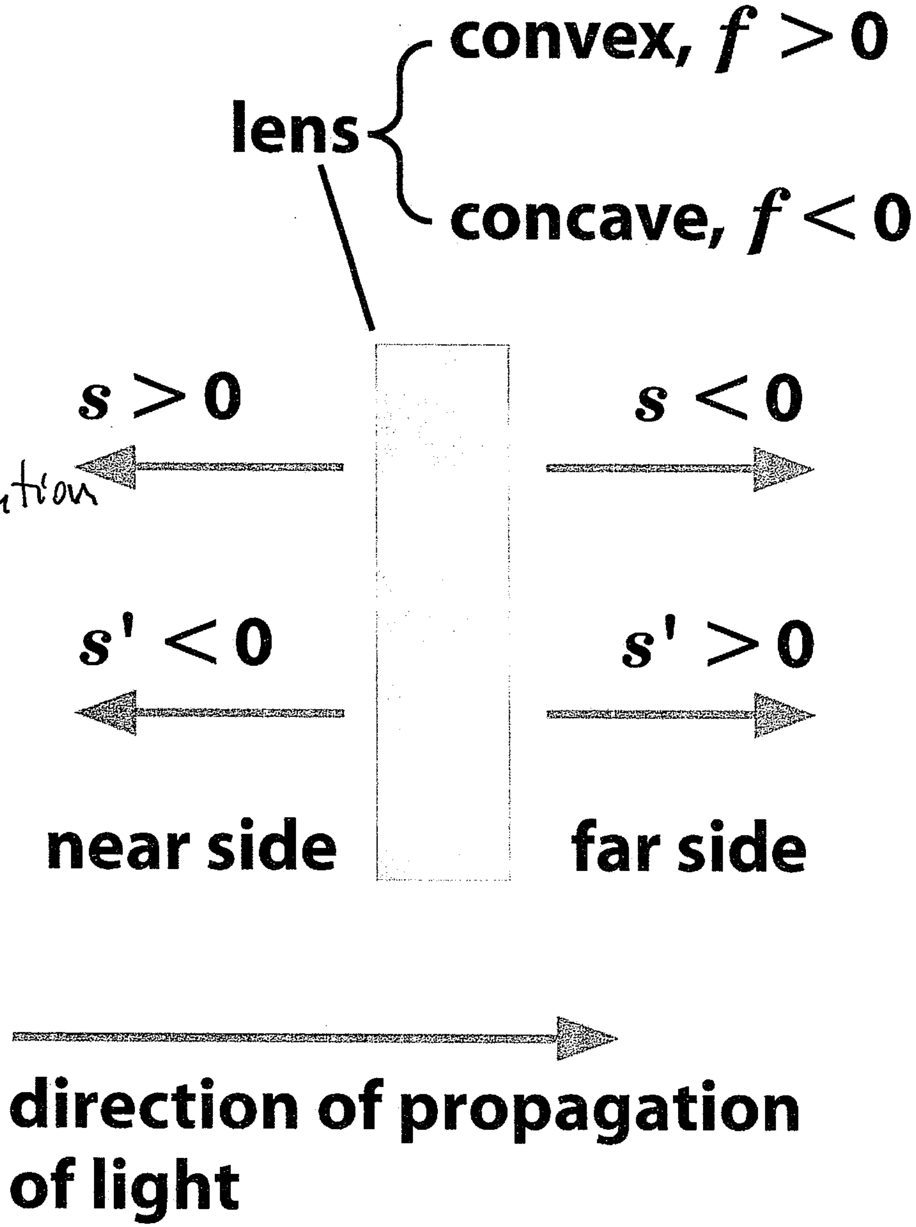


Figure 34-48 Physics for Engineers and Scientists 3/e

MIRROR AND LENS EQUATION

But there is a difference in notation between mirror and lens

$$\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}; \quad M=\frac{-s'}{s}$$

<u>MIRROR</u>; $s > 0$ on left;

<u>real image</u> (inverted)

$s' > 0$, s' on left

$f = R/2 > 0$, converging concave mirror

<u>virtual upright image</u>

<u>$s' < 0$ on right</u>

$f = R/2 < 0$, diverging convex mirror

<u>LENS;</u> $s > 0$ on left

<u>real image</u> (inverted)

$s' > 0$, s' on right

$1/f = (n-1)(1/R_1+1/R_2) > 0$, converging convex lens

<u>virtual upright image</u>

<u>$s' < 0$, on left</u>

$1/f = (n-1)(1/R_1+1/R_2) < 0$, diverging concave mirror

Focusing of Image

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

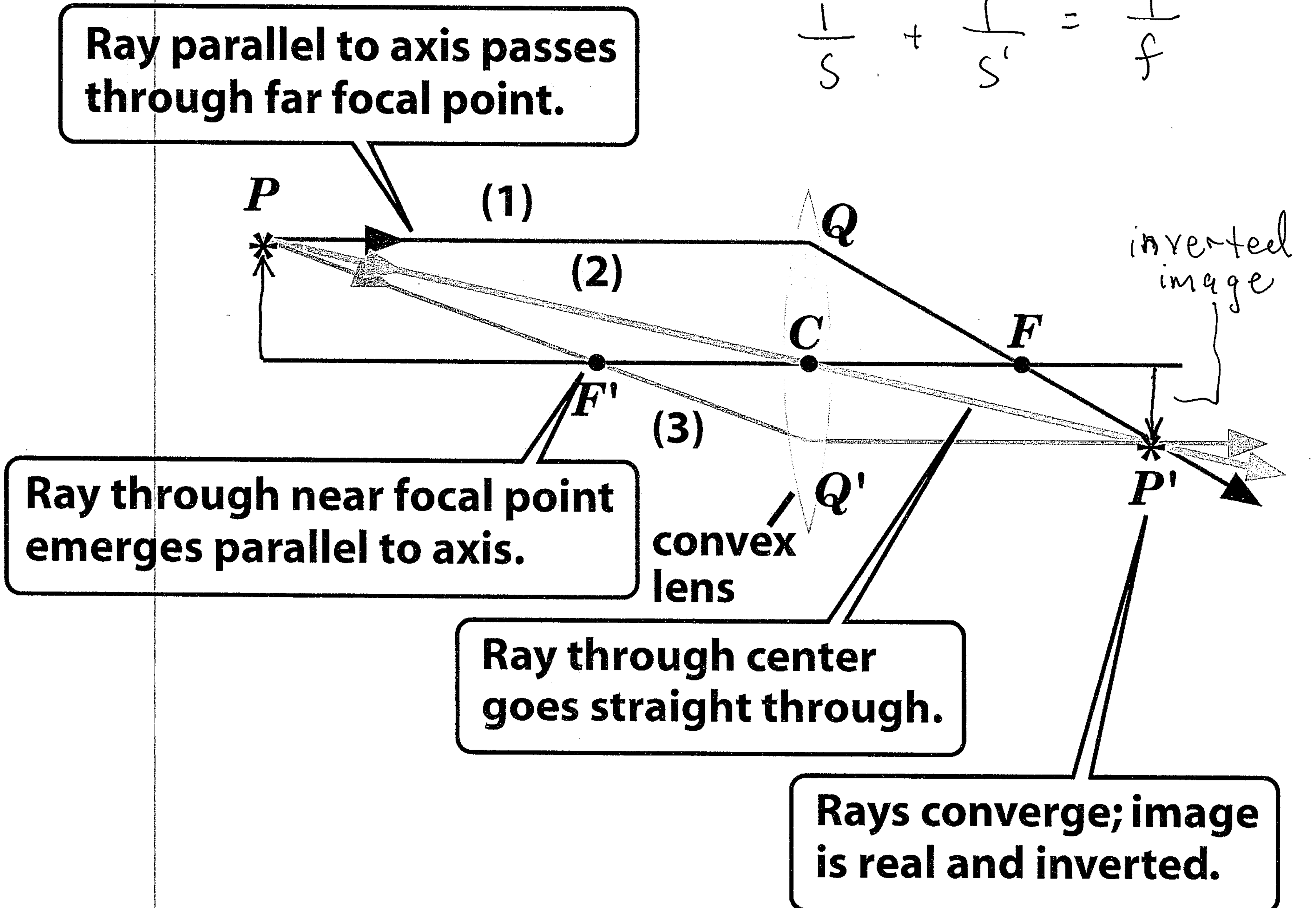


Figure 34-46 Physics for Engineers and Scientists 3/e

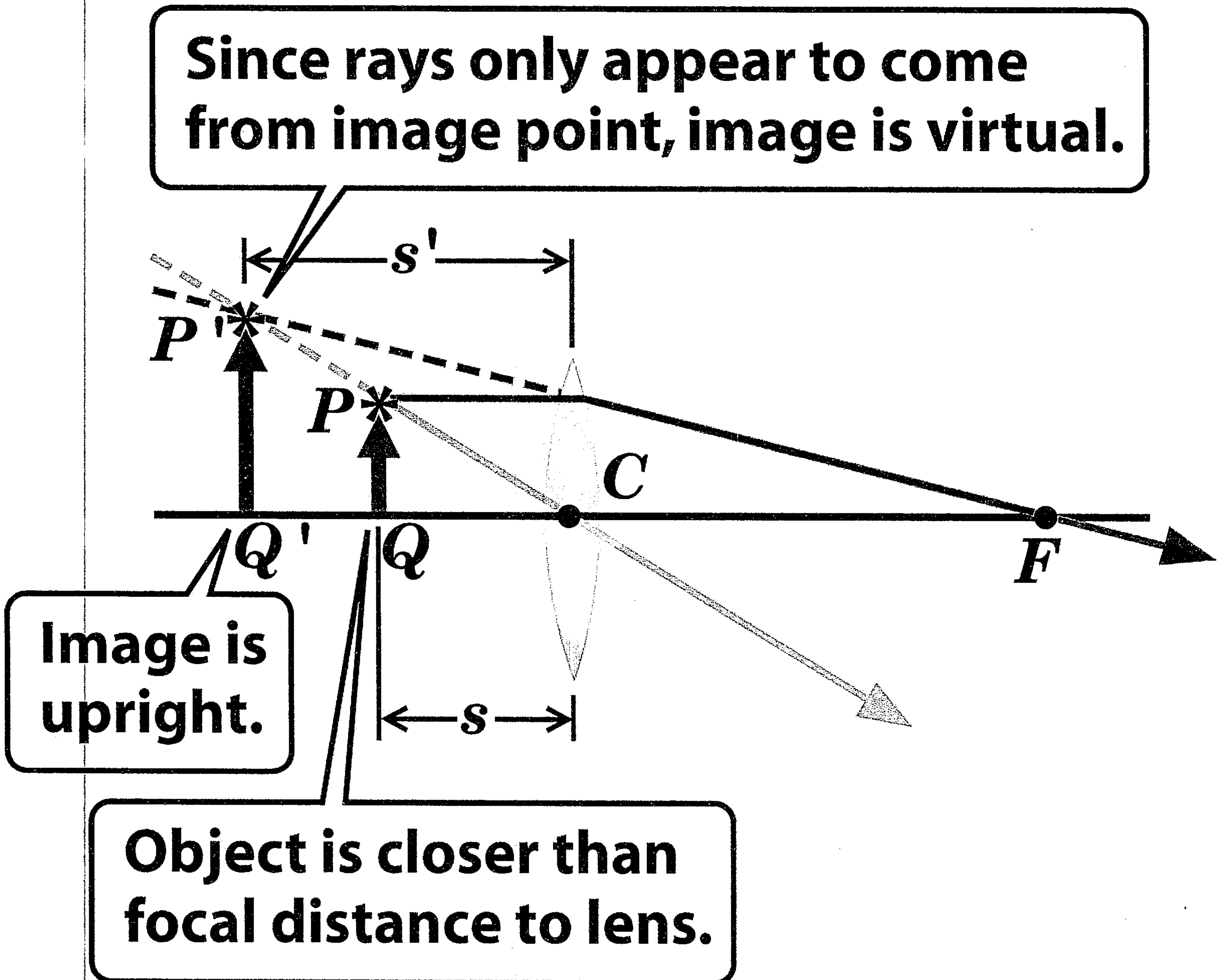


Figure 34-50 Physics for Engineers and Scientists 3/e

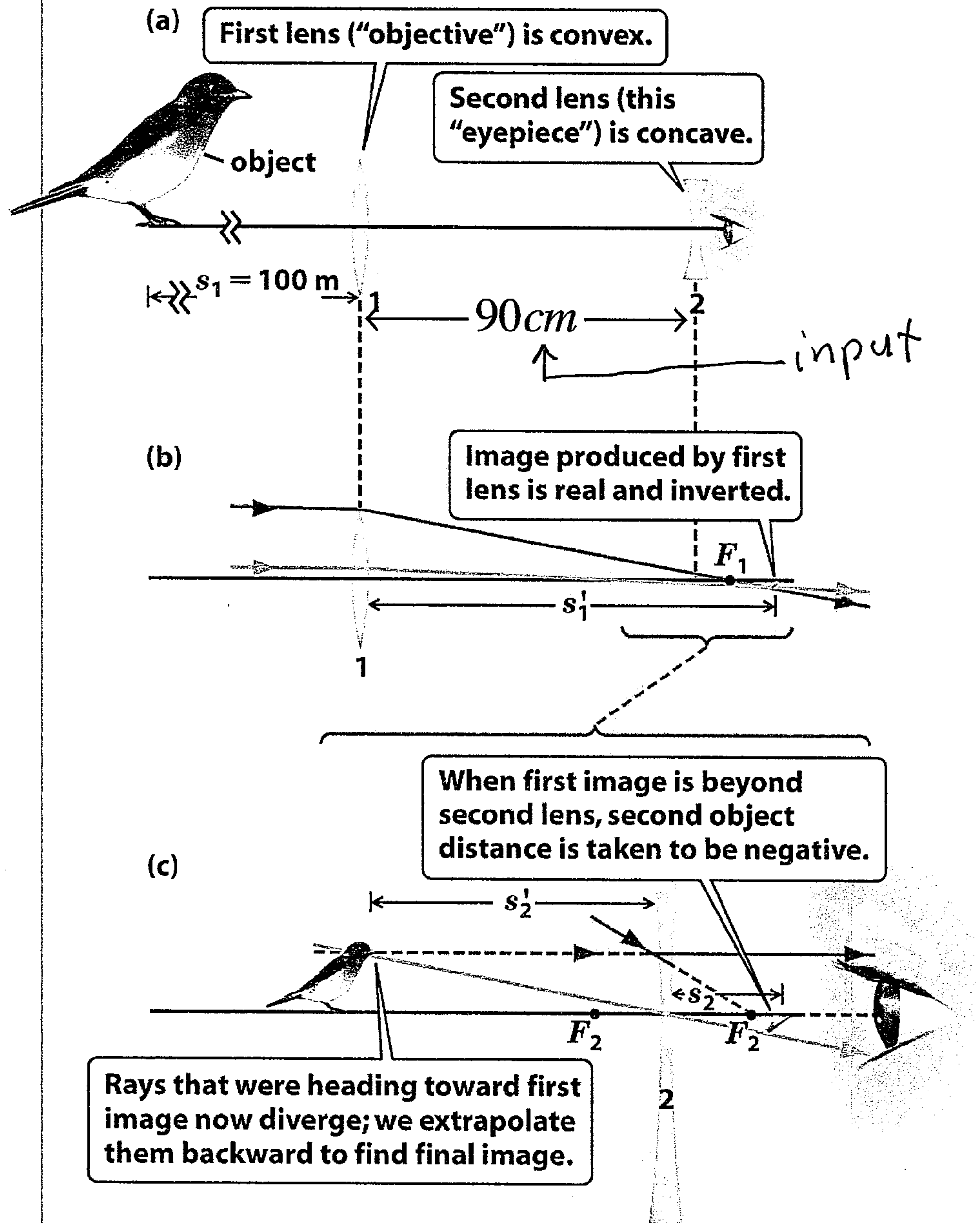


Figure 34-52 Physics for Engineers and Scientists 3/e

Input

$s_1 = 100m = 10^4 cm$

$f_1 = 100cm$

$f_2 = -8cm$

$s_1' = 101cm$

$s_2 = -11cm$

$s_2' = -29cm$

$$M_1 = -\frac{s_1'}{s_1} = -.0101$$

$$M_2 = -\frac{s_2'}{s_2} = -2.6$$

$M = M_1 M_2 = .026$ (have we gained in sight?)

Angular Width of Object

$$\Delta\theta_{obj} \simeq \frac{h}{s} = 10^{-4} h$$

Angular Width of Image

$$\Delta\theta_{img} \simeq \frac{Mh}{s_2'} = \frac{.026h}{29} \simeq .001h$$

~ 10 fold gain in angular width