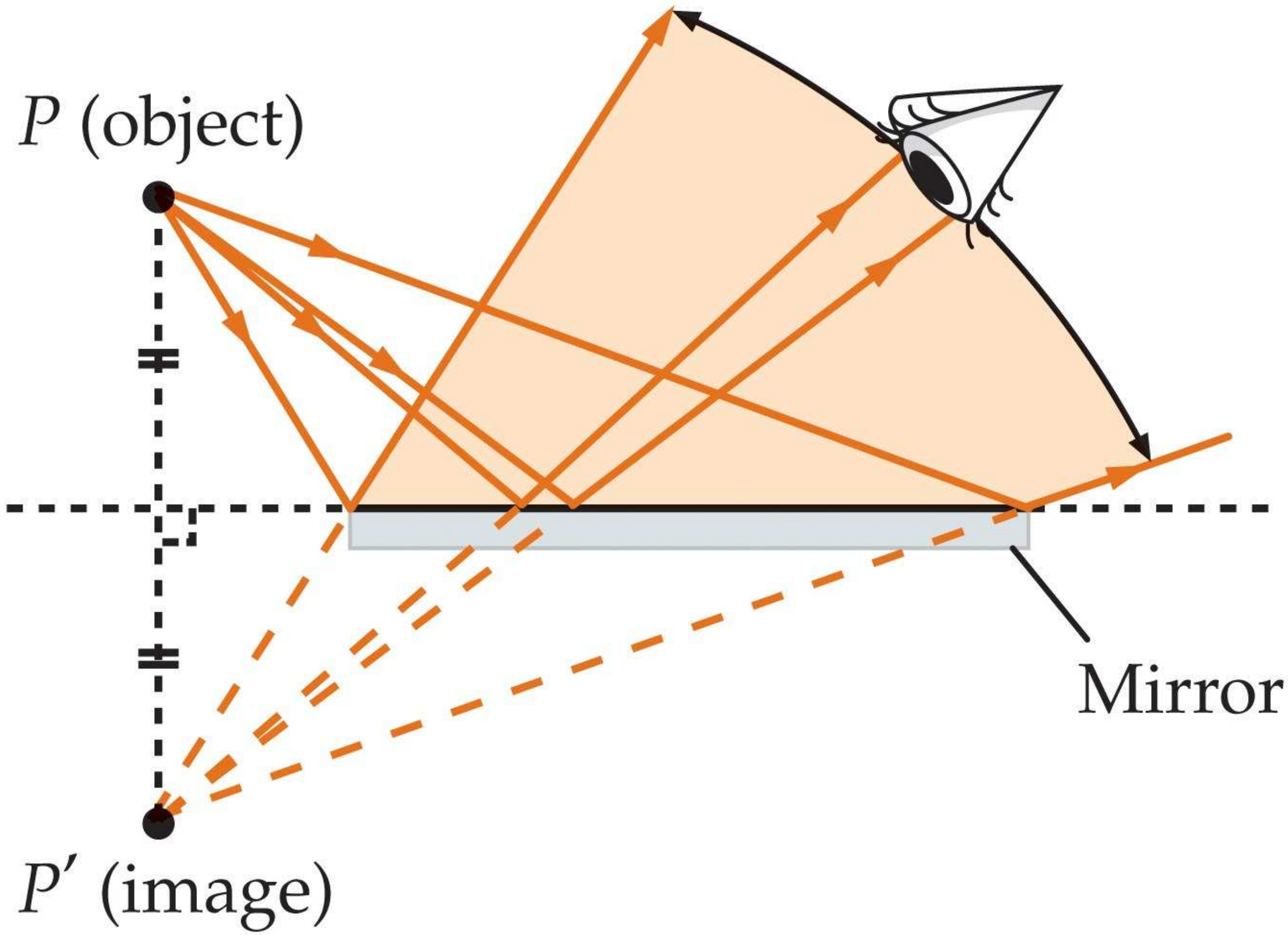
Miralls i lents

- Òptica geomètrica: rajos a miralls i lents

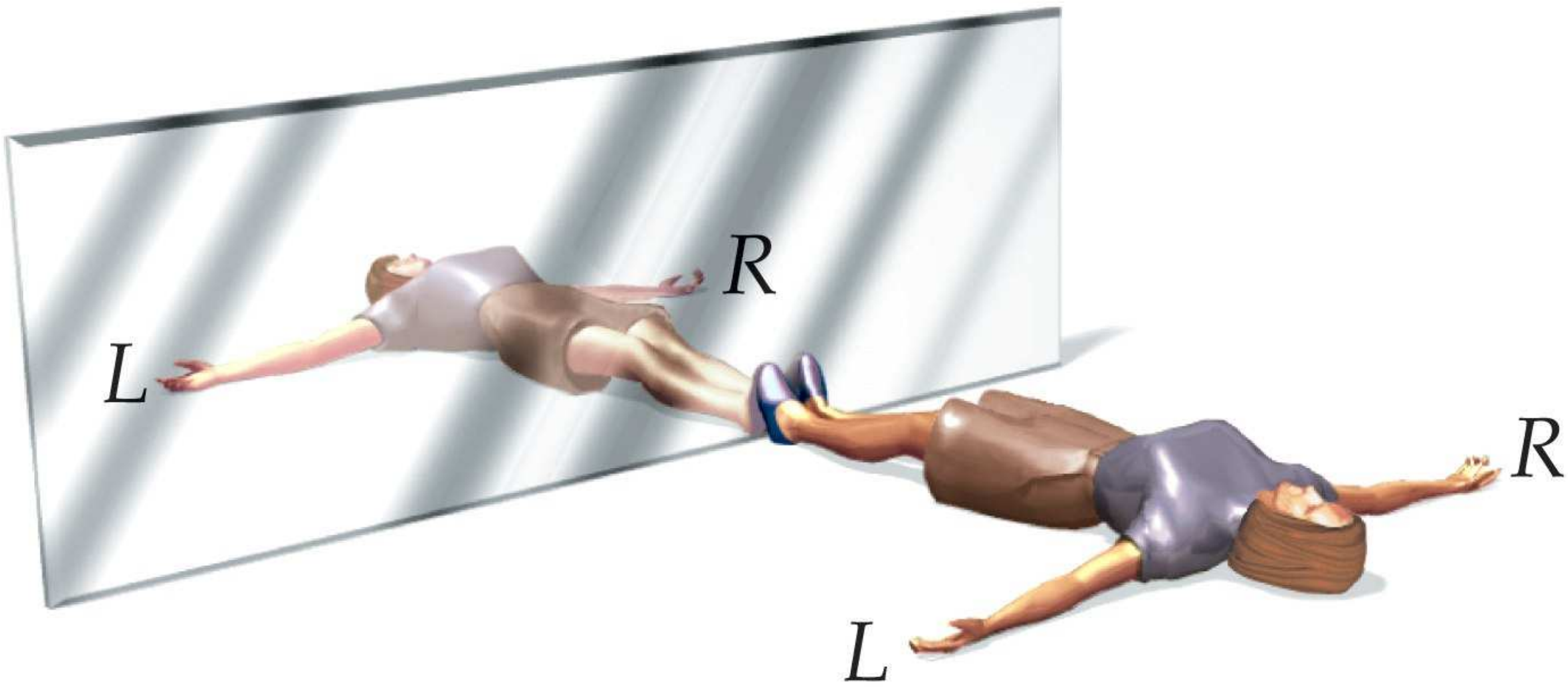
Miralls plans

Com “funcionen”

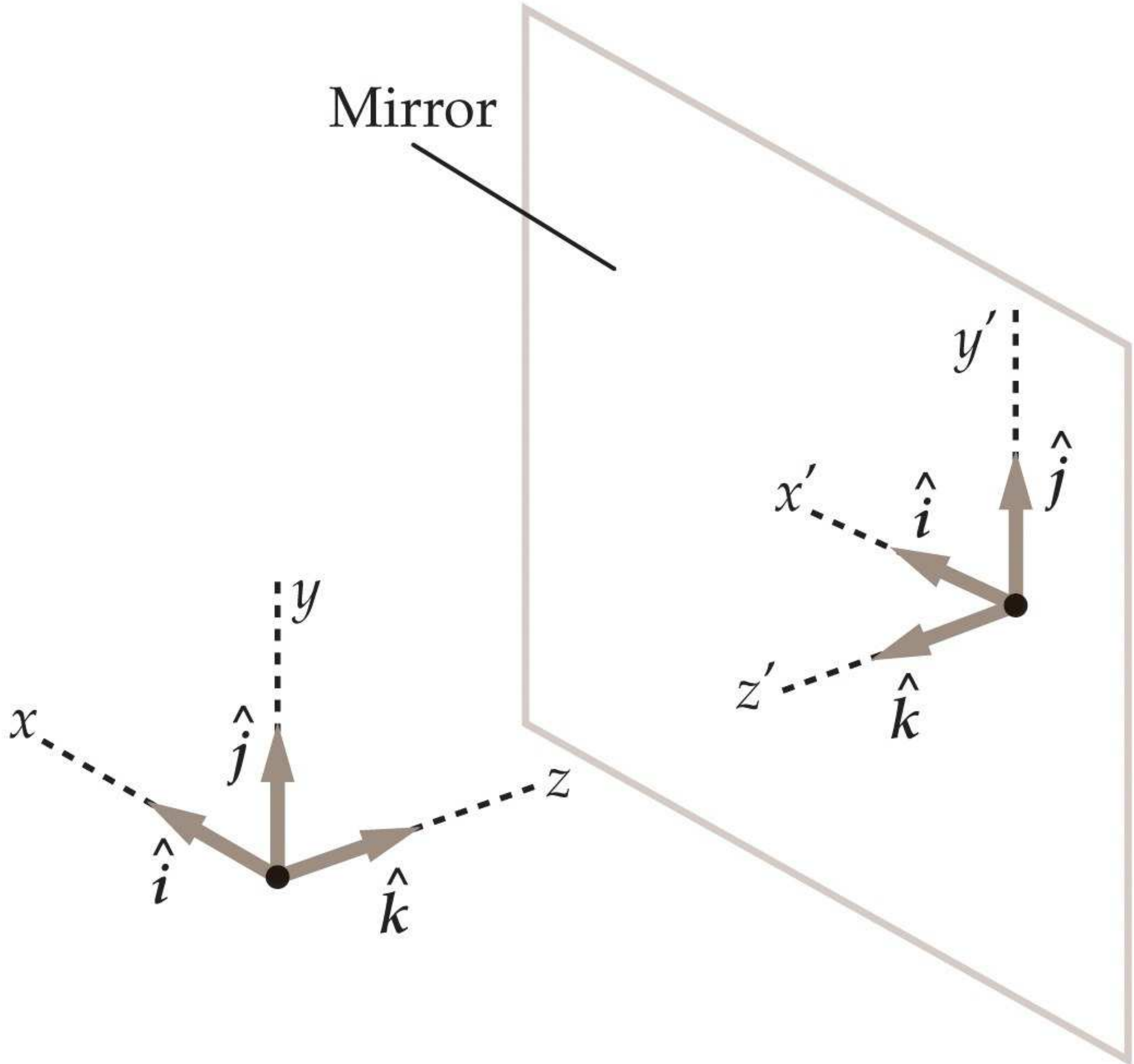


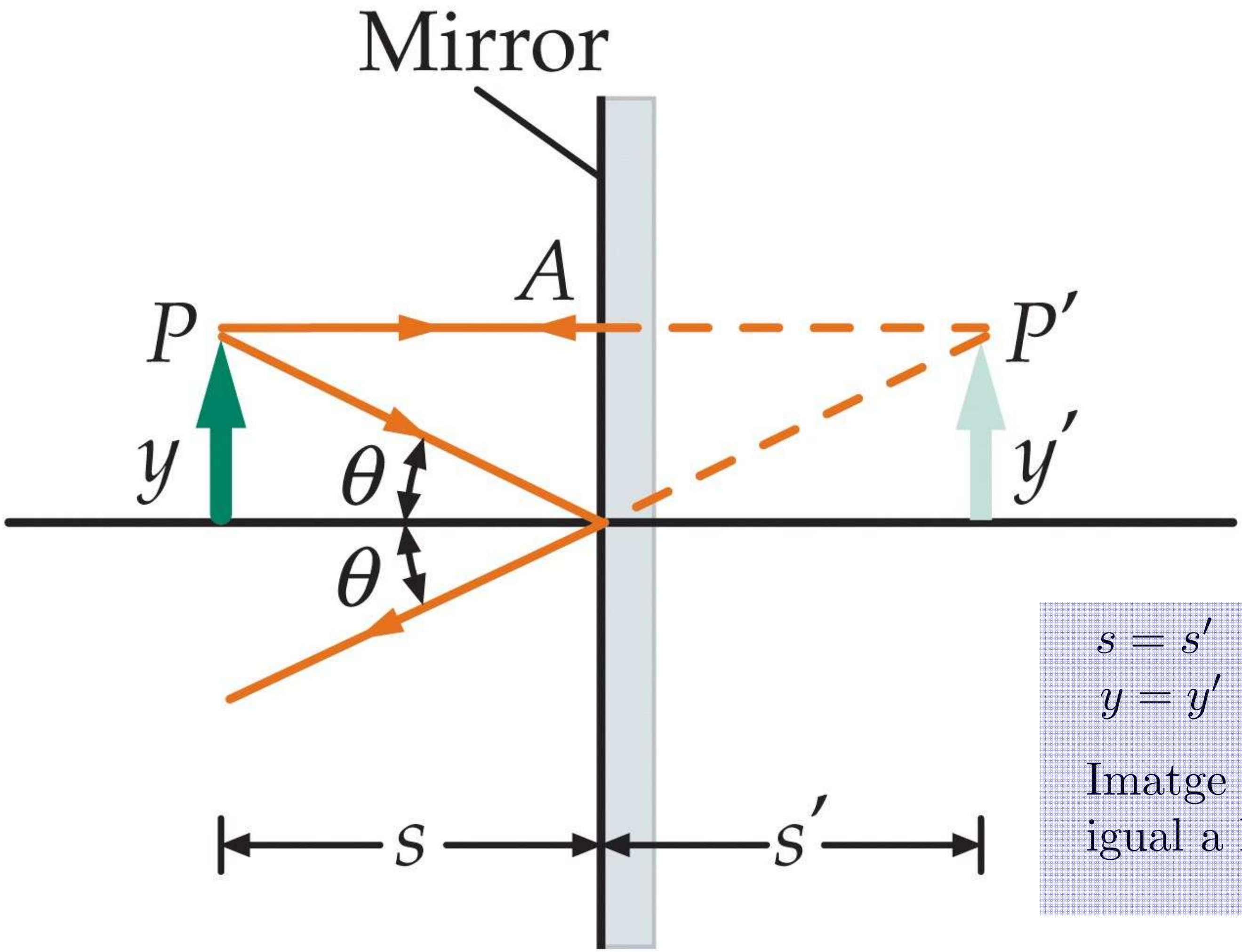
Imatges invertides

"dreta" passa a "esquerra", *canvi de quiralitat*


R
L
R
L

Inversió dels eixos

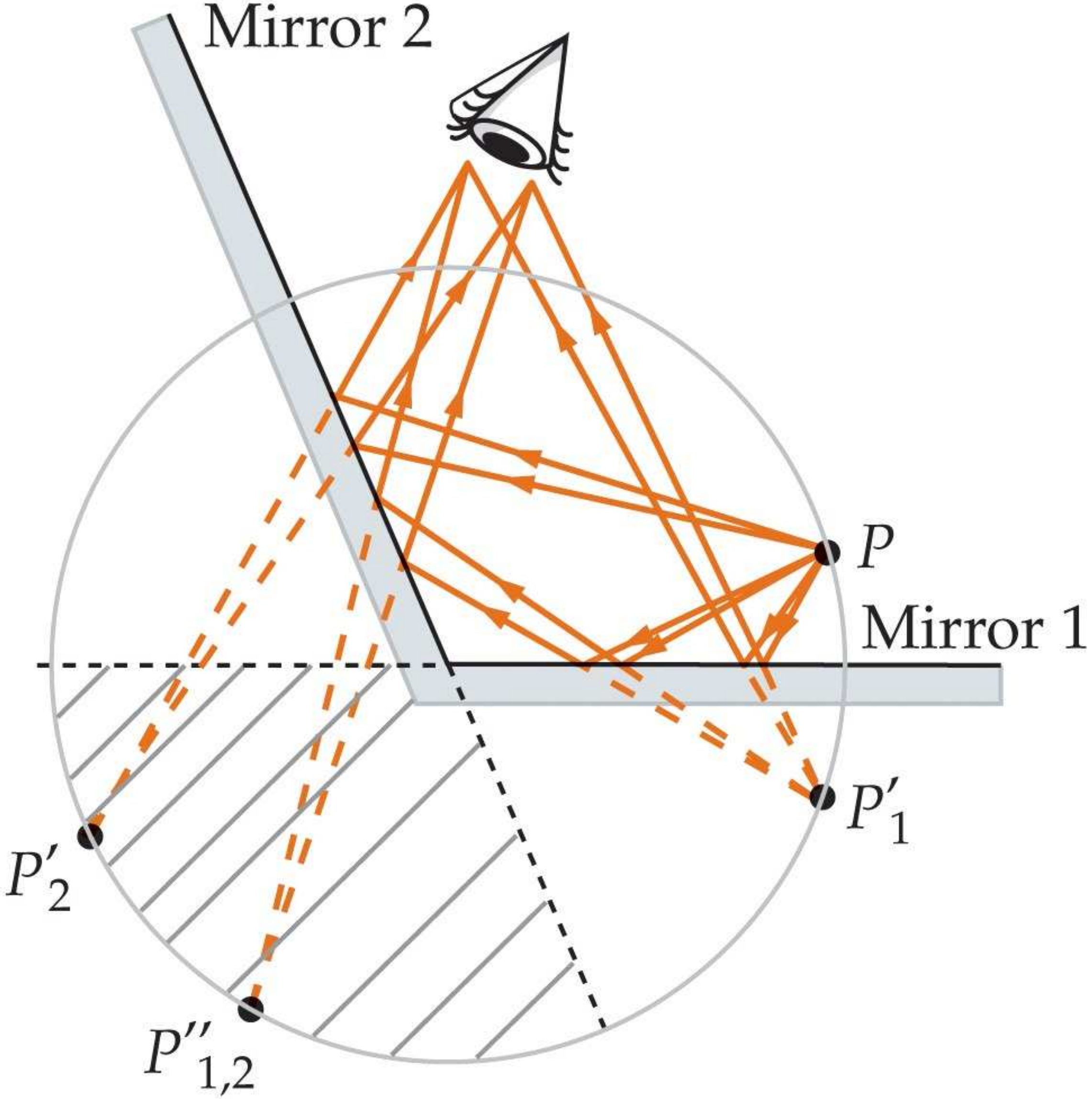




$$s = s'$$
$$y = y'$$

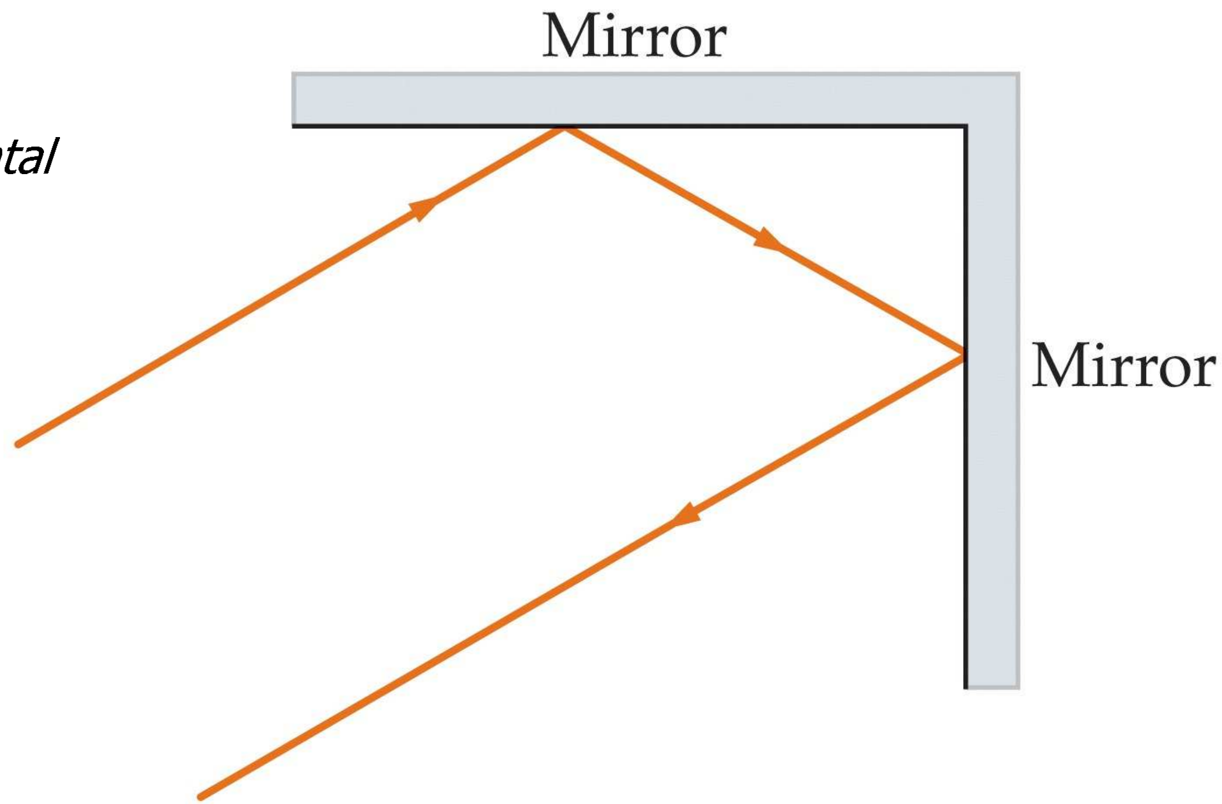
Imatge virtual
igual a l'objecte

Dos miralls

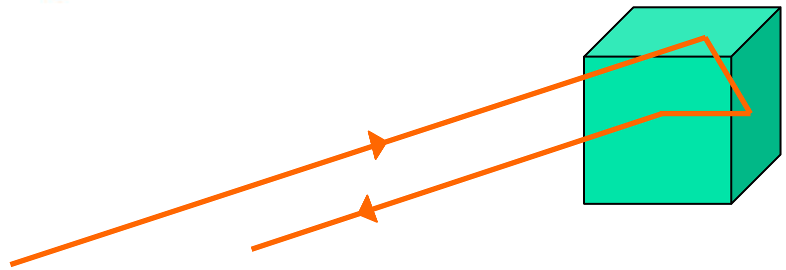


Dos miralls perpendiculars

Raig horitzontal

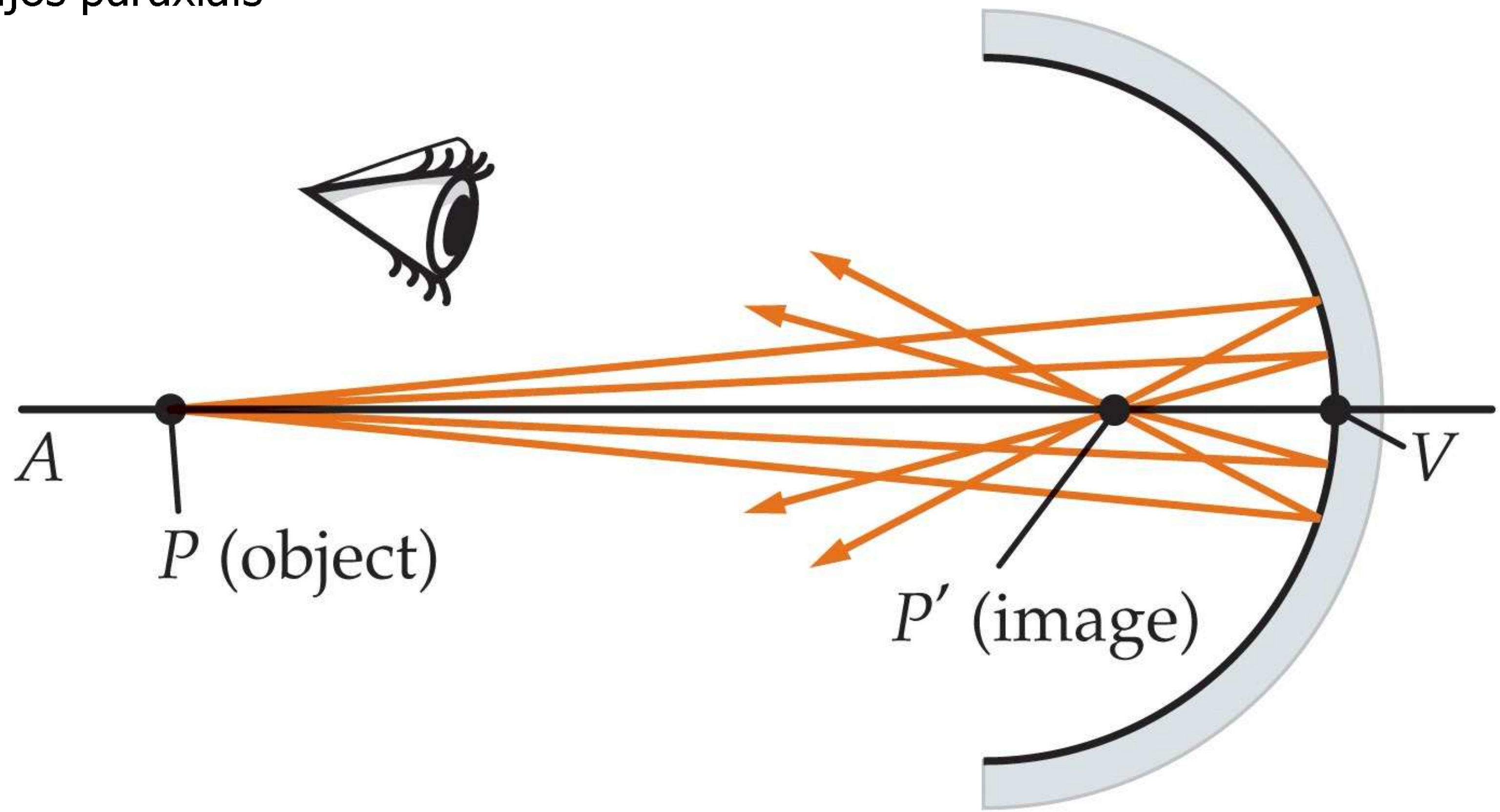


Reflectors ‘caire de cub’

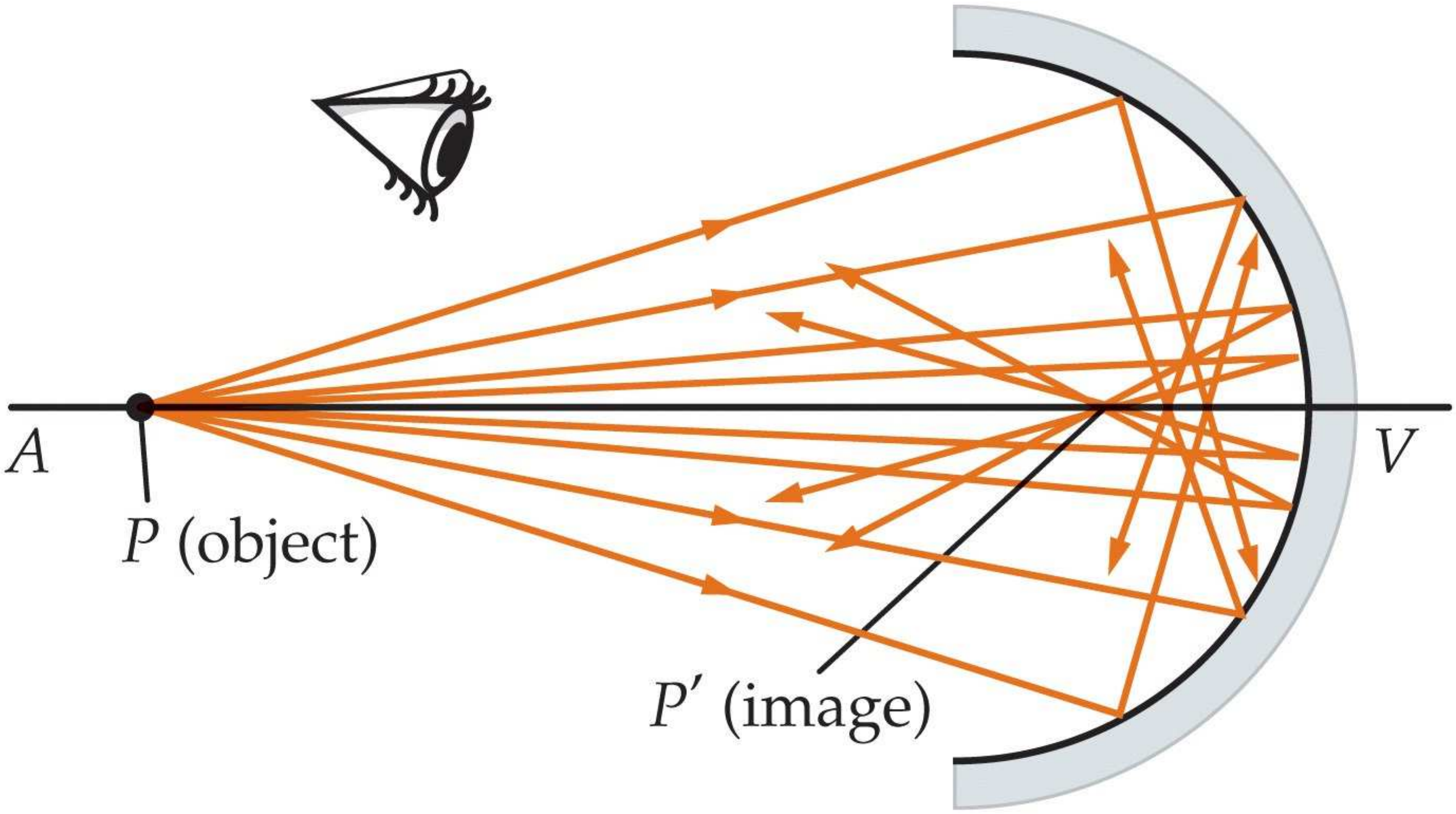


Miralls esfèrics

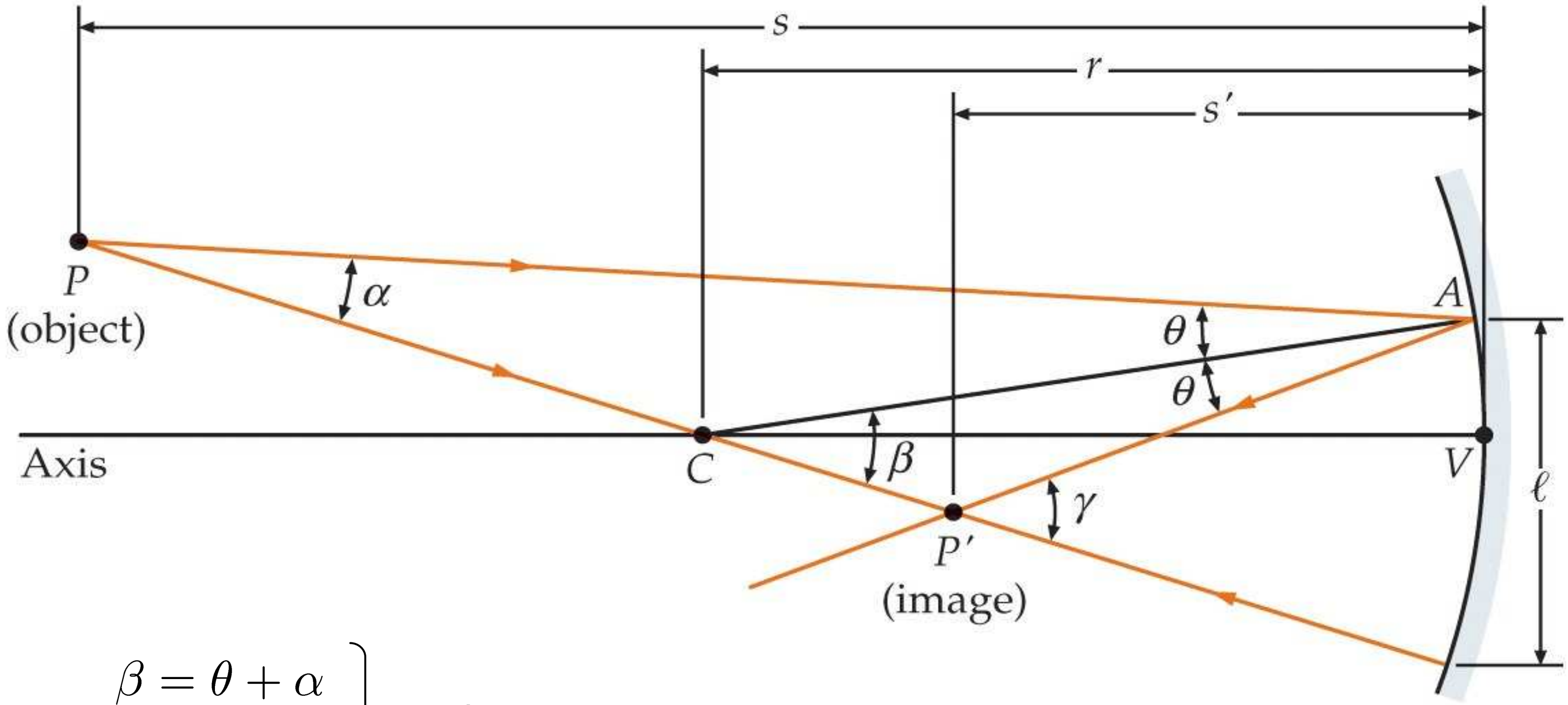
Rajos paraxials



Aberració esfèrica



Equació del mirall esfèric



$$\left.\begin{aligned}\beta &= \theta + \alpha \\ \gamma &= \beta + \theta\end{aligned}\right\} \quad 2\beta = \gamma + \alpha$$

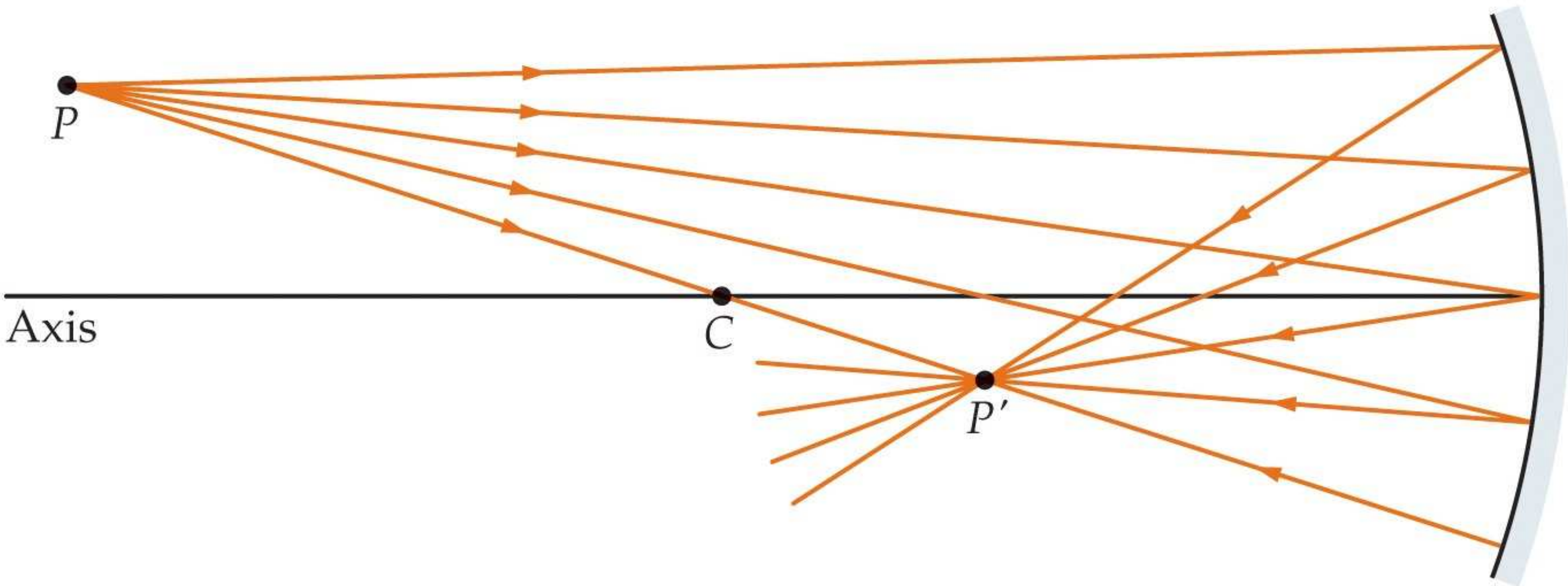
Límit paraxial

$$\alpha \approx \sin\alpha \approx \tan\alpha \approx \frac{\ell}{s}$$

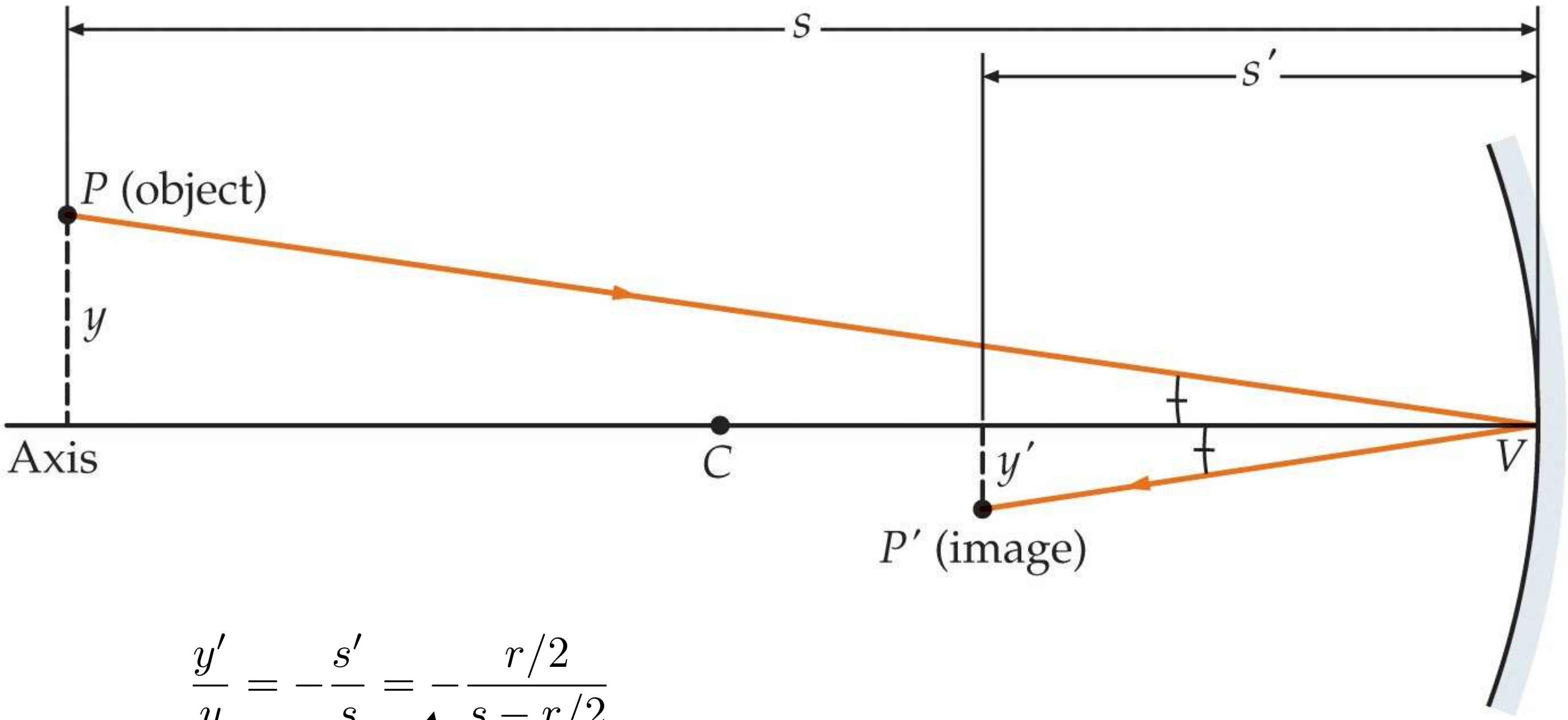
$$\beta \approx \sin\beta \approx \tan\beta \approx \frac{\ell}{r}$$

$$\gamma \approx \sin\gamma \approx \tan\gamma \approx \frac{\ell}{s'}$$

$$\boxed{\frac{1}{s} + \frac{1}{s'} = \frac{2}{r}}$$


P
Axis
C
P′

Augments

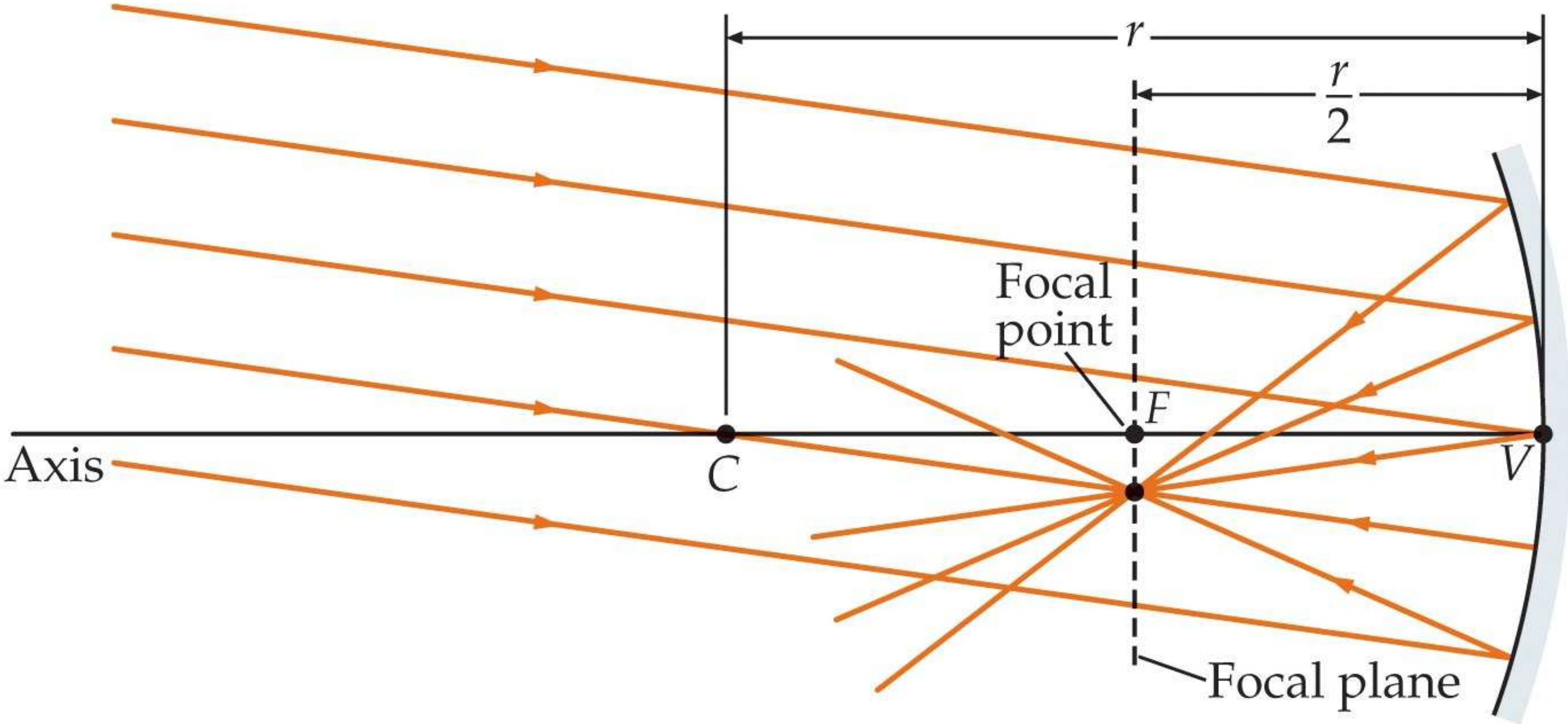


$$\frac{y'}{y} = -\frac{s'}{s} = -\frac{r/2}{s - r/2}$$

Imatge invertida

Focal

$$\left.\begin{array}{c}\dfrac{1}{s}+\dfrac{1}{s'}=\dfrac{2}{r}\\ \\ s\longrightarrow\infty\end{array}\right\}\qquad s'\equiv\boxed{f=\dfrac{r}{2}}$$



Mirall convex $r < 0$ $$\frac{1}{s} + \frac{1}{s'} = \frac{2}{r}$$

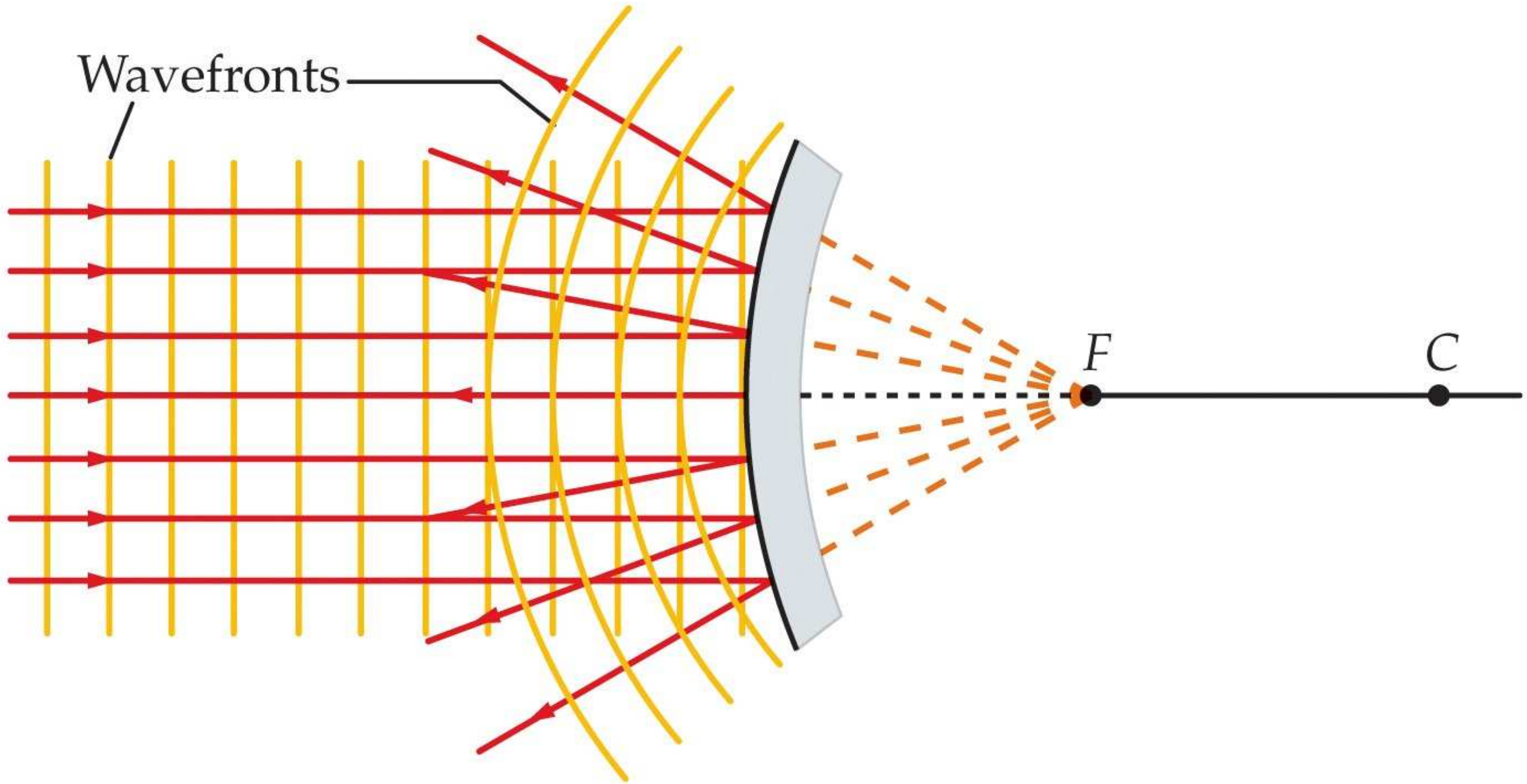
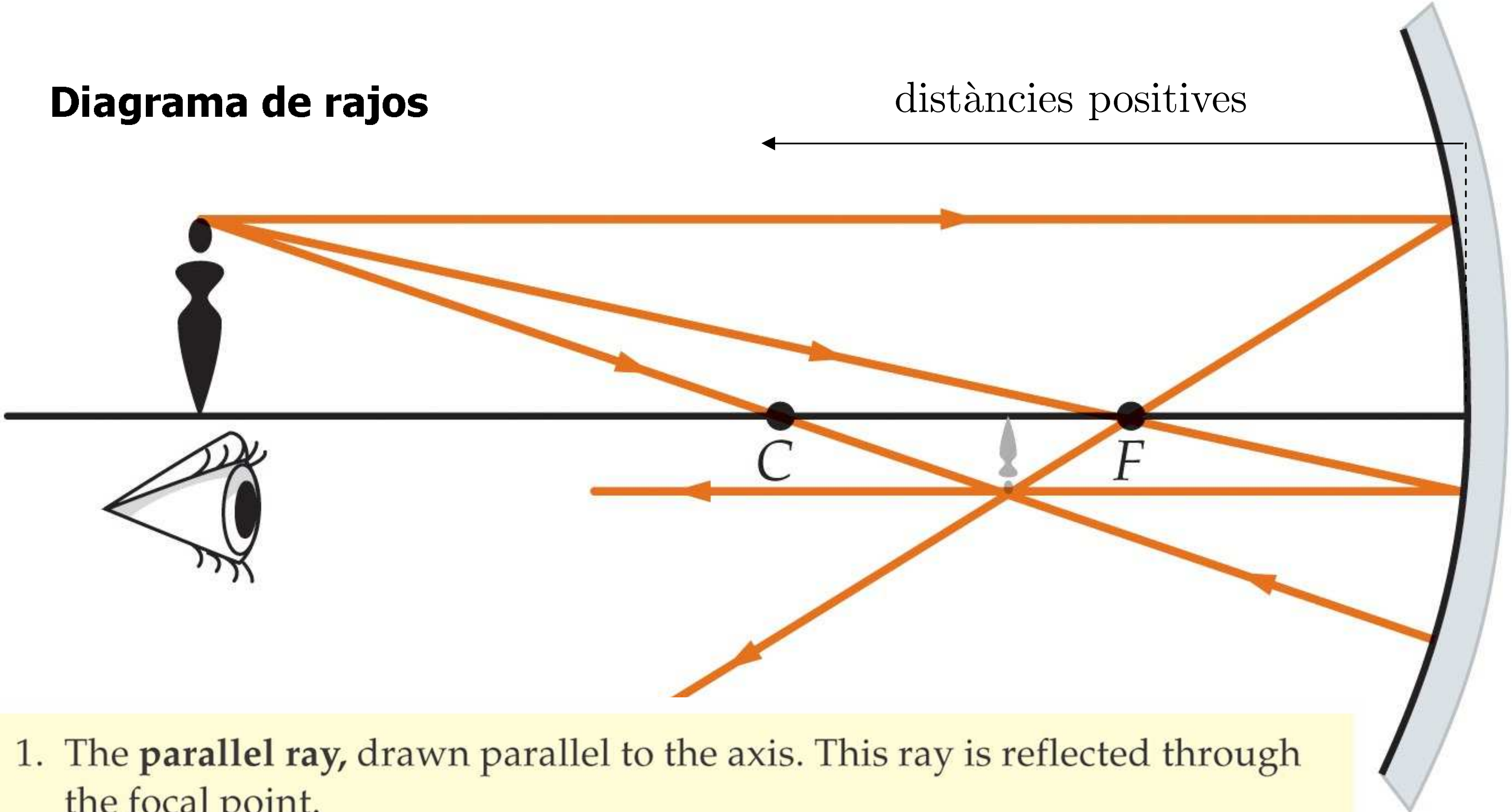
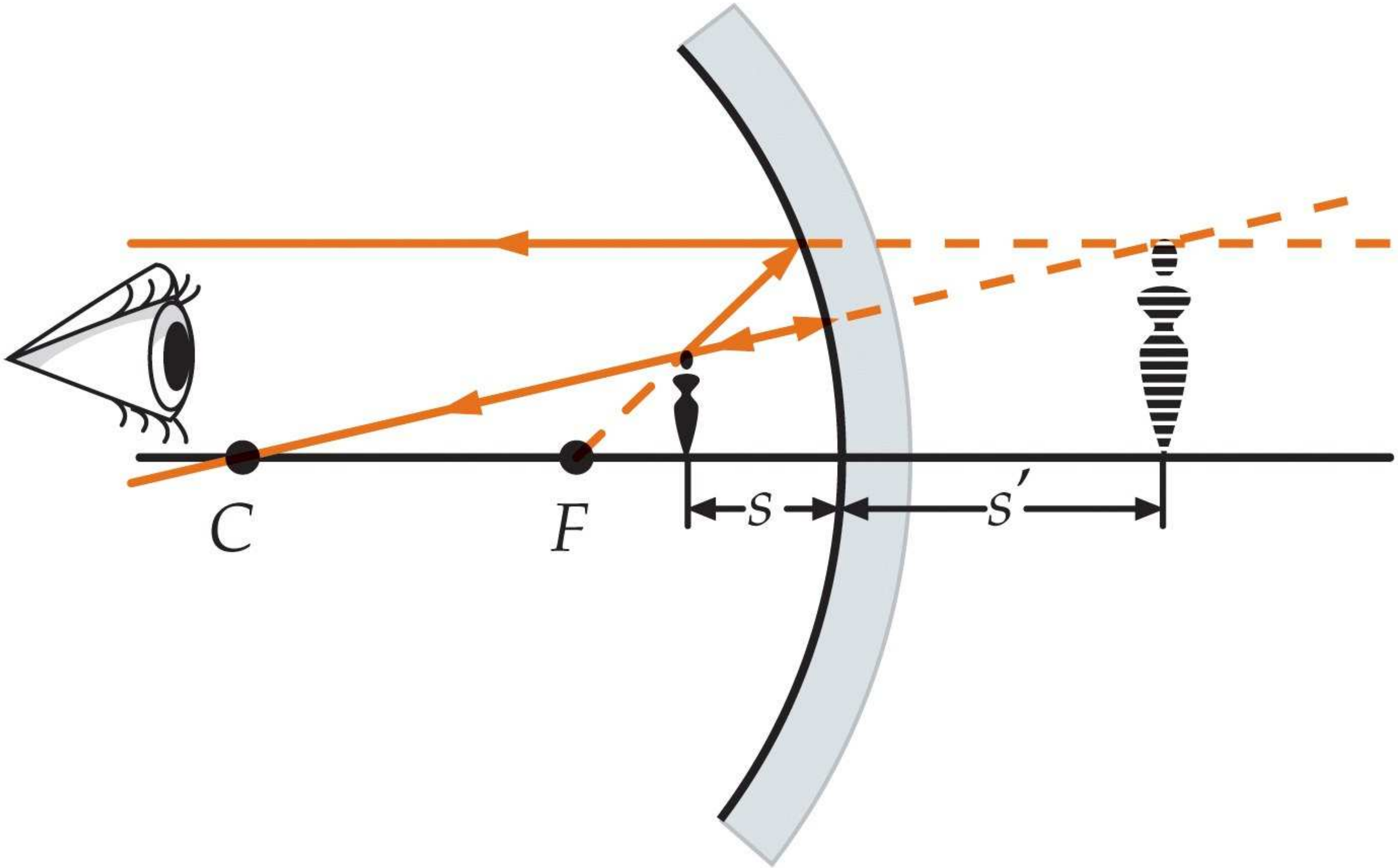


Diagrama de rajos

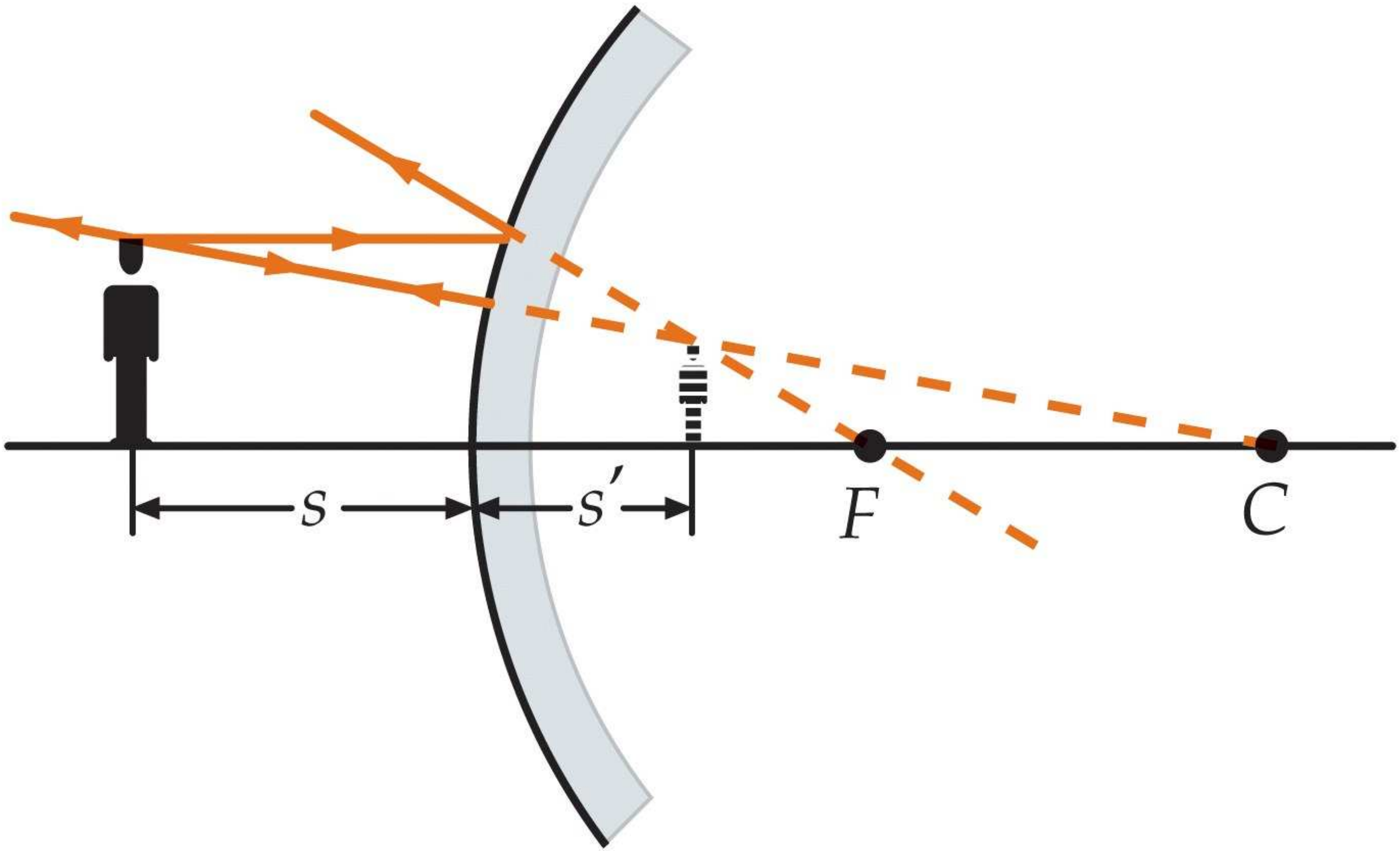


1. The **parallel ray,** drawn parallel to the axis. This ray is reflected through the focal point.
2. The **focal ray,** drawn through the focal point. This ray is reflected parallel to the axis.
3. The **radial ray,** drawn through the center of curvature. This ray strikes the mirror perpendicular to its surface and is thus reflected back on itself.

PRINCIPAL RAYS FOR A MIRROR

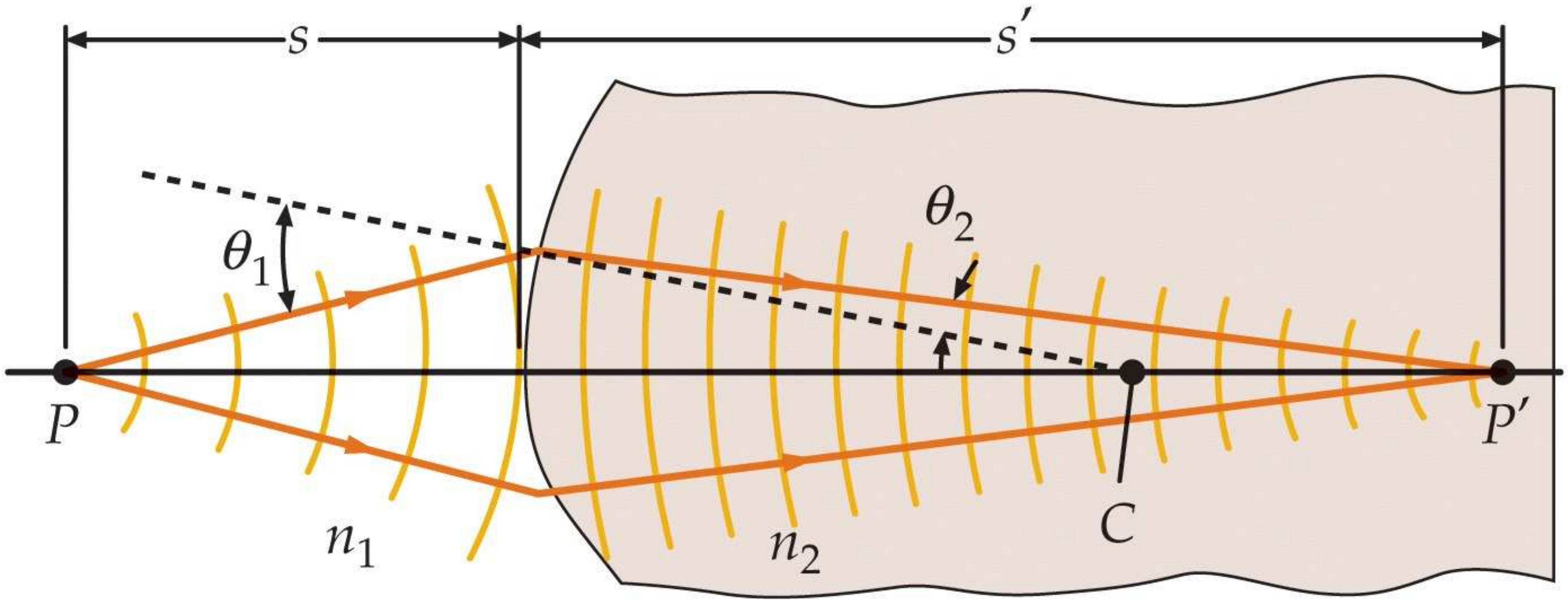


C
F
s
s′



s
s′
F
C

Refracció a una superfície esfèrica

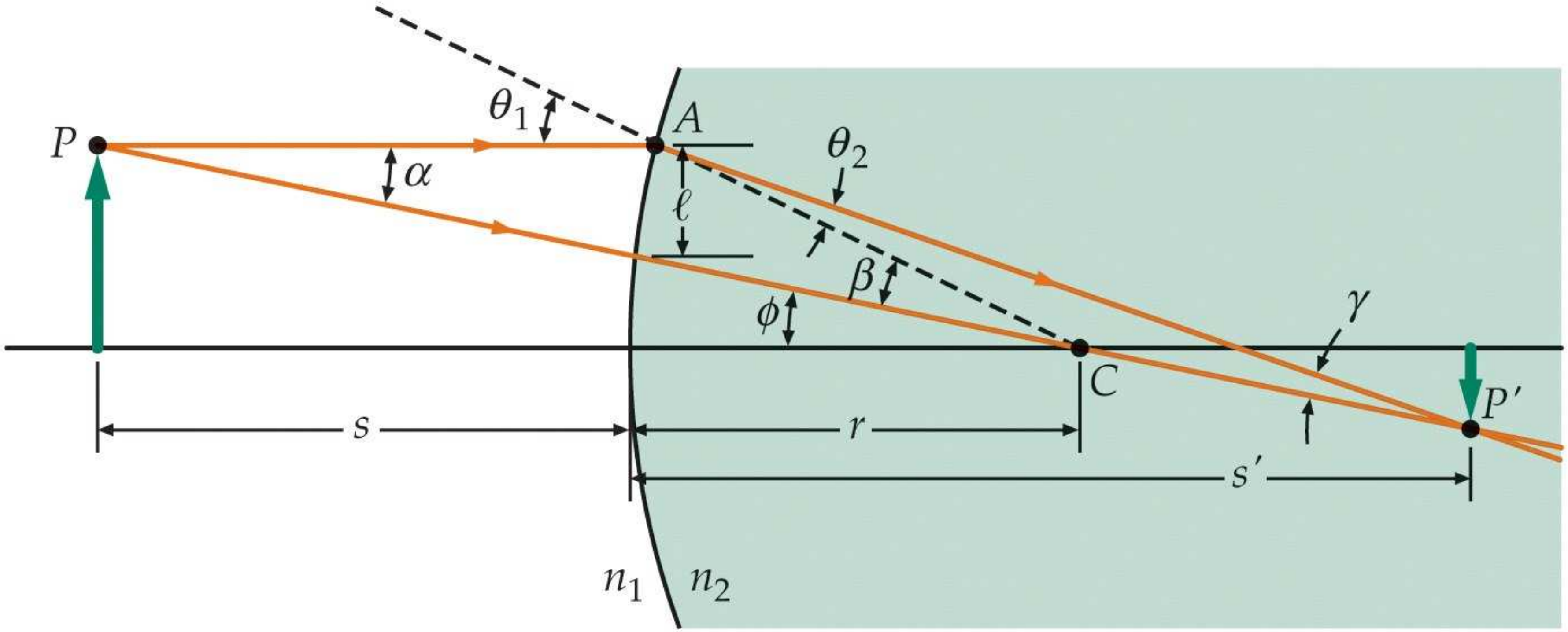


$$\frac{n_1}{s} + \frac{n_2}{s'} = \frac{n_2 - n_1}{r} \qquad 32\text{-}6$$

REFRACTION AT A SINGLE SURFACE

1. s is positive for objects on the incident-light side of the surface.
2. s' is positive for images on the refracted-light side of the surface.
3. r is positive if the center of curvature is on the refracted-light side of the surface.

SIGN CONVENTIONS FOR REFRACTION†



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

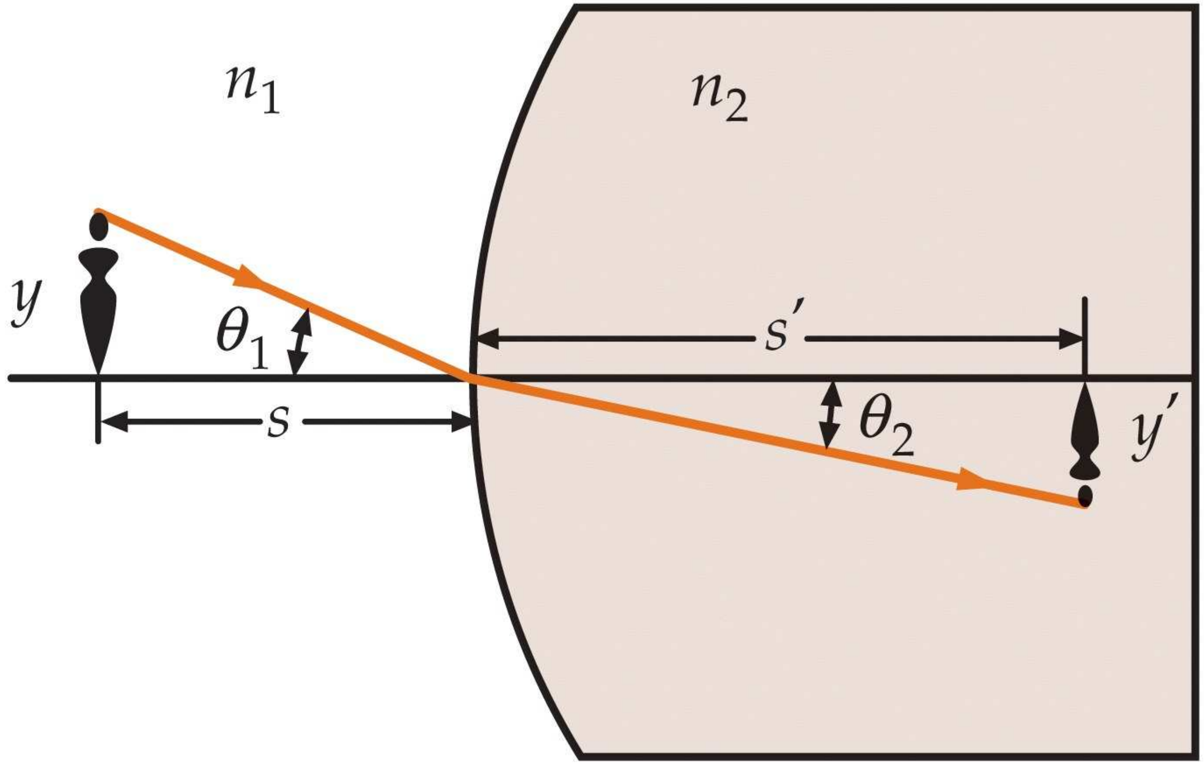
$$ACP' \Longrightarrow \beta = \theta_2 + \gamma = \frac{n_1}{n_2}\theta_1 + \gamma$$

$$PAC \Longrightarrow \theta_1 = \alpha + \beta$$

$$\alpha \approx \frac{\ell}{s} \qquad \beta \approx \frac{\ell}{r} \qquad \gamma \approx \frac{\ell}{s'}$$

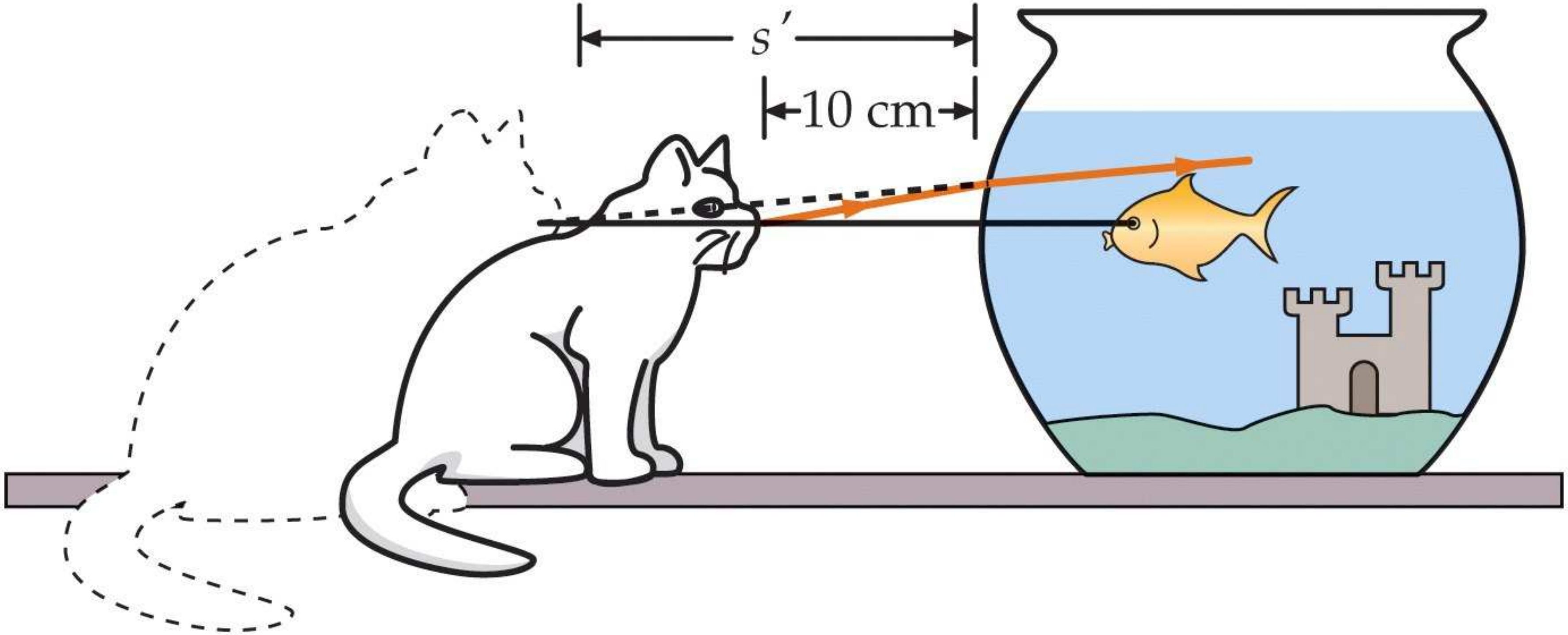
$$n_1\alpha + n_2\gamma = (n_2 - n_1)\beta$$

$$\frac{n_1}{s} + \frac{n_2}{s'} = \frac{(n_2 - n_1)}{r}$$



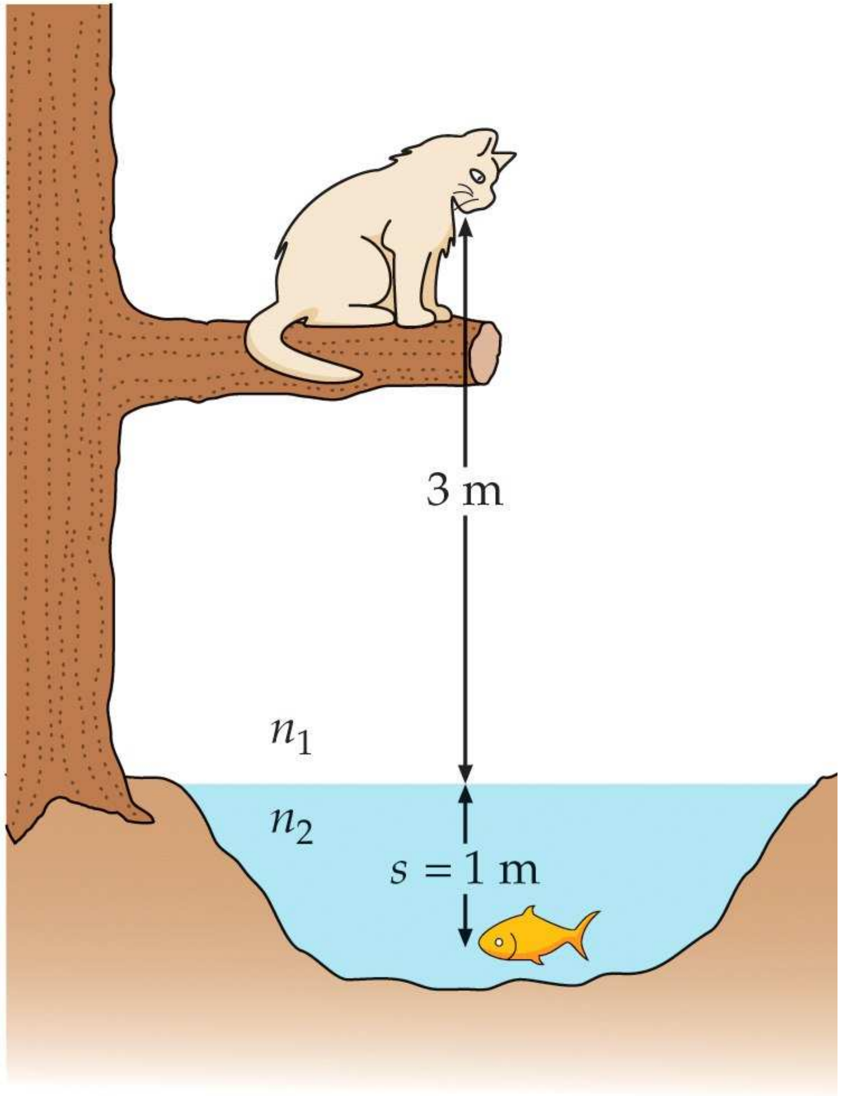
$$m = \frac{y'}{y} = -\frac{n_1 s'}{n_2 s} \qquad 32\text{-}7$$

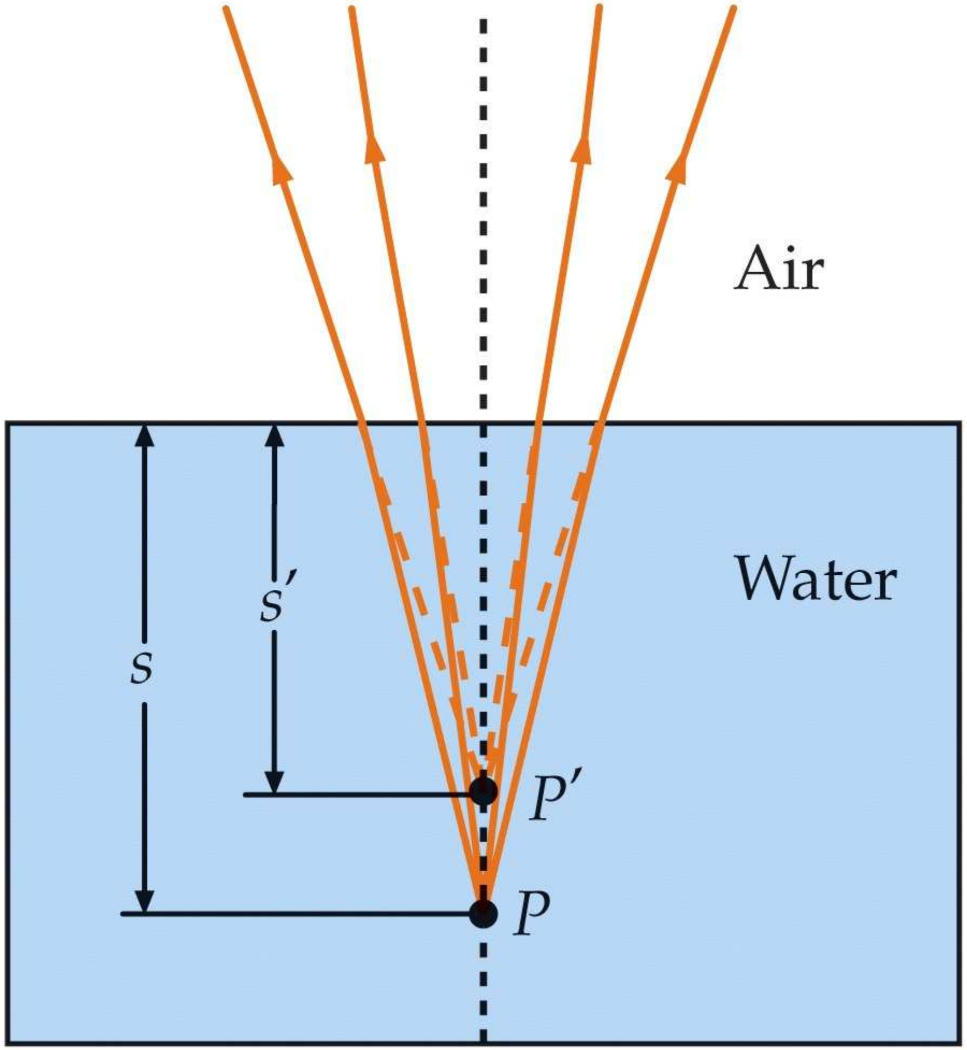
Magnification for a Refracting Boundary



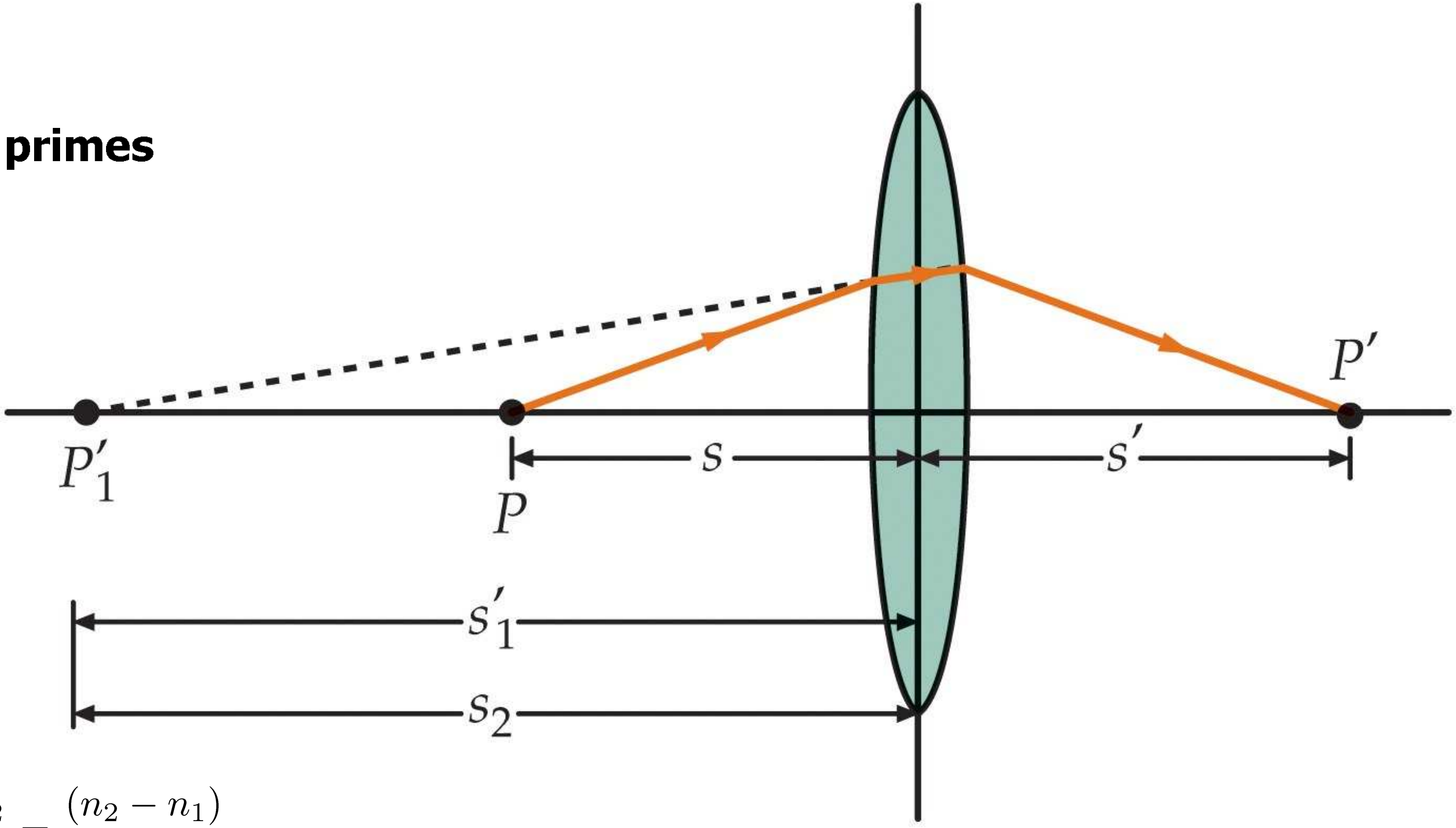
$$s' = -17.1 \text{ cm}$$

$$m = 1.29$$


3 m
n_1
n_2
$s = 1$ m


Air
Water
s'
s
P'
P

Lents primes

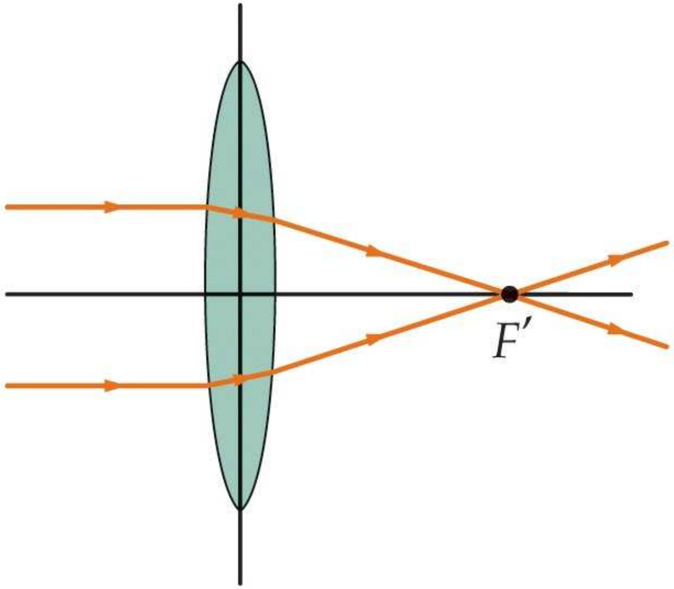
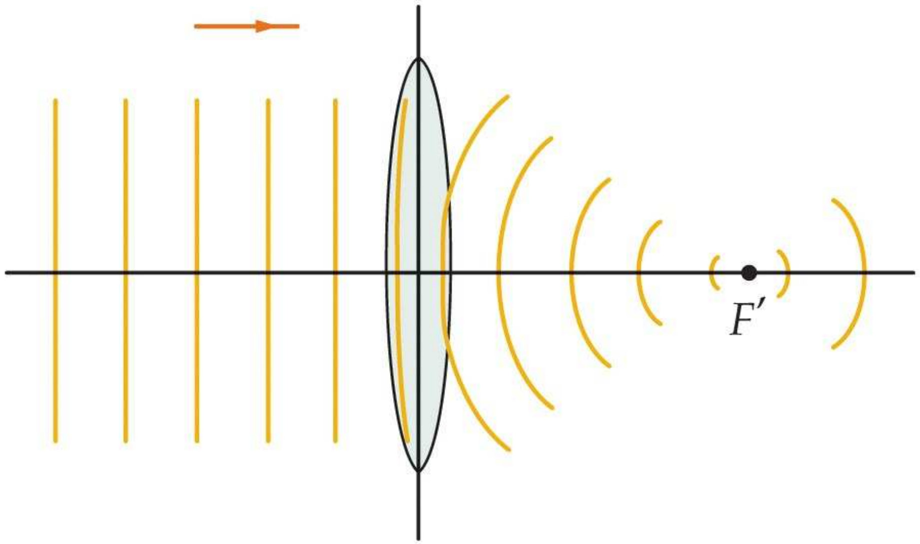
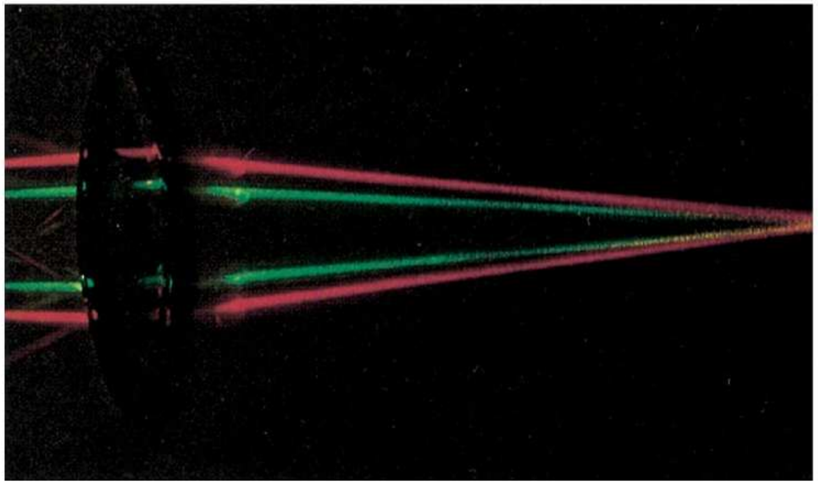
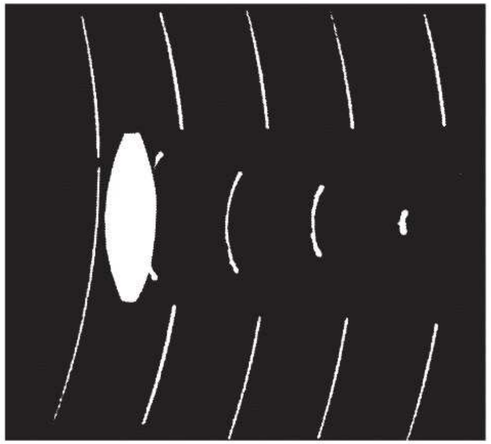


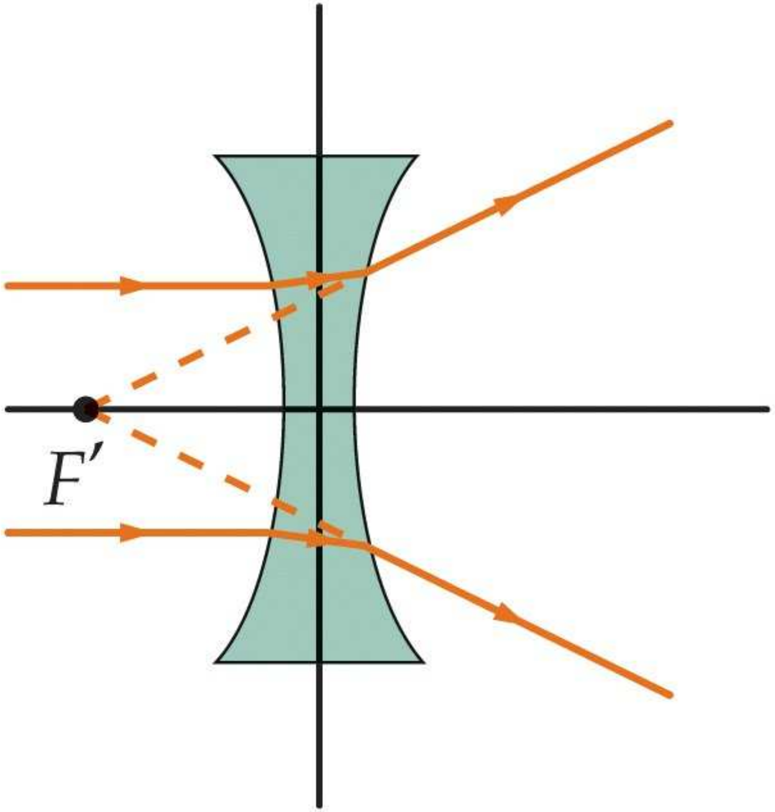
$$\frac{n_1}{s} + \frac{n_2}{s'} = \frac{(n_2 - n_1)}{r}$$

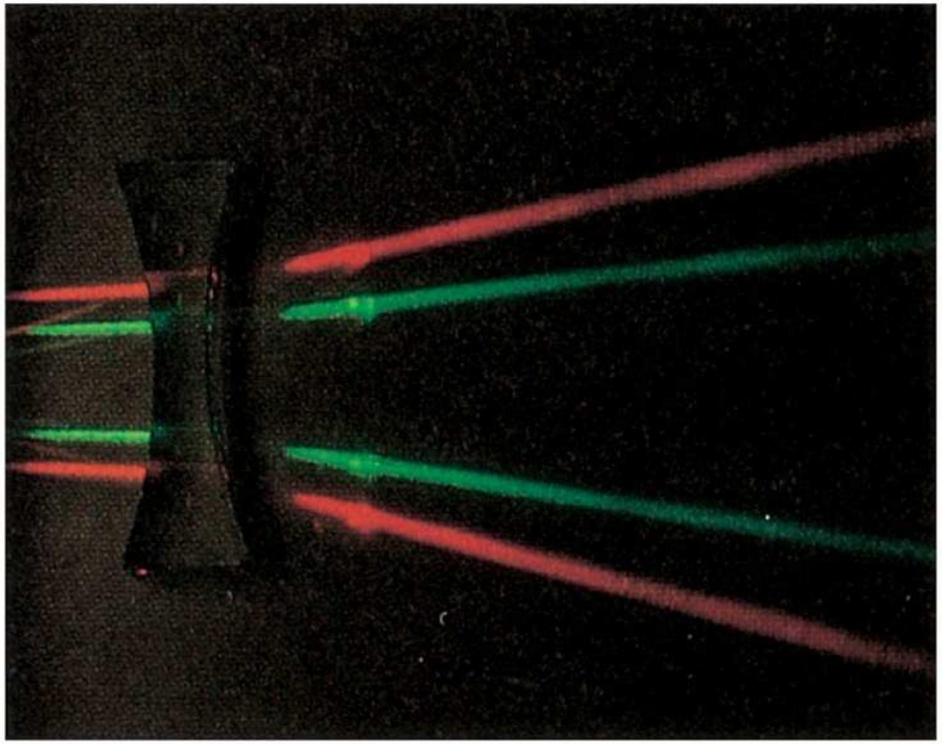
$$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

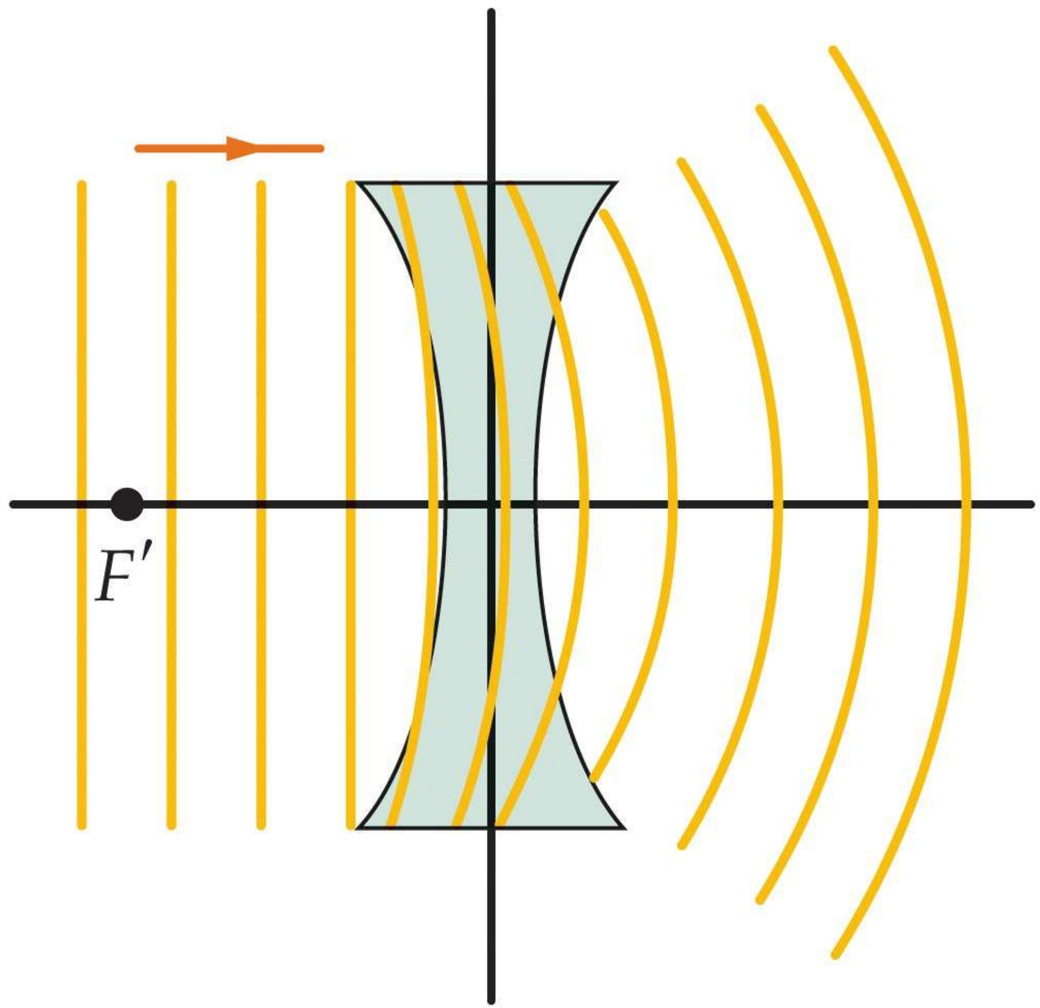
$$\left.\begin{array}{l} \dfrac{1}{s} + \dfrac{n}{s'_1} = \dfrac{(n-1)}{r_1} \\ \\ \dfrac{n}{-s'_1} + \dfrac{1}{s'} = \dfrac{(1-n)}{r_2} \end{array}\right\} \quad \frac{1}{s} + \frac{1}{s'} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

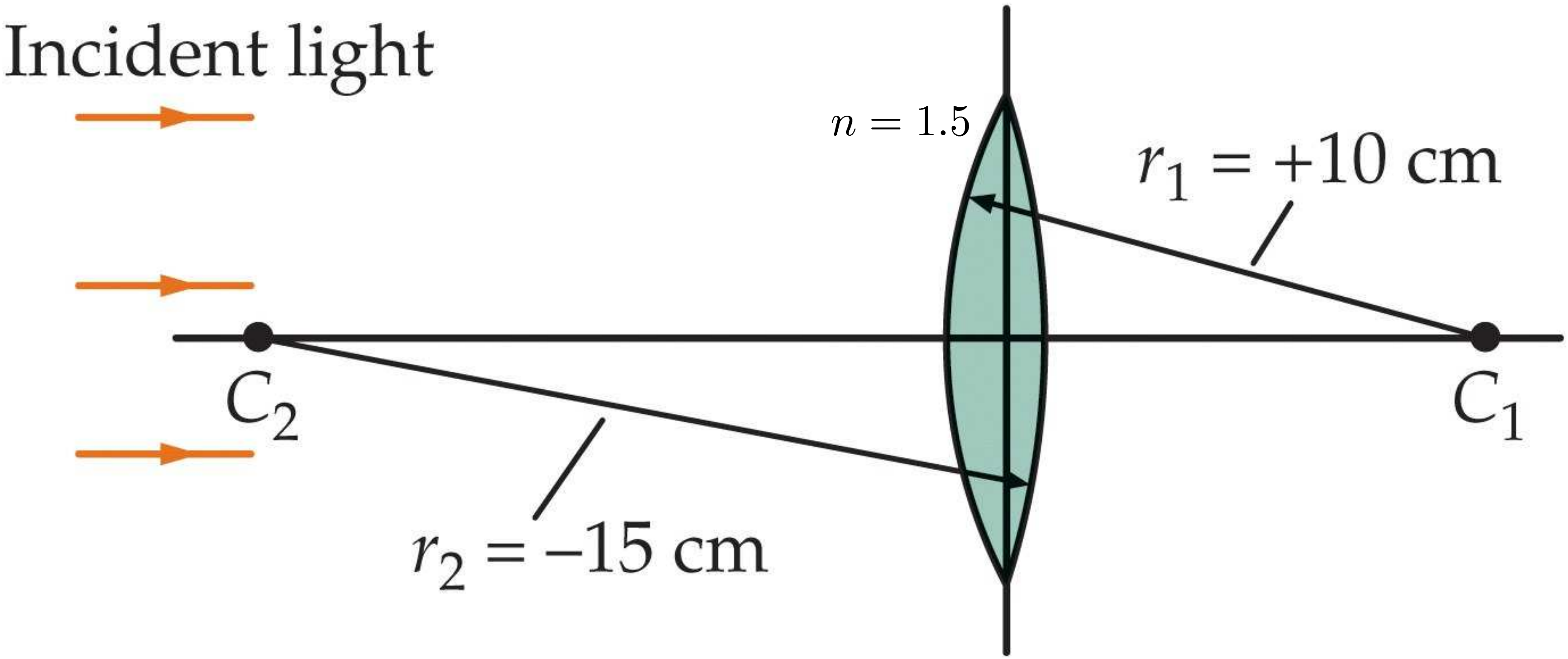
$$\boxed{\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}}$$


F′

F′




F′




F′



$$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

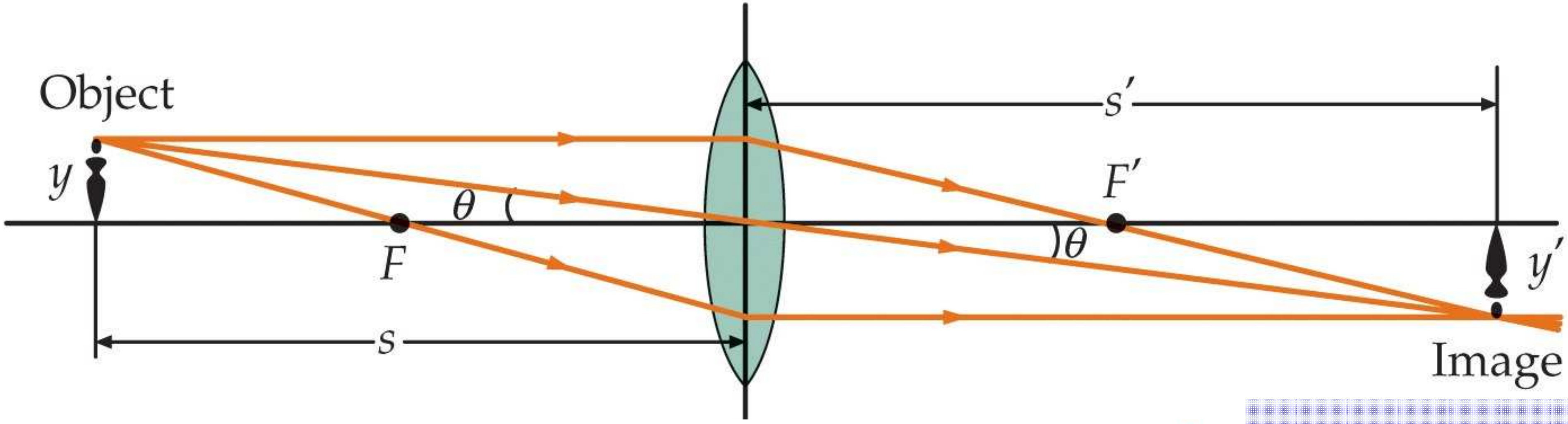
$$f = 12 \text{ cm}$$

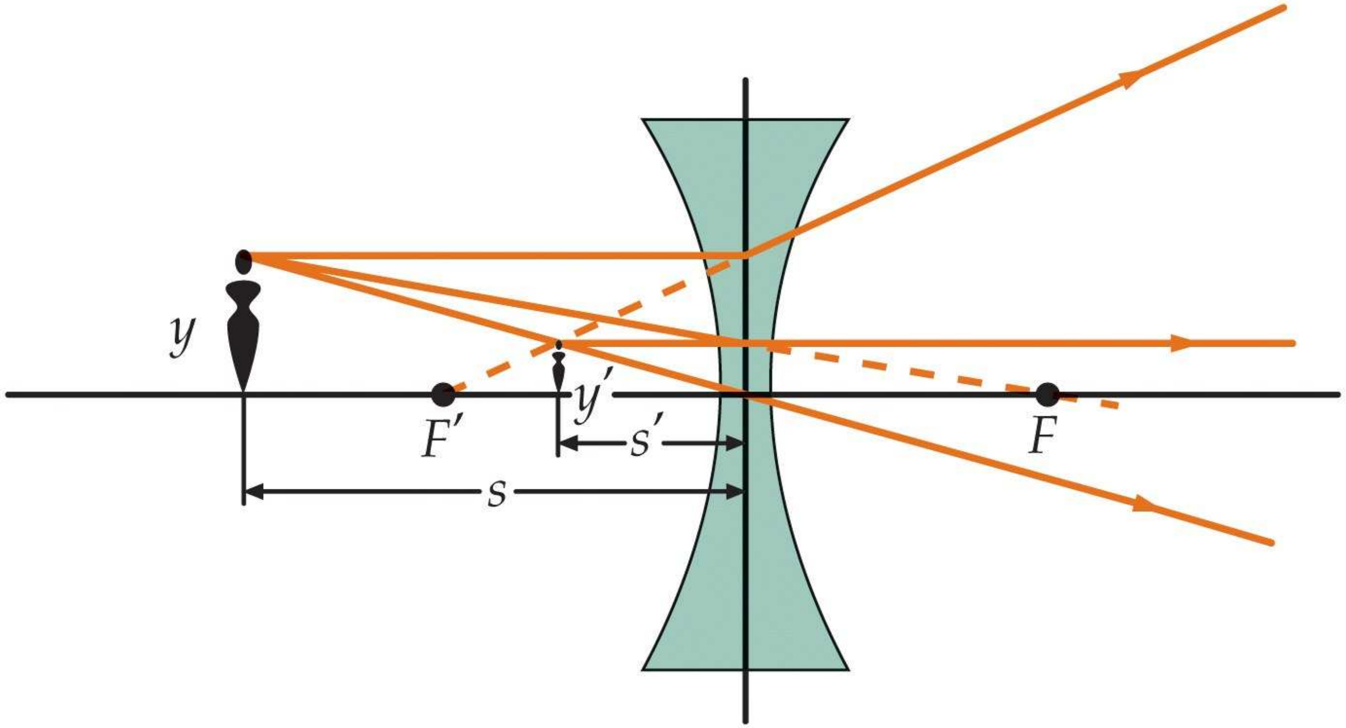
1. The **parallel ray,** drawn parallel to the axis. The emerging ray is directed toward (or away from) the second focal point of the lens.
2. The **central ray,** drawn through the center (the vertex) of the lens. This ray is undeflected. (The faces of the lens are parallel at this point, so the ray emerges in the same direction but displaced slightly. Since the lens is thin, the displacement is negligible.)
3. The **focal ray,** drawn through the first focal point.† This ray emerges parallel to the axis.

PRINCIPAL RAYS FOR A THIN LENS

Potència: $$P = \frac{1}{f}$$

unitat $$[P] = \frac{1}{\mathrm{m}} = \mathrm{D}$$ dioptría

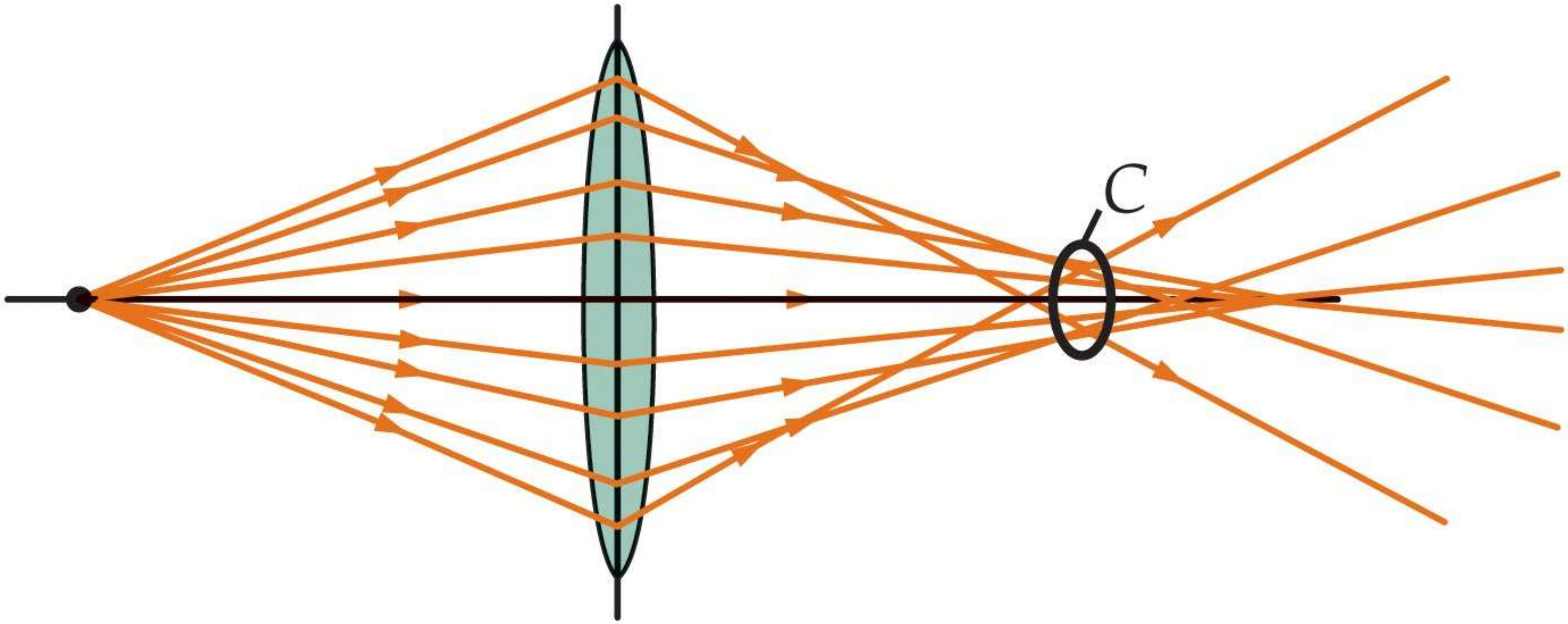




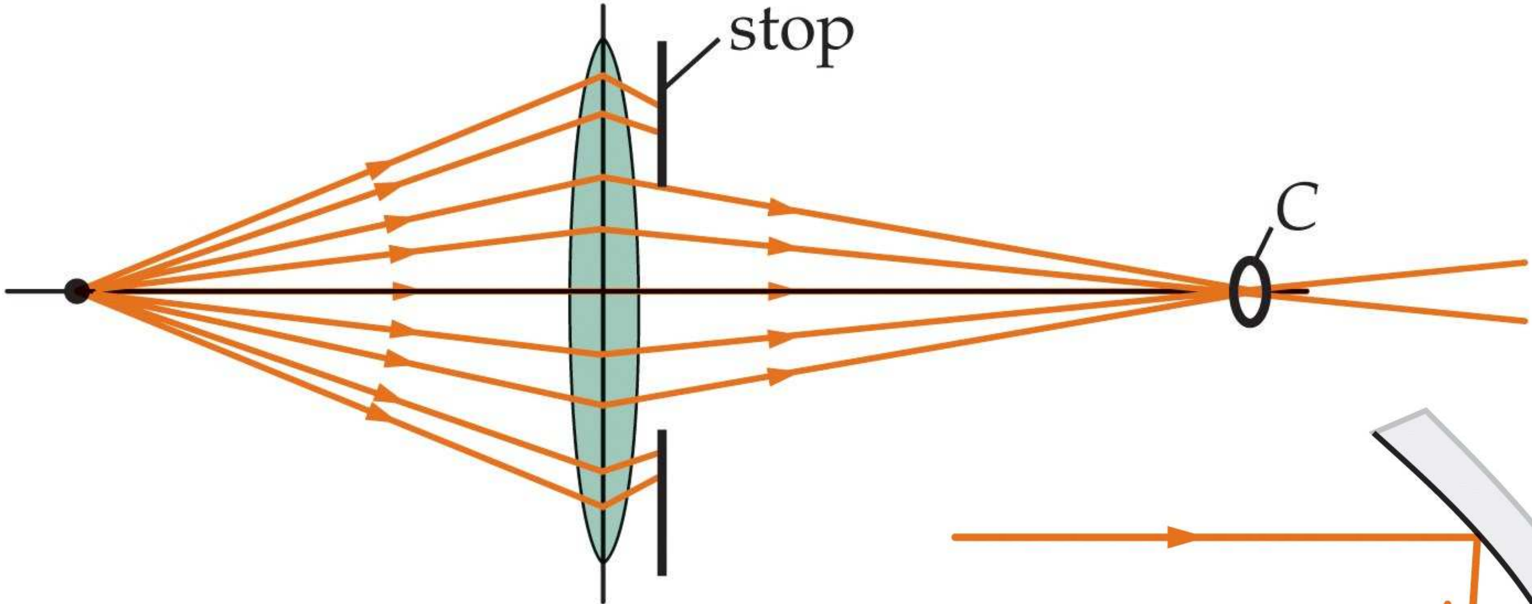
augment

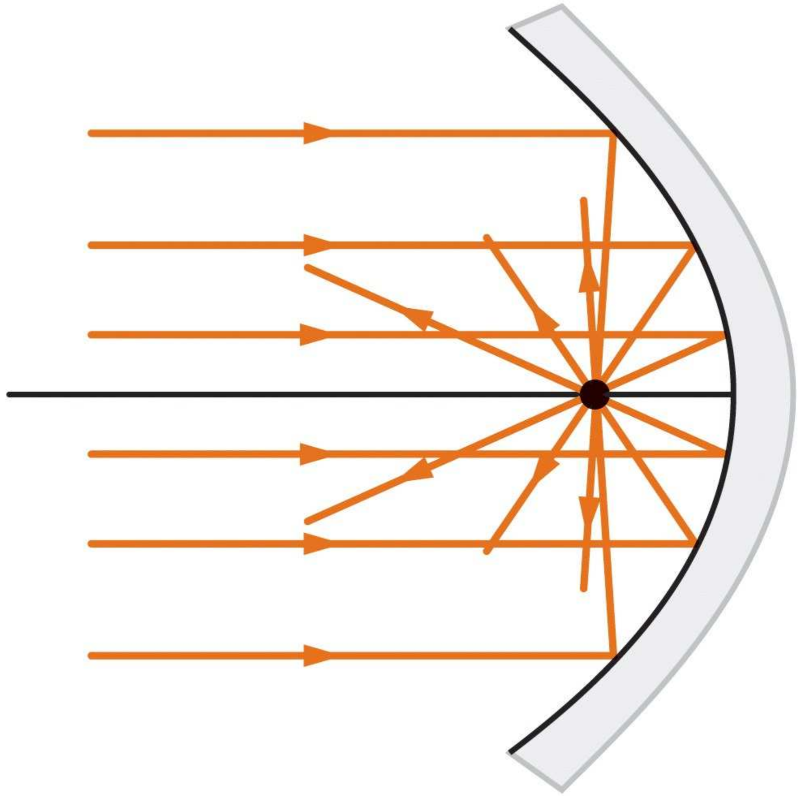
$$m = \frac{y'}{y} = -\frac{s'}{s}$$

Aberració esfèrica

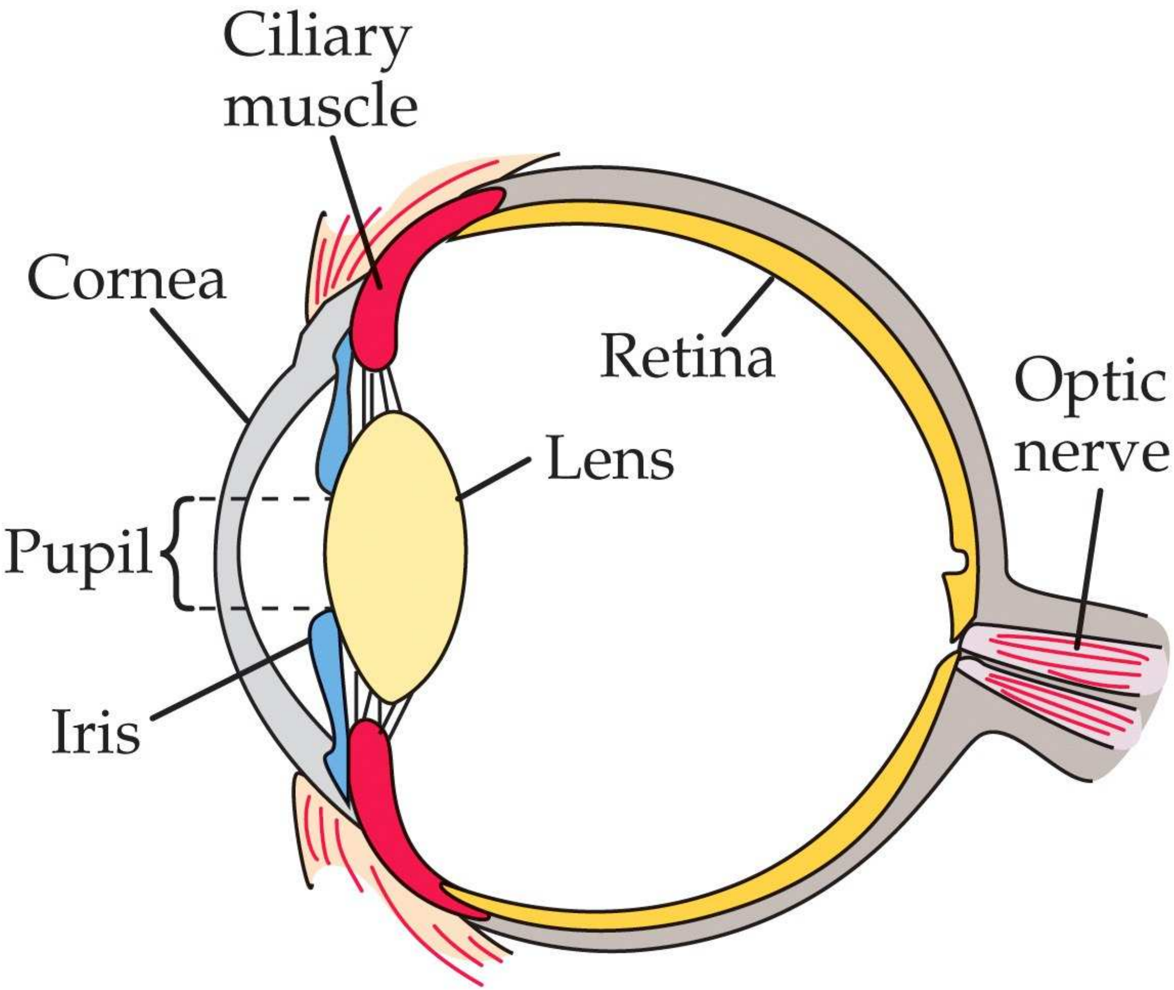


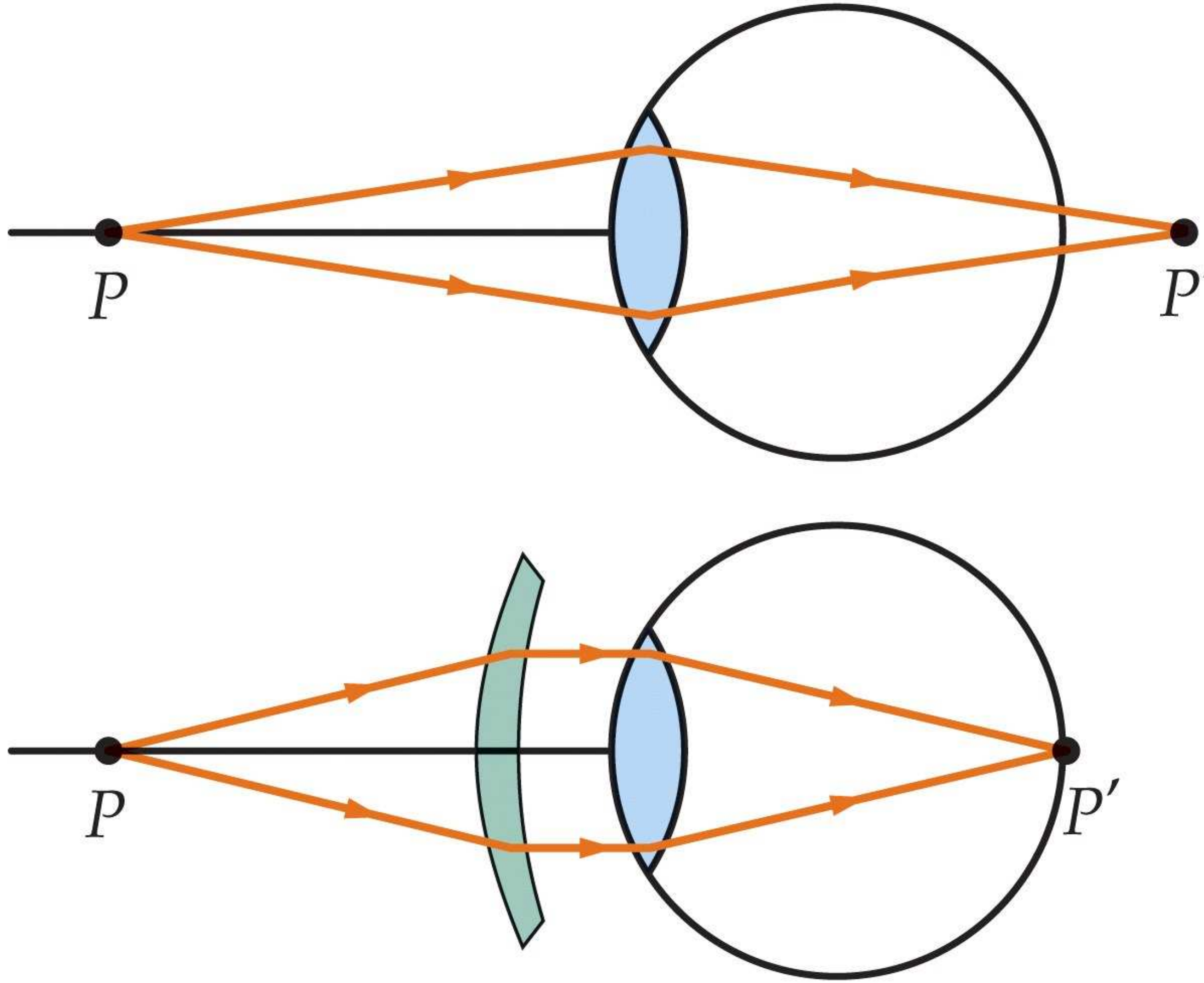
Aberració cromàtica


stop
C

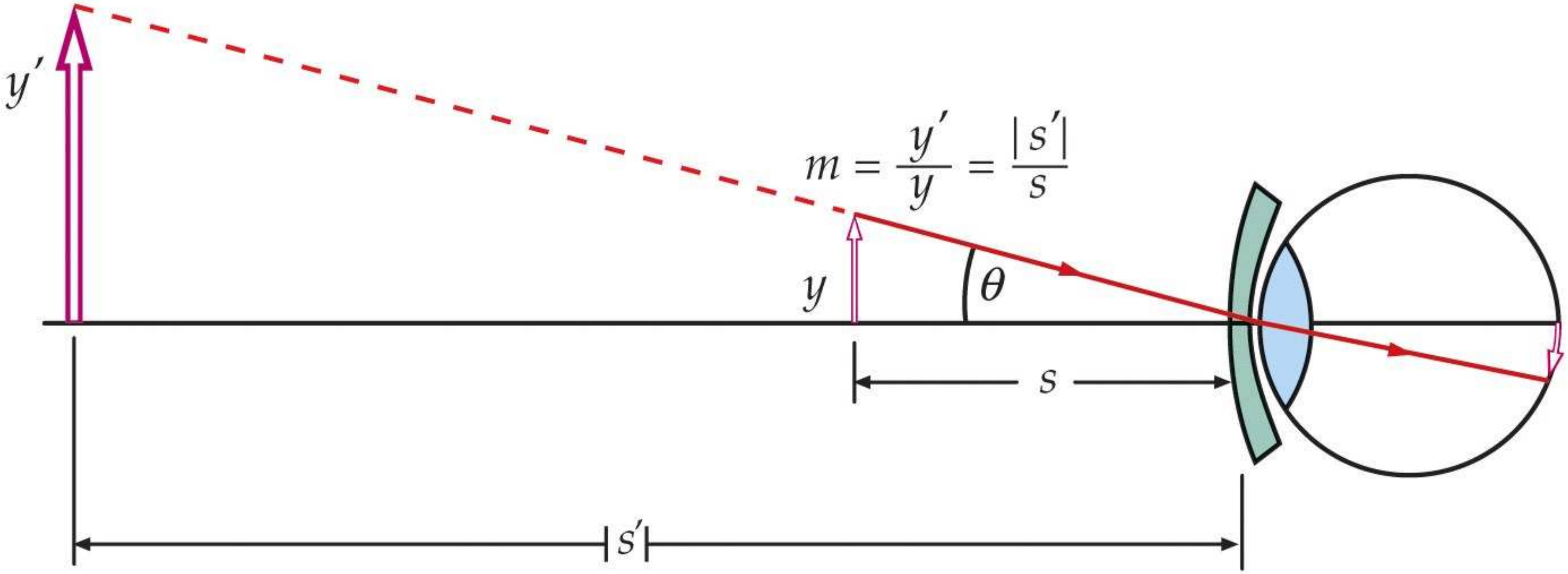


Ull

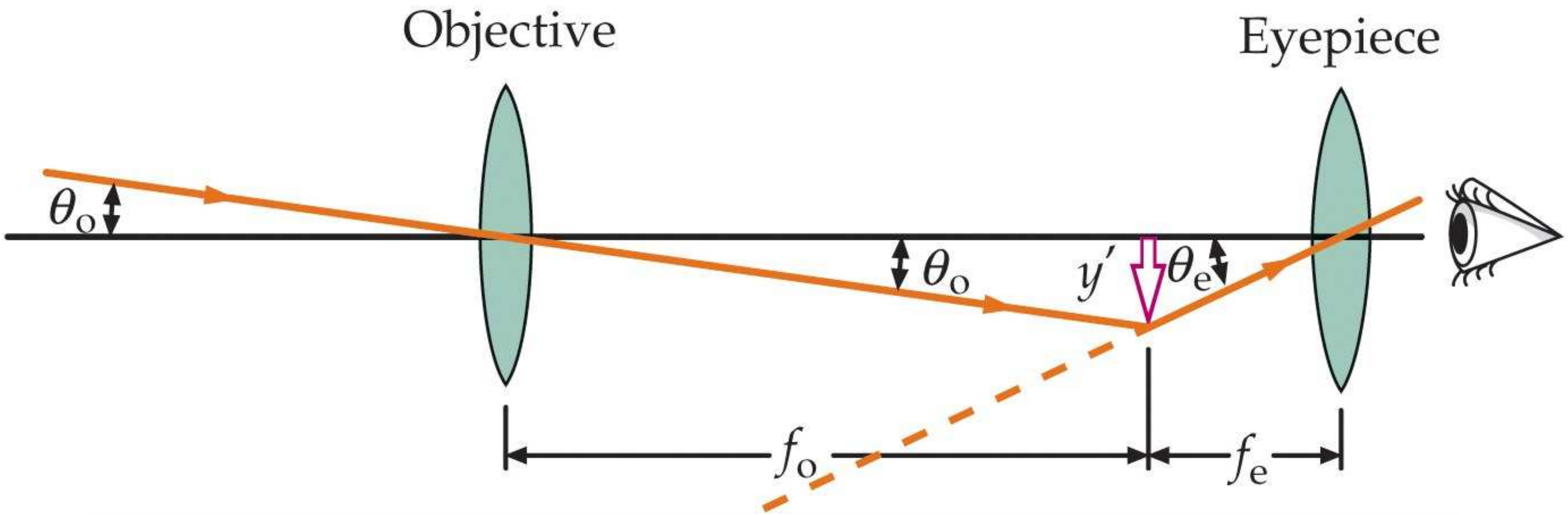



P
P′
P
P′

Lupa

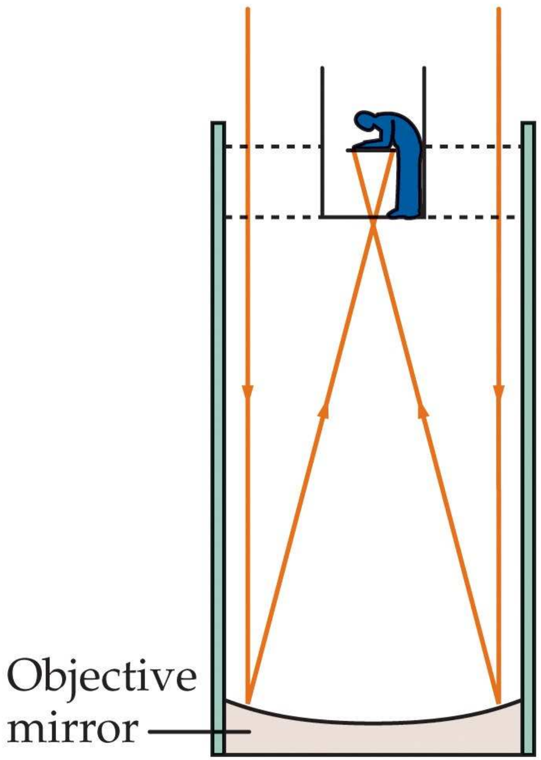


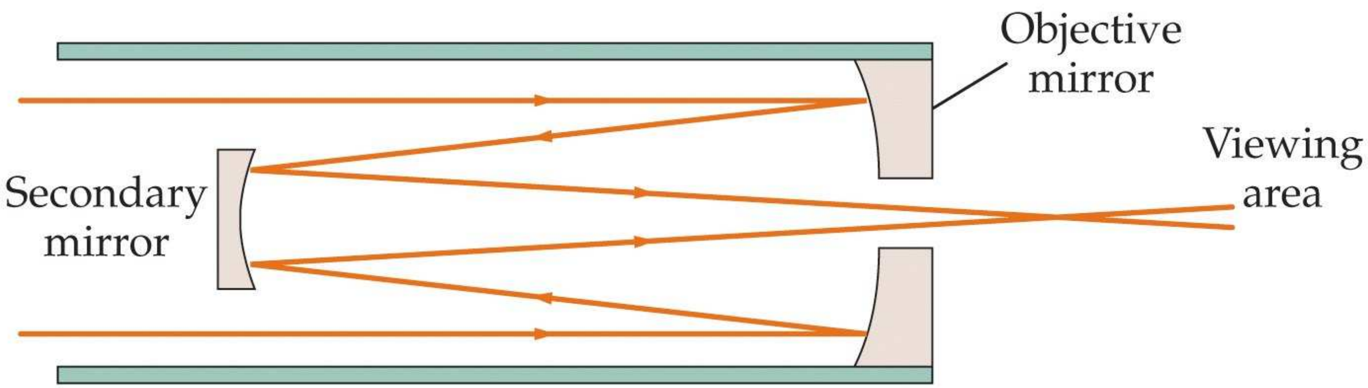
Telescopi



$$M = \frac{\theta_e}{\theta_o} = -\frac{f_o}{f_e} \qquad 32\text{-}23$$

MAGNIFYING POWER OF A TELESCOPE


Objective
mirror

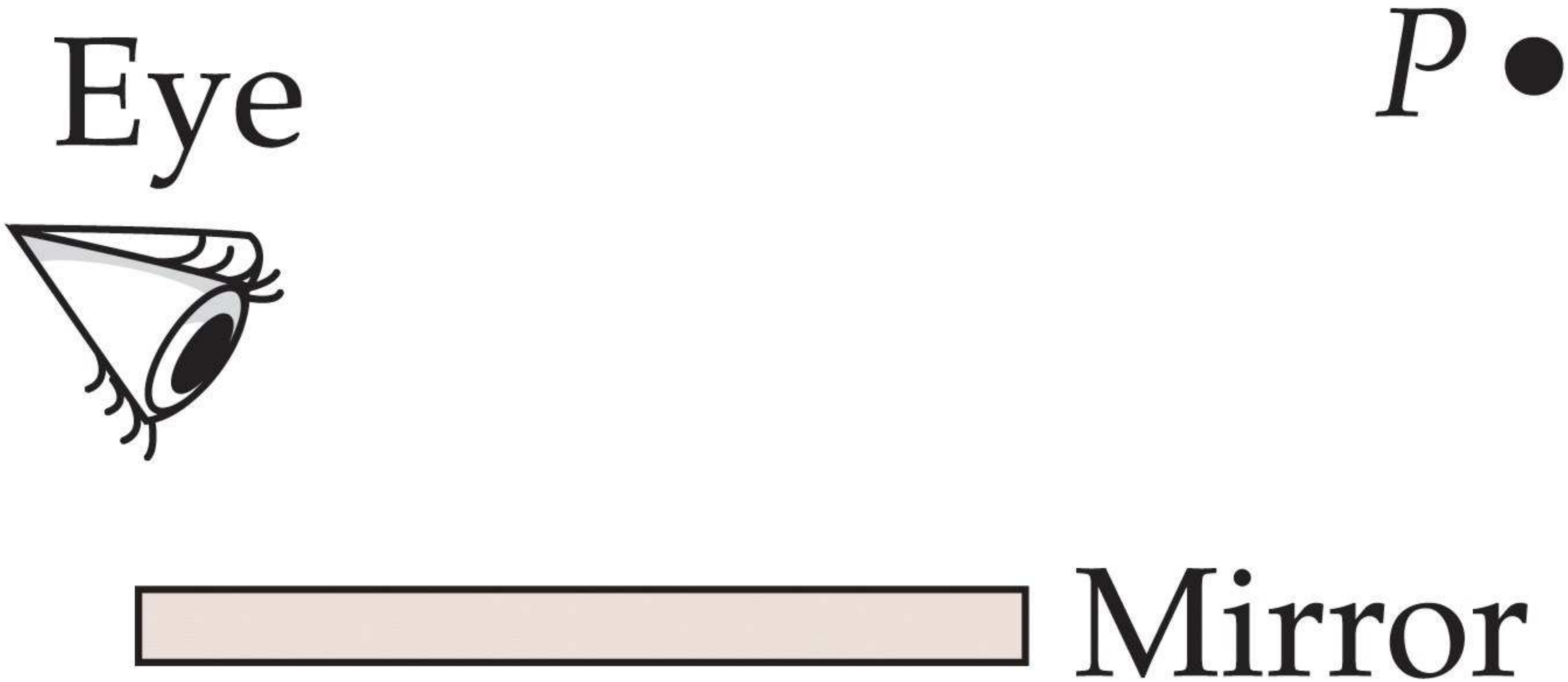

Objective
mirror
Viewing
area
Secondary
mirror

Problems

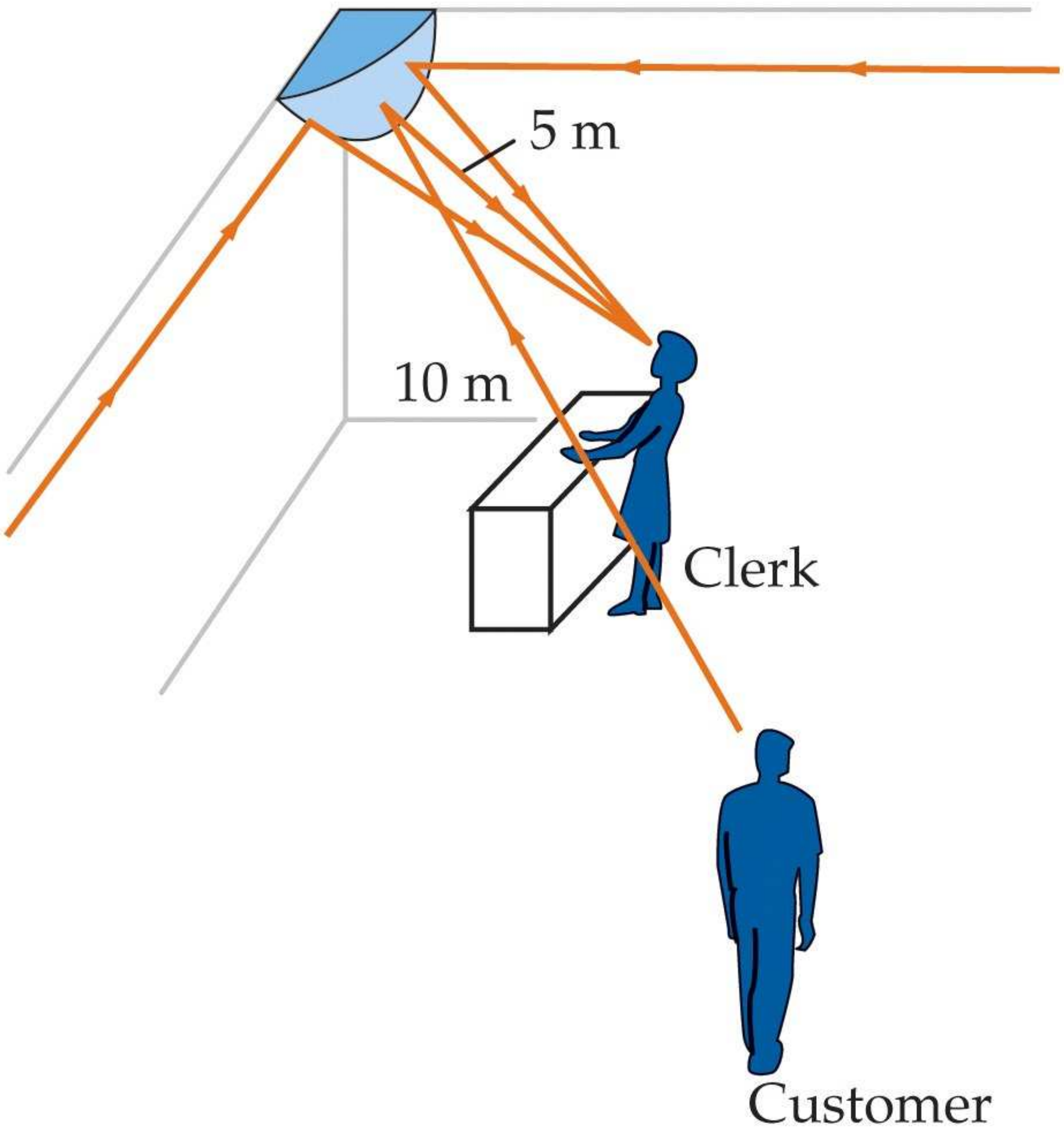
32.1

32.2

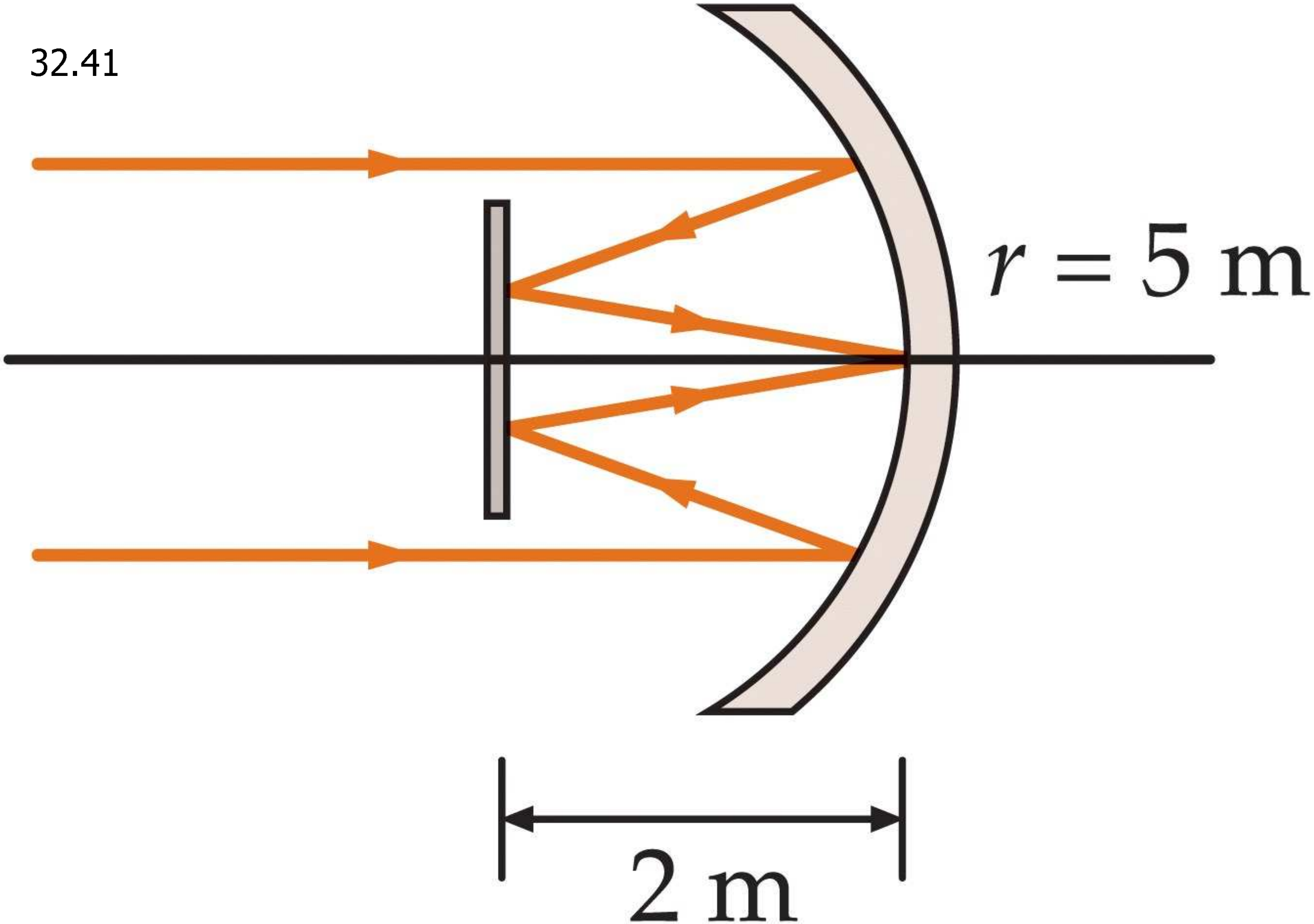
32.25



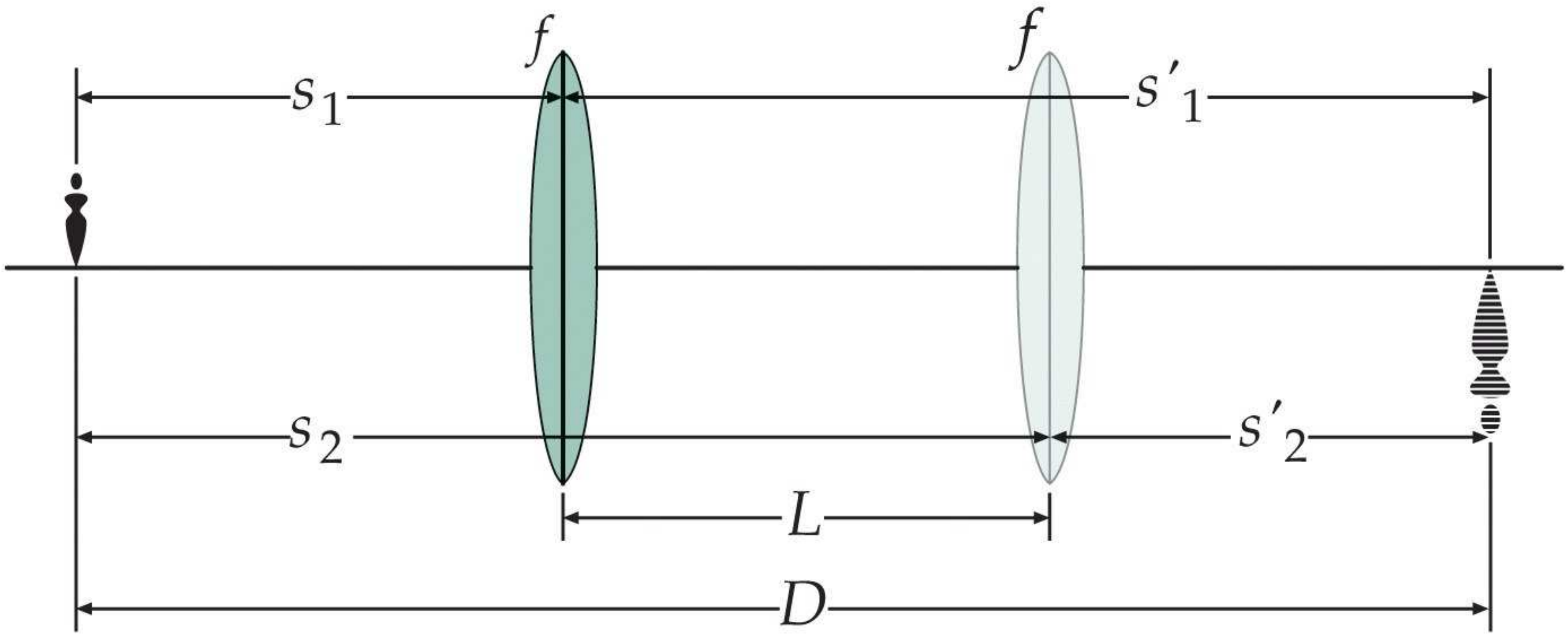
32.36



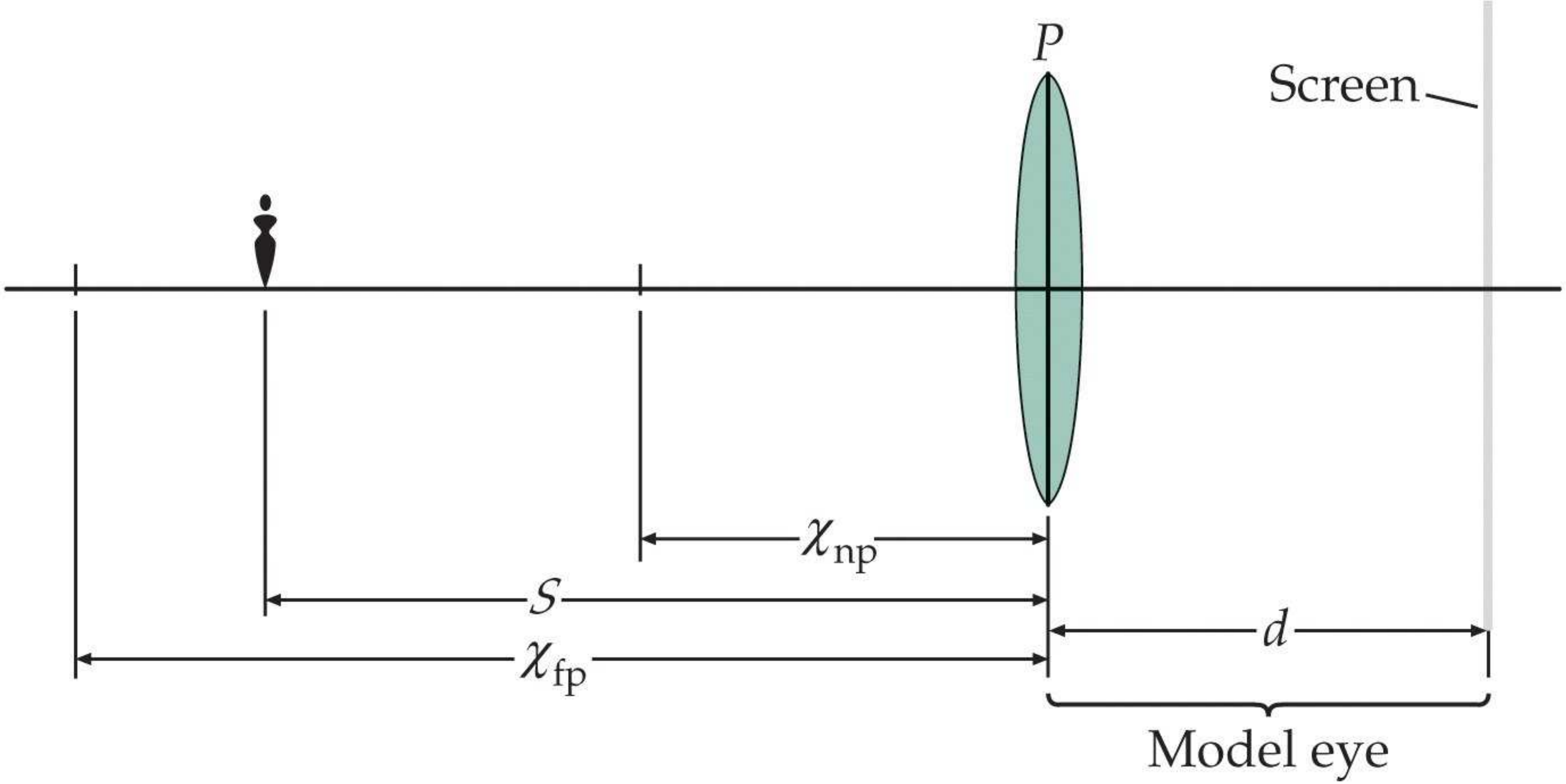
32.41



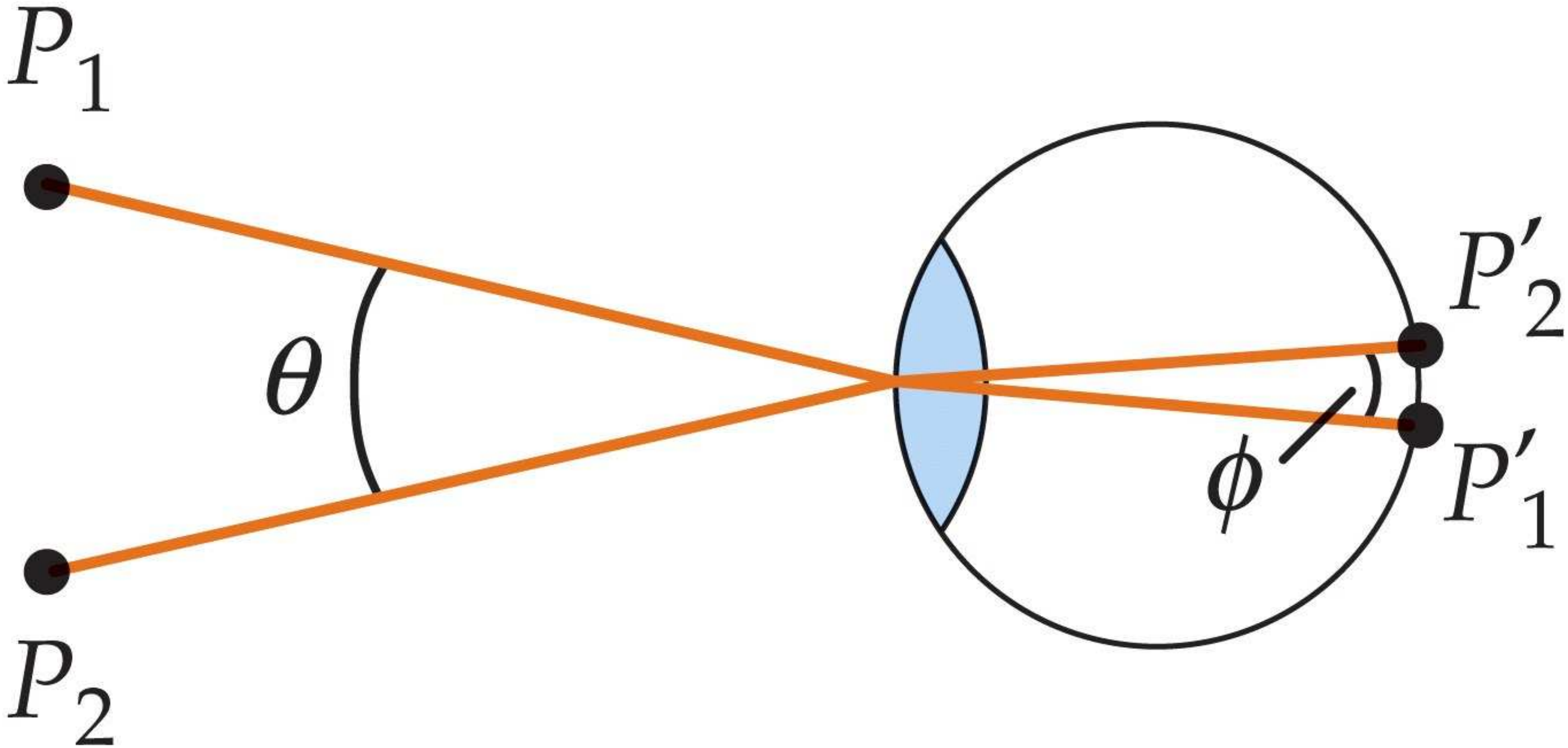
32.67



32.73



32.79



32.123