Refraction

- When a light ray moves from one medium to another, the ray bends.
  - If the second medium has a higher index of refraction than the first, the refracted ray is bent towards the normal relative to the incident ray.

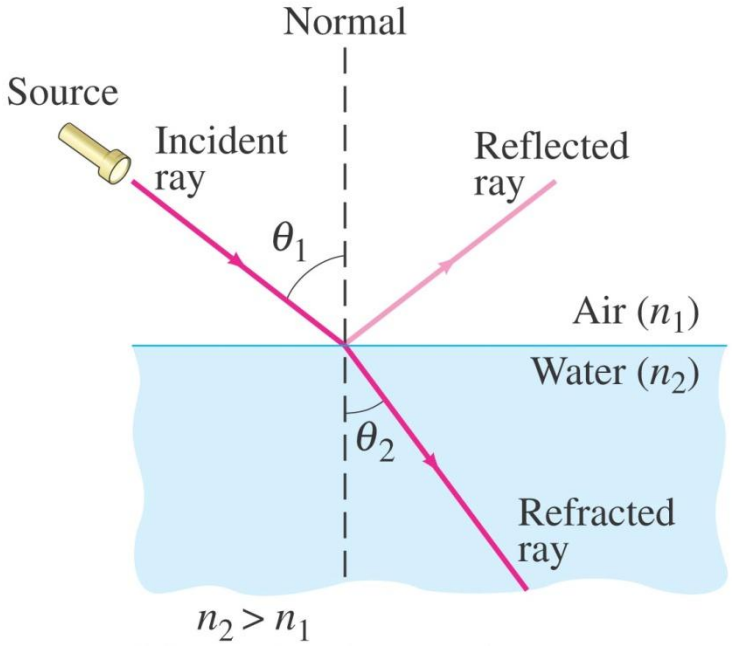


Figure 32.21a

Snell's Law

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

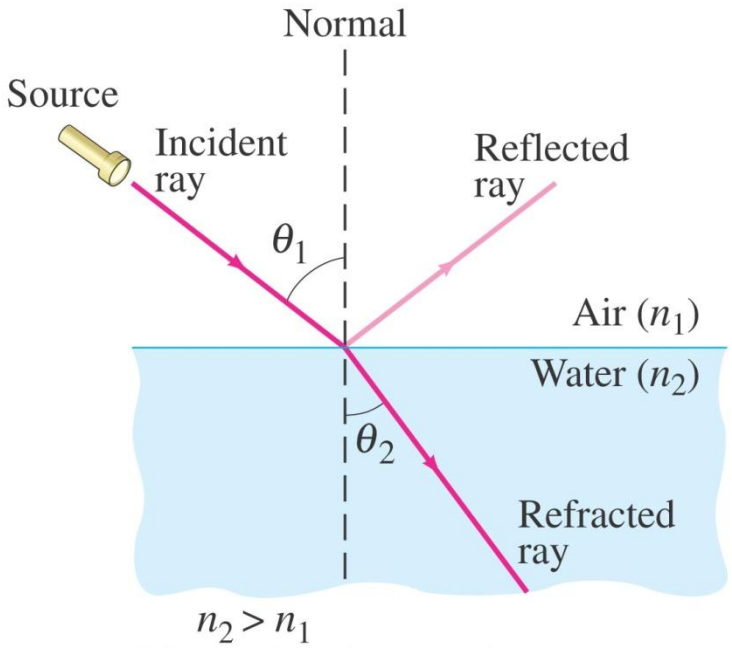
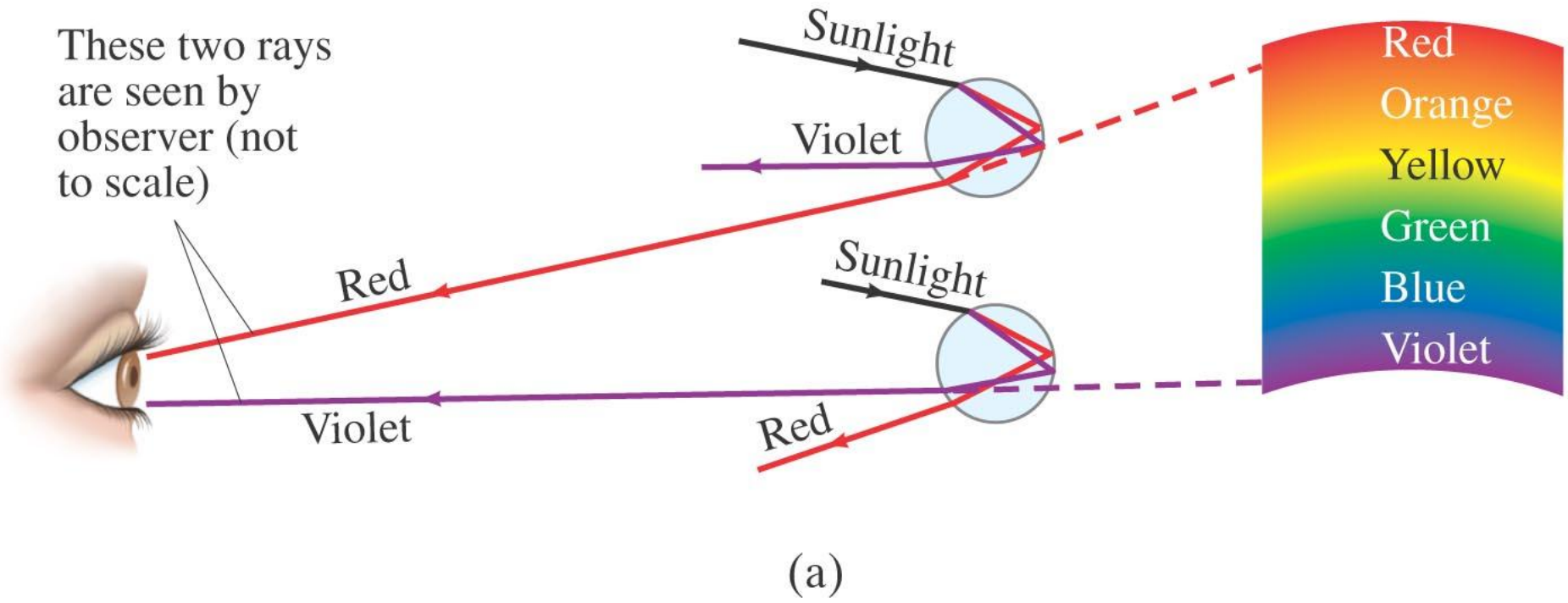


Figure 32.21a



(a)

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Figure 32.30a

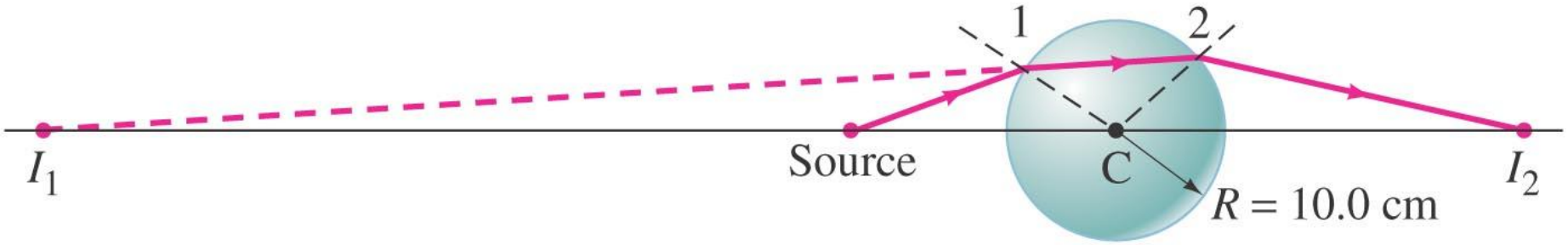

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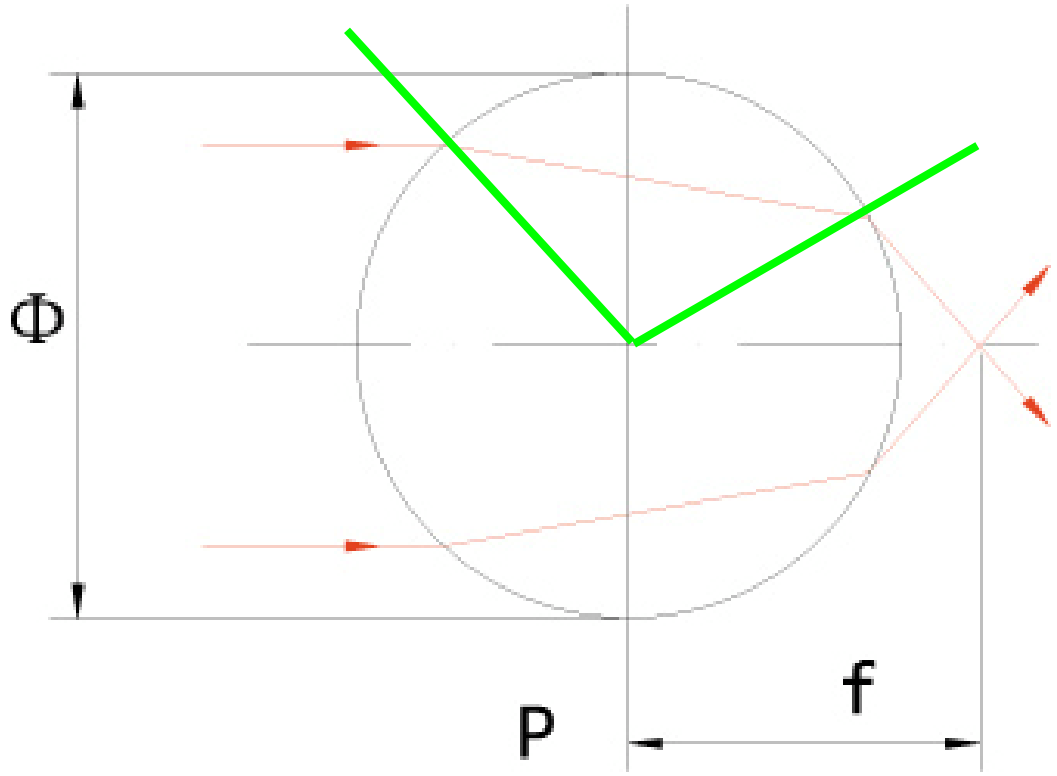
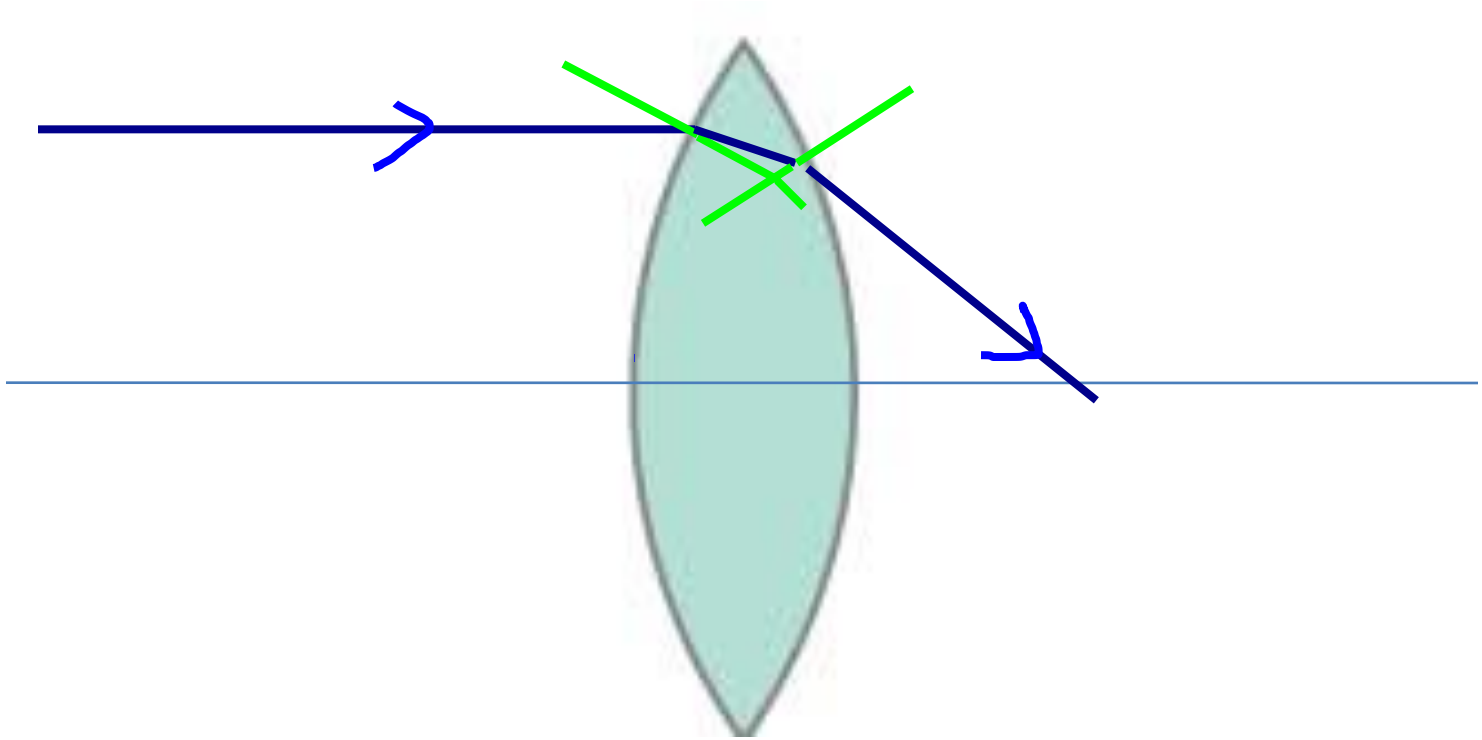
Figure 32.40



http://noconsensus.wordpress.com/2011/01/02/light-scattering-by-the-earth%E2%80%99s-atmosphere-aerosols-and-clouds-part-one-%E2%80%93-basic-concepts/

Lenses



Thin-lens approximation – If the thickness of the lens is small compared to the focal length *f*, all rays parallel to the principal axis will (seem to) converge at the focal point.

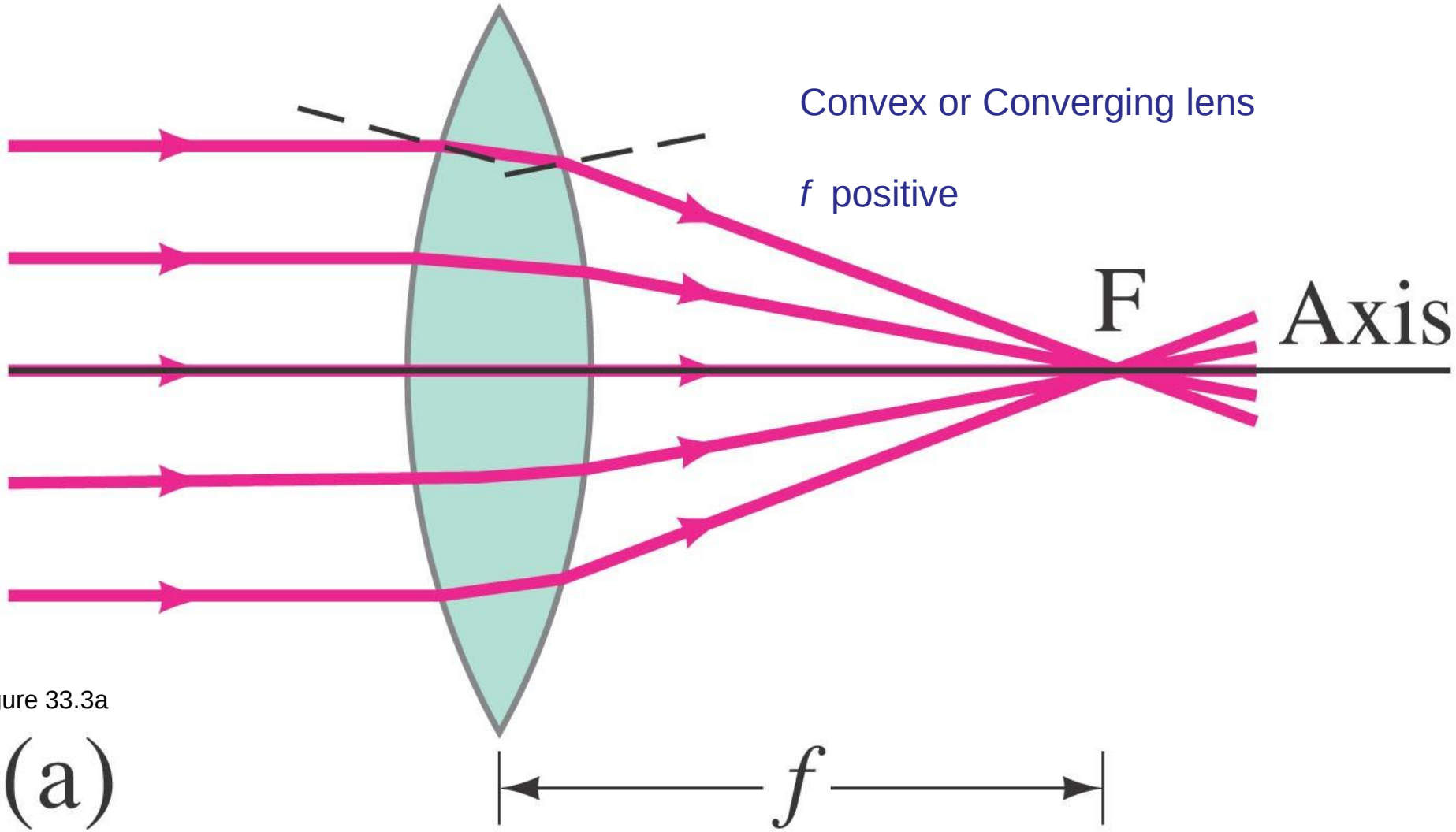


Figure 33.3a

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Concave or Diverging lens

f negative

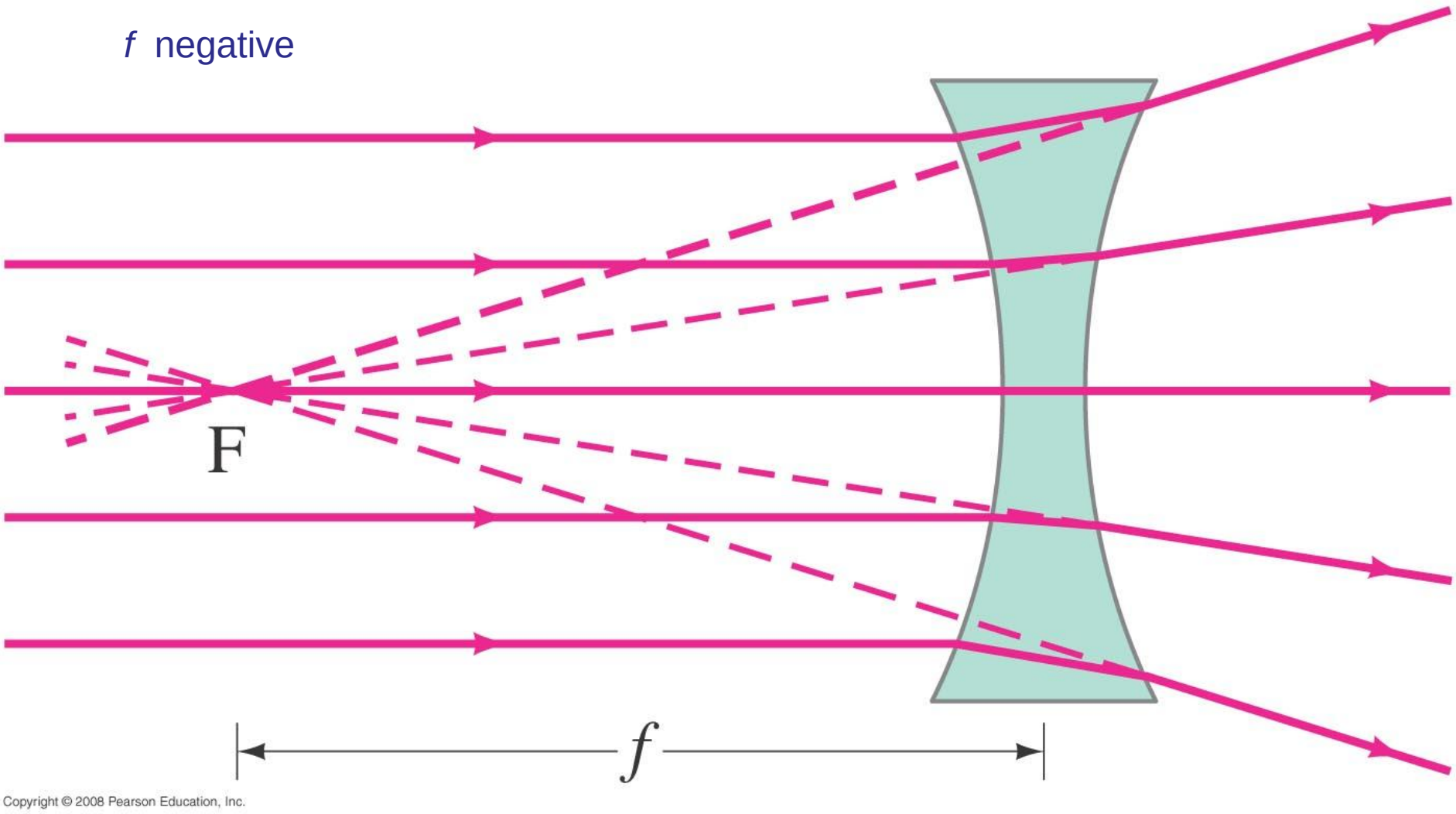

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Figure 33.5

Lenses generally have two focal points.

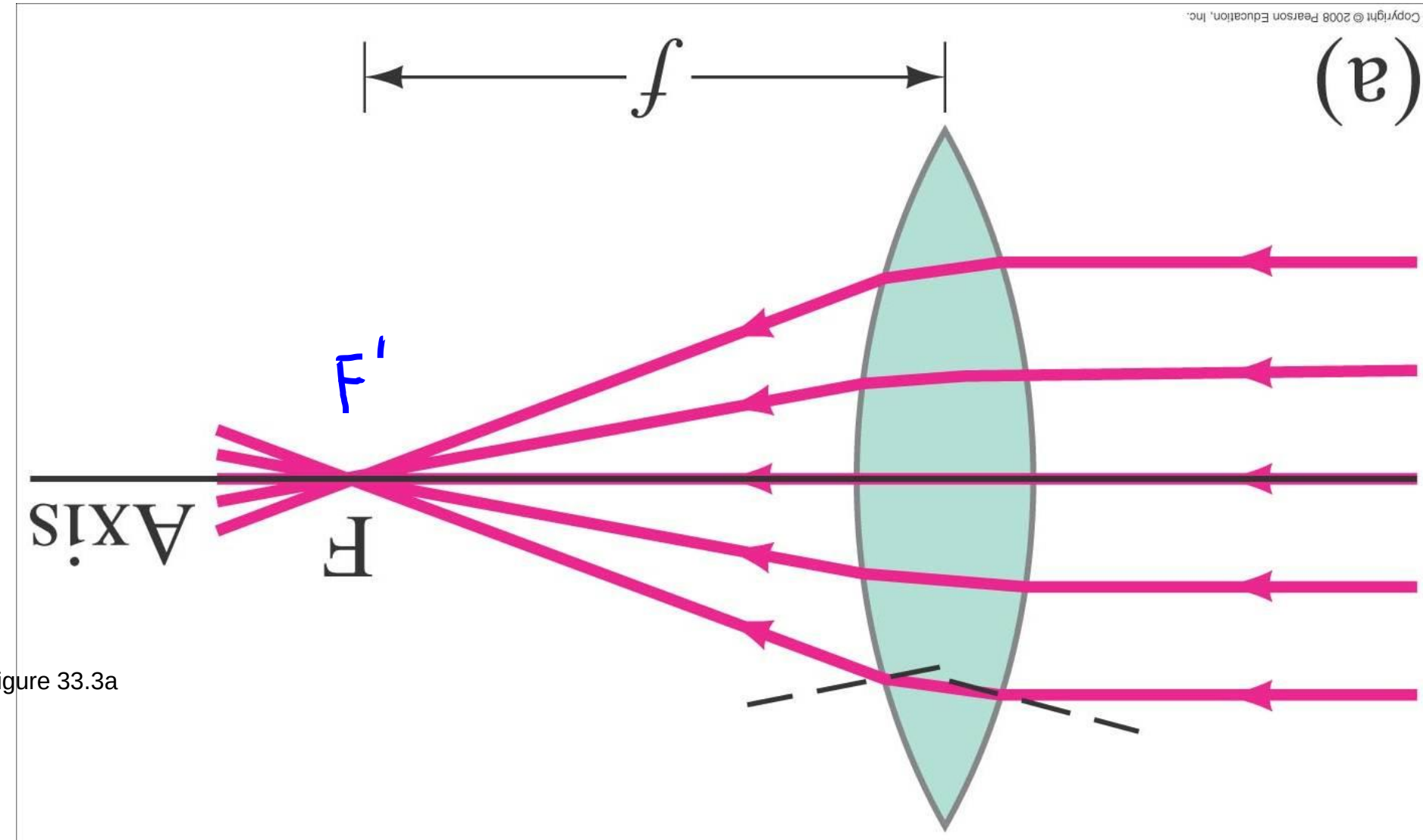

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Figure 33.3a

Ray diagrams

- Three rays leave one point on an "object":

1) A ray parallel to the principal axis (aka optic axis), will (seem to) pass through the focal point F.

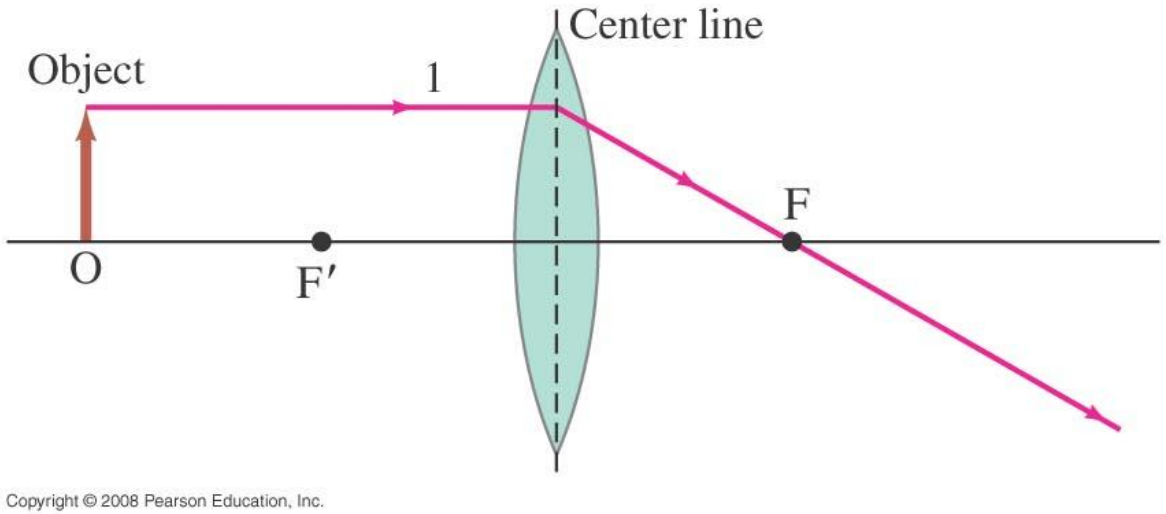

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Figure 33.6a

Ray diagrams

- Three rays leave one point on an "object":

1) A ray parallel to the principal axis (aka optic axis), will (seem to) pass through the focal point F.
2) A ray that (seems to) pass(es) through F', will end up parallel to the principal axis.

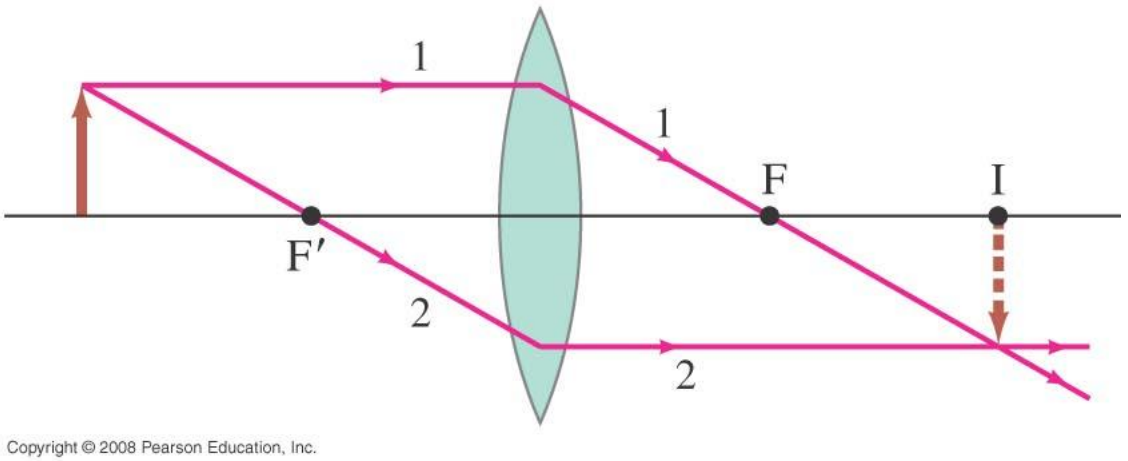

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Figure 33.6b

Ray diagrams

- Three rays leave one point on an "object":

1) A ray parallel to the principal axis (aka optic axis), will (seem to) pass through the focal point F.
2) A ray that (seems to) pass(es) through F', will end up parallel to the principal axis.
3) A ray that passes through the center of the lens, will continue virtually undeflected.

- Where these three rays converge (or seem to converge), is the corresponding point on the image.

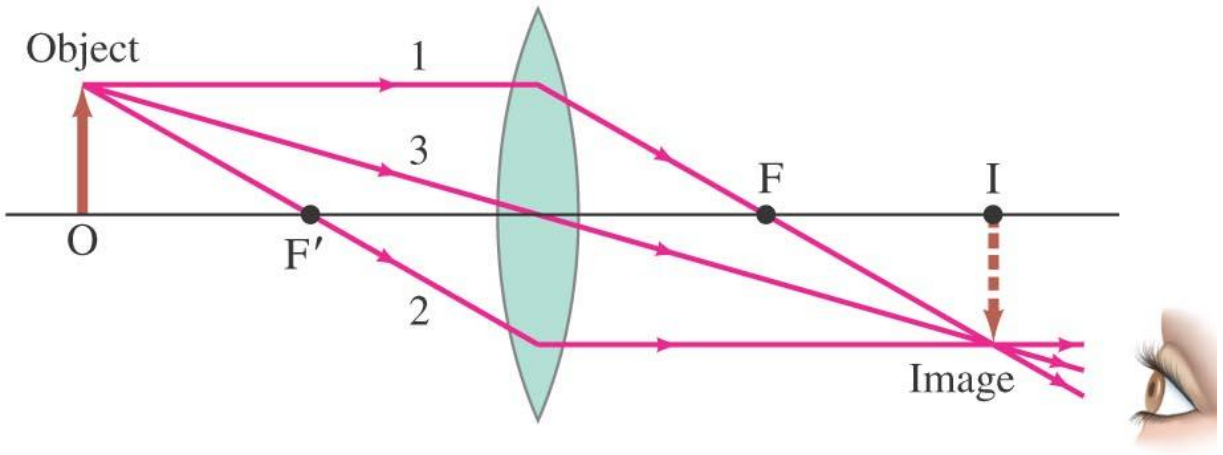

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Figure 33.6c

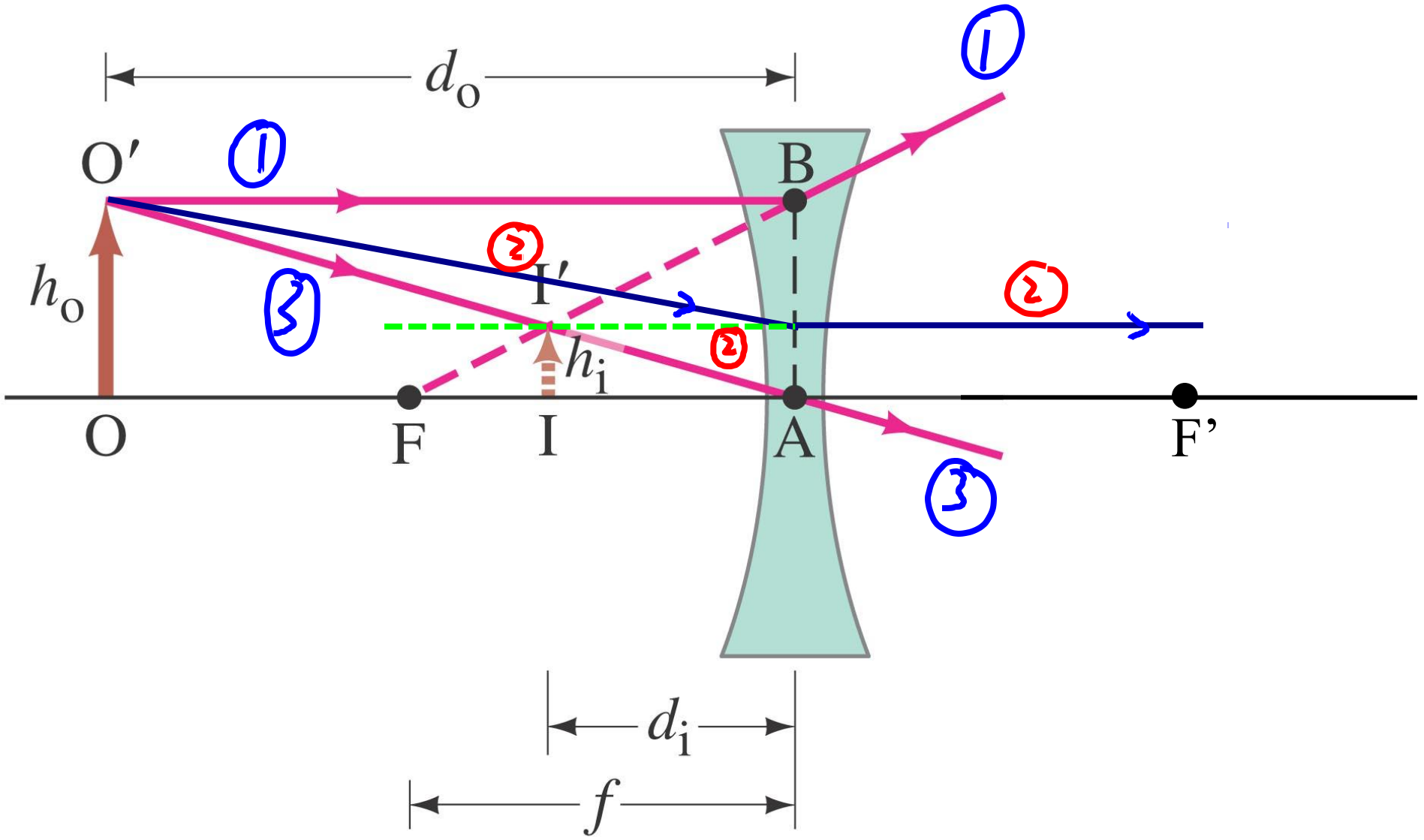

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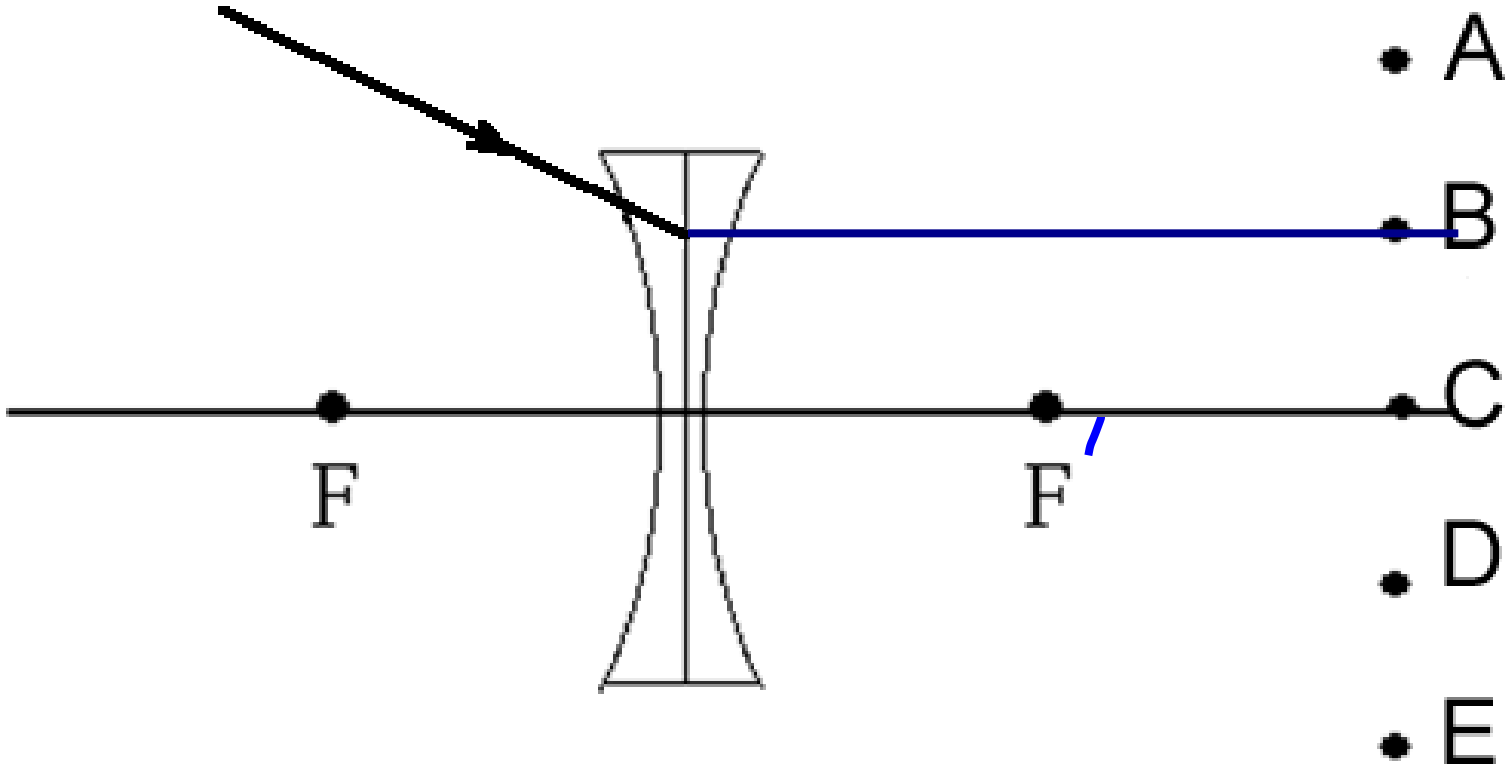
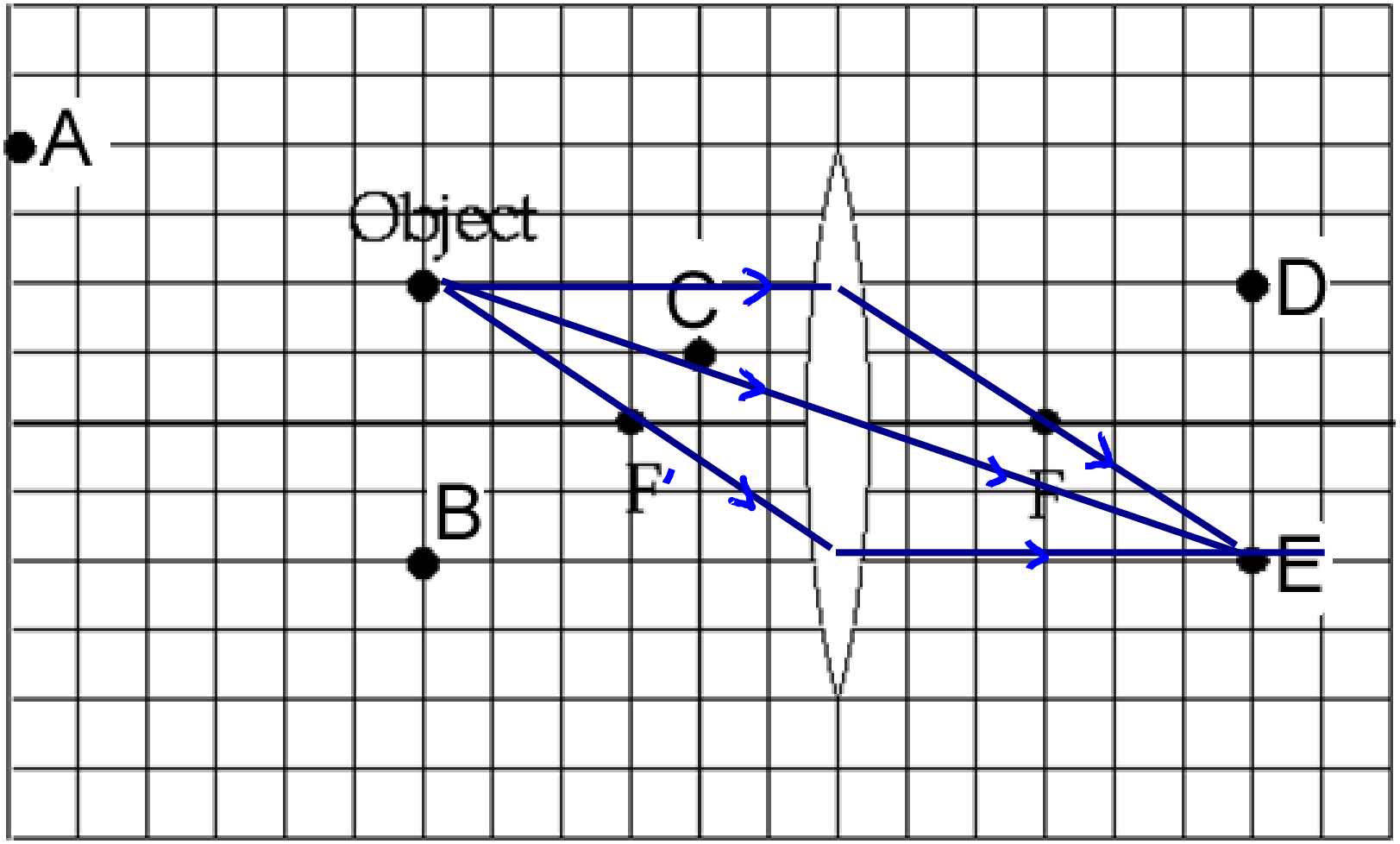
Figure 33.10

When the ray in the diagram is continued through the diverging lens, it passes through which point? (F marks the two focal points.)



The image produced by the converging lens is at which point? (F marks the two focal points.)



Object and Image distances

- d_0 = "object distance" = distance of object from lens.
- d_i = "image distance" = distance of image from lens.
- f = "focal length" = distance of F from lens.

- d_0 is positive if the object is on the same side of the lens as the incident rays.
- d_i is positive if the image is on the same side of the lens as the transmitted rays.
  - d_i positive means image is "real and inverted".
  - d_i negative means image is "virtual and upright".
- f is positive if incident rays parallel to the optic axis actually converge at F (or F').
  f is negative if the rays only appear to converge at F (or F').

$$\frac{1}{d_o}+\frac{1}{d_i}=\frac{1}{f}$$

$$m=\frac{h_i}{h_o}=-\frac{d_i}{d_o}$$

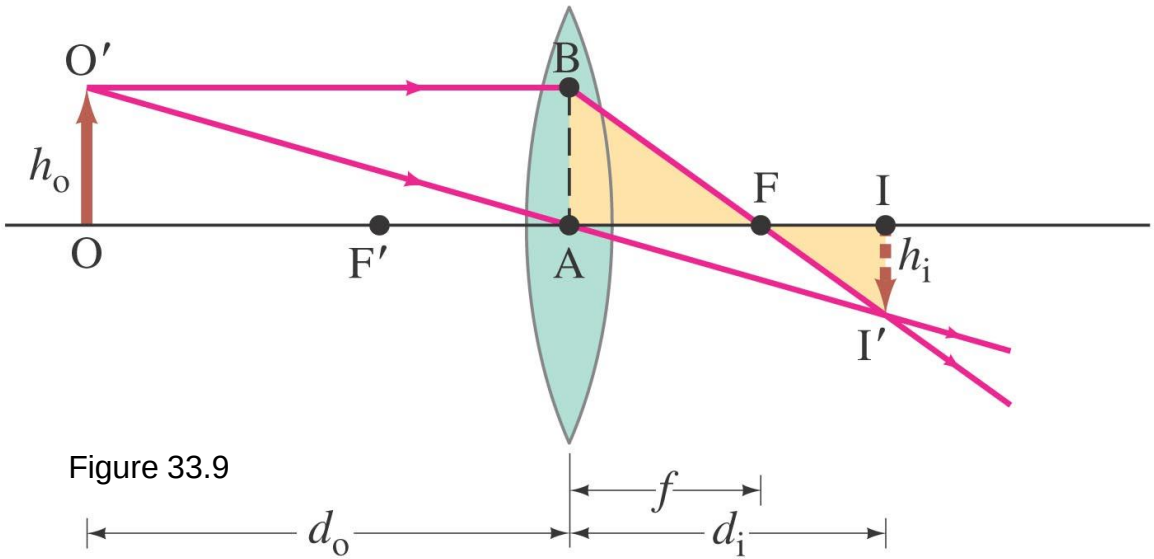


Figure 33.9

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A convex lens has a focal length *f*. The only way to get a magnification of –1 is to

1) place a real object at the focal point.
2) place a real object at a distance 2*f* from the lens.
3) place a real object at a distance 3*f* from the lens.
4) Magnifications from a positive lens can never be negative.
5) None of these is correct.