Phys 202

Recitation 6

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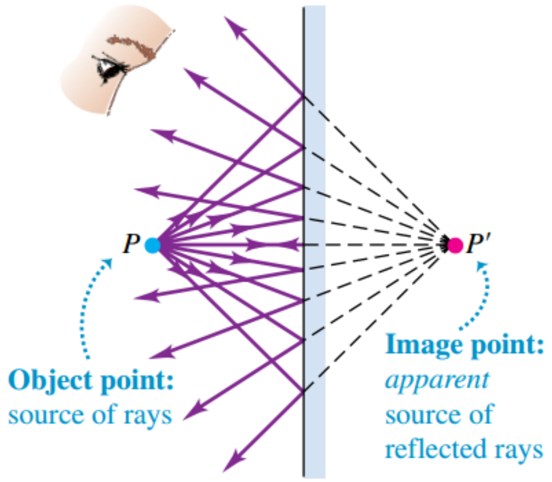
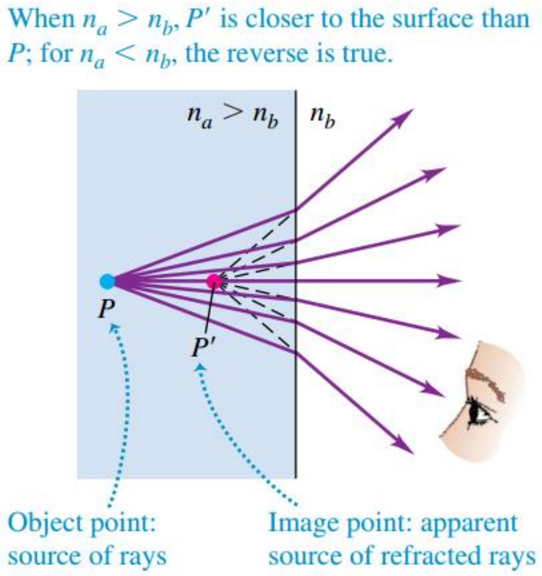
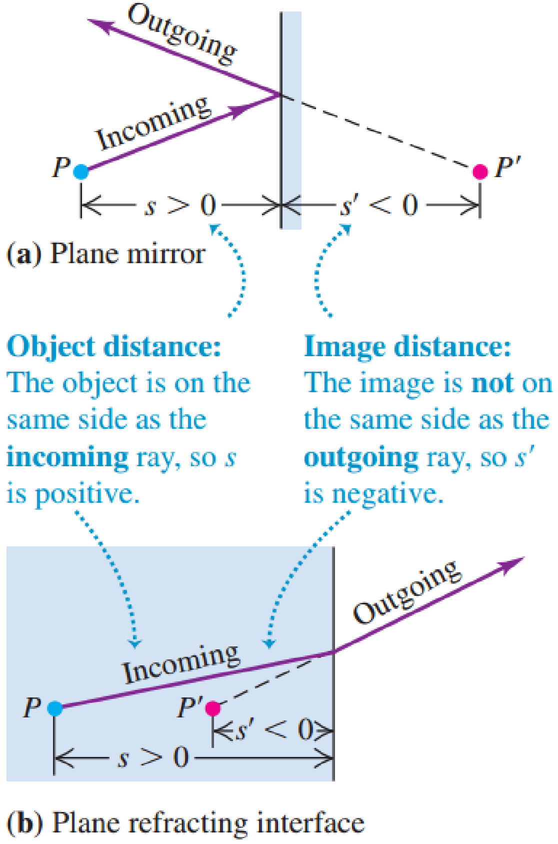
Formulae







Sign rules for object and image distances

Object distance: When the object is on the same side of the reflecting or refracting surface as the incoming light, the object distance s is positive; otherwise, it is negative.

Image distance: When the image is on the same side of the reflecting or refracting surface as the outgoing light, the image distance s' is positive; otherwise, it is negative.

Definition of lateral magnification

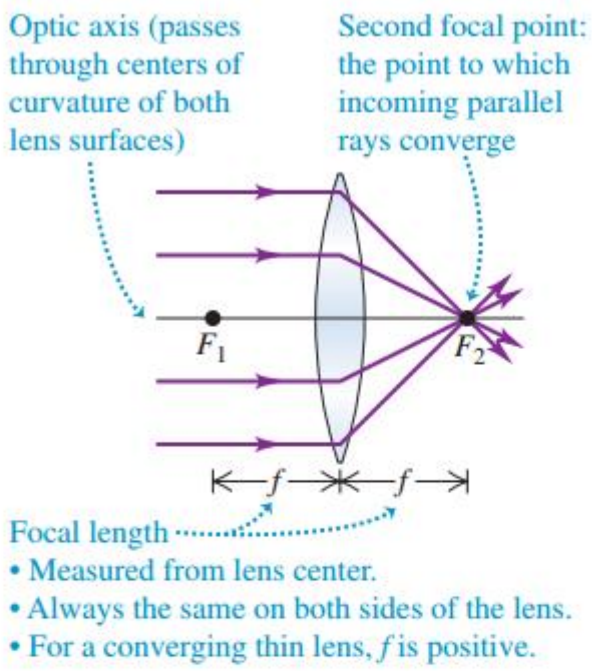
For object height y and image height y', the lateral magnification m is

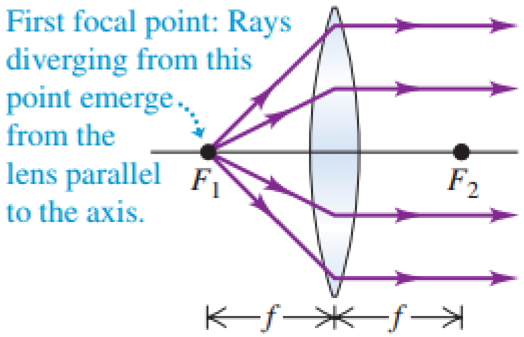
$$m = \frac{y'}{y}.$$

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}. \qquad \text{(spherical mirror)}$$

(a) All parallel rays incident on a spherical mirror reflect through the focal point.

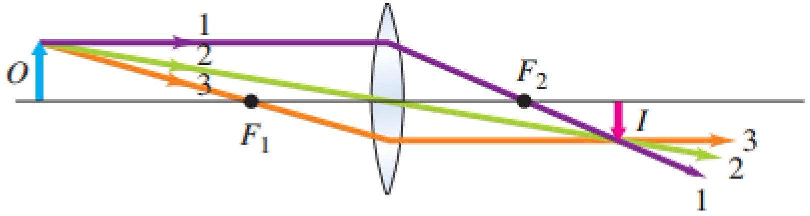
(b) Rays diverging from the focal point reflect to form parallel outgoing rays.



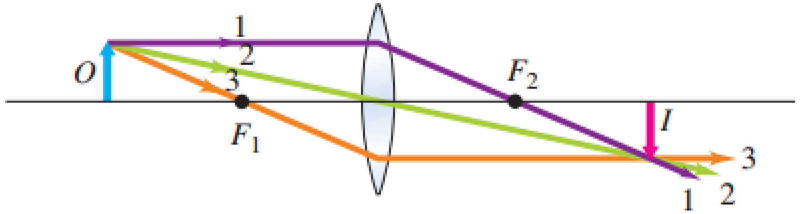


Thin-lens equation

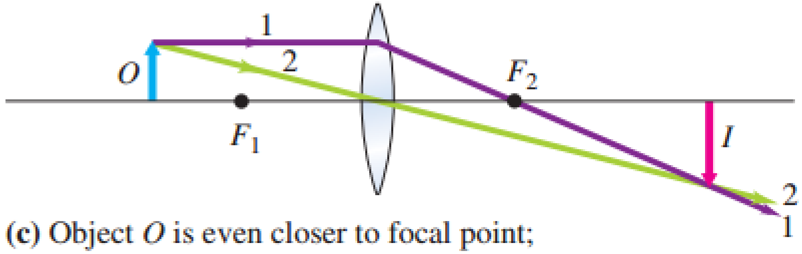
$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} = (n - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right).$$



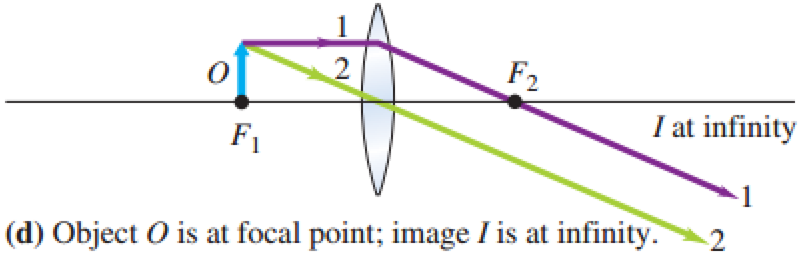
(a) Object O is outside focal point; image I is real.



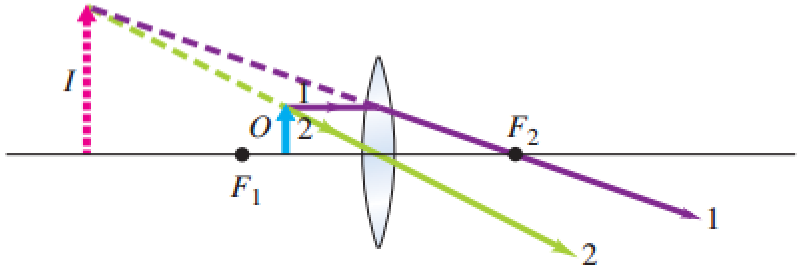
(b) Object O is closer to focal point; image I is real and farther aw



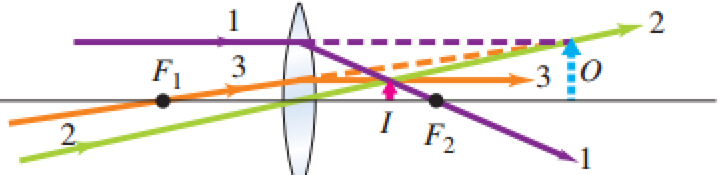
(c) Object O is even closer to focal point; image I is real and even farther away.



(d) Object O is at focal point; image I is at infinity.

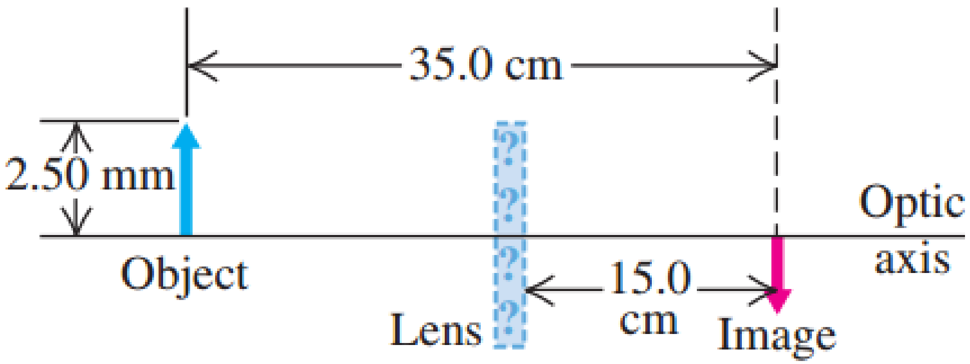


(e) Object O is inside focal point; image I is virtual and larger than object.



(f) A virtual object O (light rays are *converging* on lens)

32. ●● Figure 24.45 shows an object and its image formed by a thin lens. (a) What is the focal length of the lens and what type of lens (converging or diverging) is it? (b) What is the height of the image? Is it real or virtual?

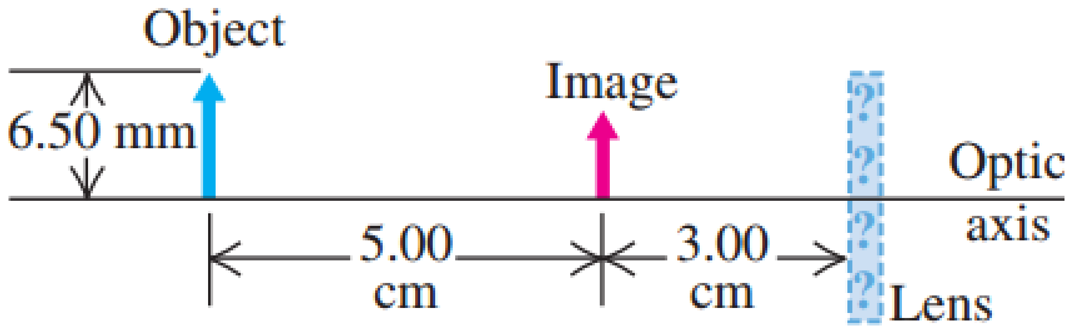


24.32. Set Up: $\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}$. The type of lens determines the sign of f. $m=\frac{y'}{y}=-\frac{s'}{s}$. The sign of s' depends on whether the image is real or virtual. $s'=+15.0\text{ cm}$; s' is positive because the image is on the side of the lens opposite to the object. $s=35.0\text{ cm}-15.0\text{ cm}=20.0\text{ cm}$.

Solve: (a) $\frac{1}{f}=\frac{s+s'}{ss'}$ and $f=\frac{ss'}{s+s'}=\frac{(20.0\text{ cm})(15.0\text{ cm})}{20.0\text{ cm}+15.0\text{ cm}}=+8.57\text{ cm}$. f is positive so the lens is converging.

(b) $m=-\frac{s'}{s}=-\frac{15.0\text{ cm}}{20.0\text{ cm}}=-0.750$. $y'=my=(-0.750)(2.50\text{ mm})=-1.88\text{ mm}$. The image is 1.88 mm tall. $s'>0$ and the image is real.

33. ●● Figure 24.46 shows an object and its image formed by a thin lens. (a) What is the focal length of the lens and what type of lens (converging or diverging) is it? (b) What is the height of the image? Is it real or virtual?



***24.33. Set Up:** $\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}$. The type of lens determines the sign of f. $m=\frac{y'}{y}=-\frac{s'}{s}$. The sign of s' determines whether the image is real or virtual. $s=+8.00\text{ cm}$. $s'=-3.00\text{ cm}$. s' is negative because the image is on the same side of the lens as the object.

Solve: **(a)** $\frac{1}{f}=\frac{s+s'}{ss'}$ and $f=\frac{ss'}{s+s'}=\frac{(8.00\text{ cm})(-3.00\text{ cm})}{8.00\text{ cm}-3.00\text{ cm}}=-4.80\text{ cm}$. f is negative so the lens is diverging.

(b) $m=-\frac{s'}{s}=-\frac{-3.00\text{ cm}}{8.00\text{ cm}}=+0.375$. $y'=my=(0.375)(6.50\text{ mm})=2.44\text{ mm}$. $s'<0$ and the image is virtual.

51. • A diverging lens with a focal length of -48.0 cm forms a virtual image 8.00 mm tall, 17.0 cm to the right of the lens. (a) Determine the position and size of the object. Is the image erect or inverted? Are the object and image on the same side or opposite sides of the lens? (b) Draw a principal-ray diagram for this situation.

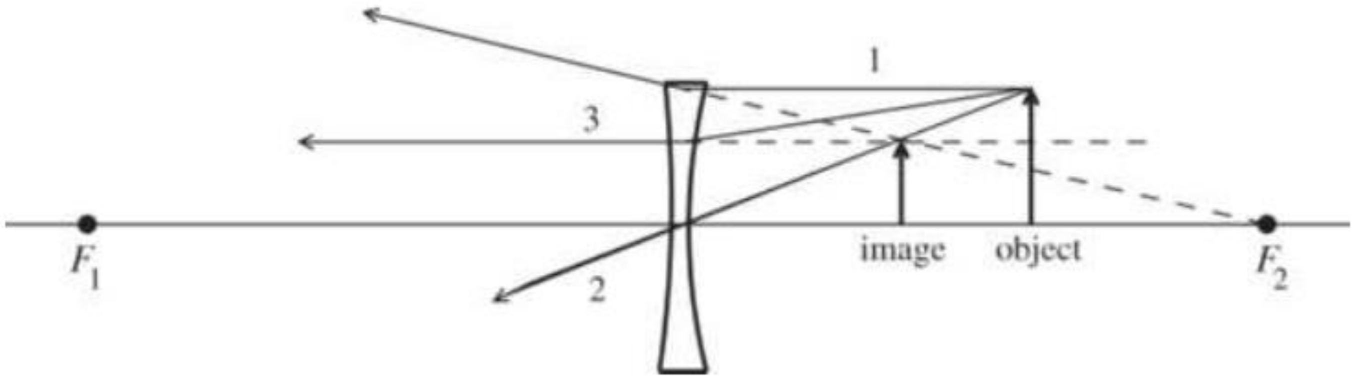
24.51. Set Up: Use Eq. (24.21) to calculate the object distance s. Calculate m from Eq. (24.18) and use that to determine the size and orientation of the image. We are given $f = -48.0\text{ cm}$ and we have a virtual image 17.0 cm from lens so $s' = -17.0\text{ cm}$.

Solve: (a) $\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}$, so $\frac{1}{s'}=\frac{1}{f}-\frac{1}{s}=\frac{s-f}{sf}$

$$s=\frac{s'f}{s'-f}=\frac{(-17.0\text{ cm})(-48.0\text{ cm})}{-17.0\text{ cm}-(-48.0\text{ cm})}=+26.3\text{ cm}$$

$$m=-\frac{s'}{s}=-\frac{-17.0\text{ cm}}{+26.3\text{ cm}}=+0.646$$

$$m=\frac{y'}{y}\text{ so }|y|=\frac{|y|}{|m|}=\frac{8.00\text{ mm}}{0.646}=12.4\text{ mm}$$



- A converging lens with a focal length of 7.00 cm forms an image of a 4.00-mm-tall real object that is to the left of the lens. The image is 1.30 cm tall and erect. Where are the object and image located? Is the image real or virtual?