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.

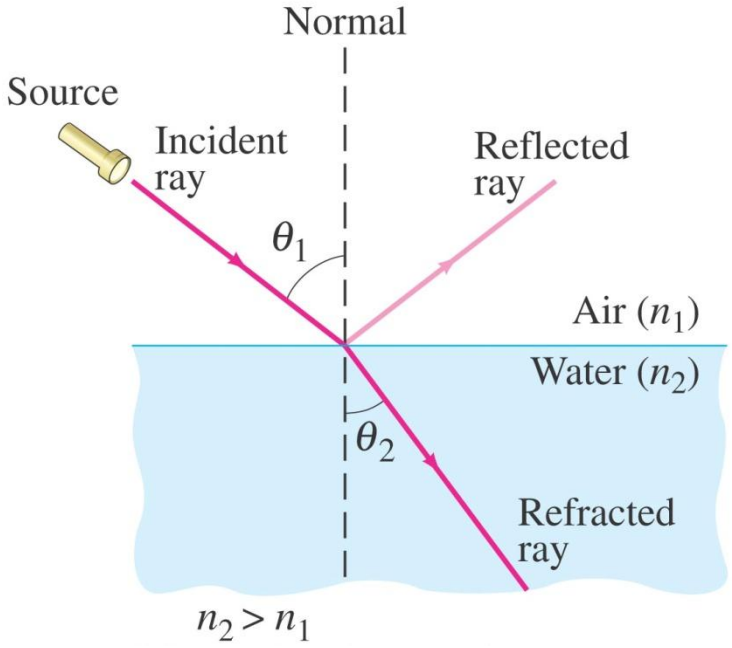


Figure 32.21a

Snell's Law

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

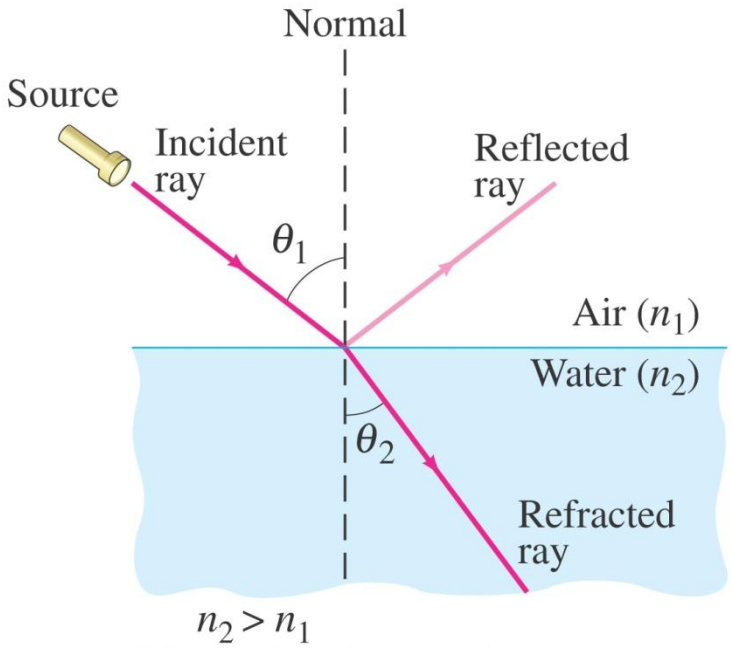
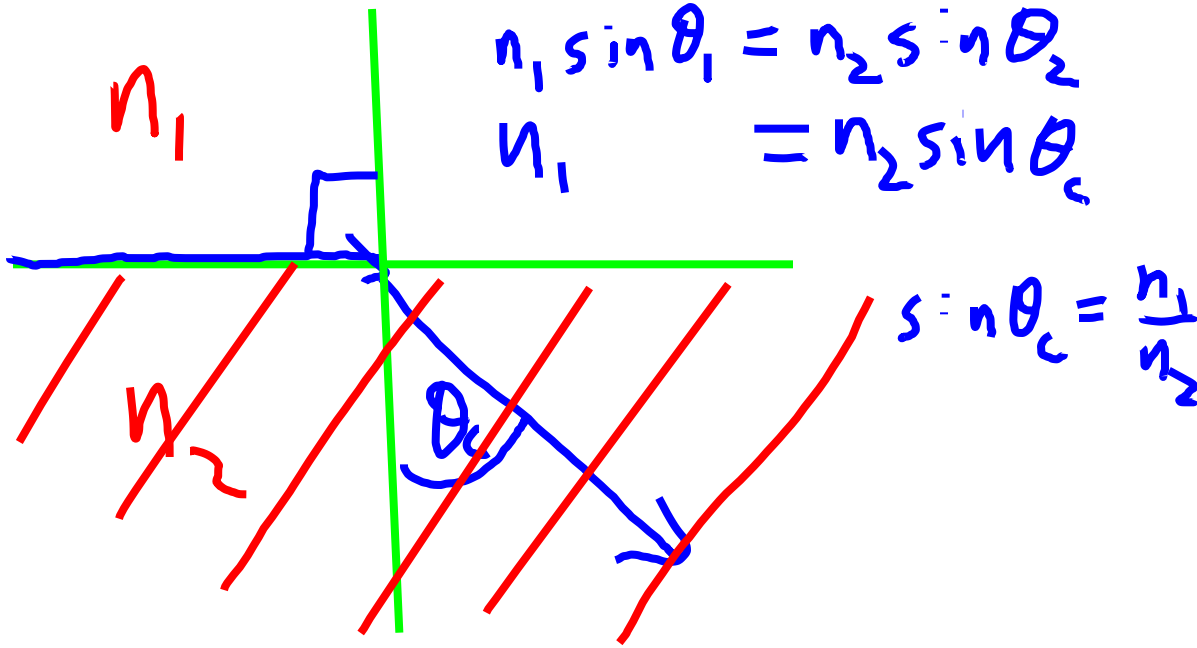
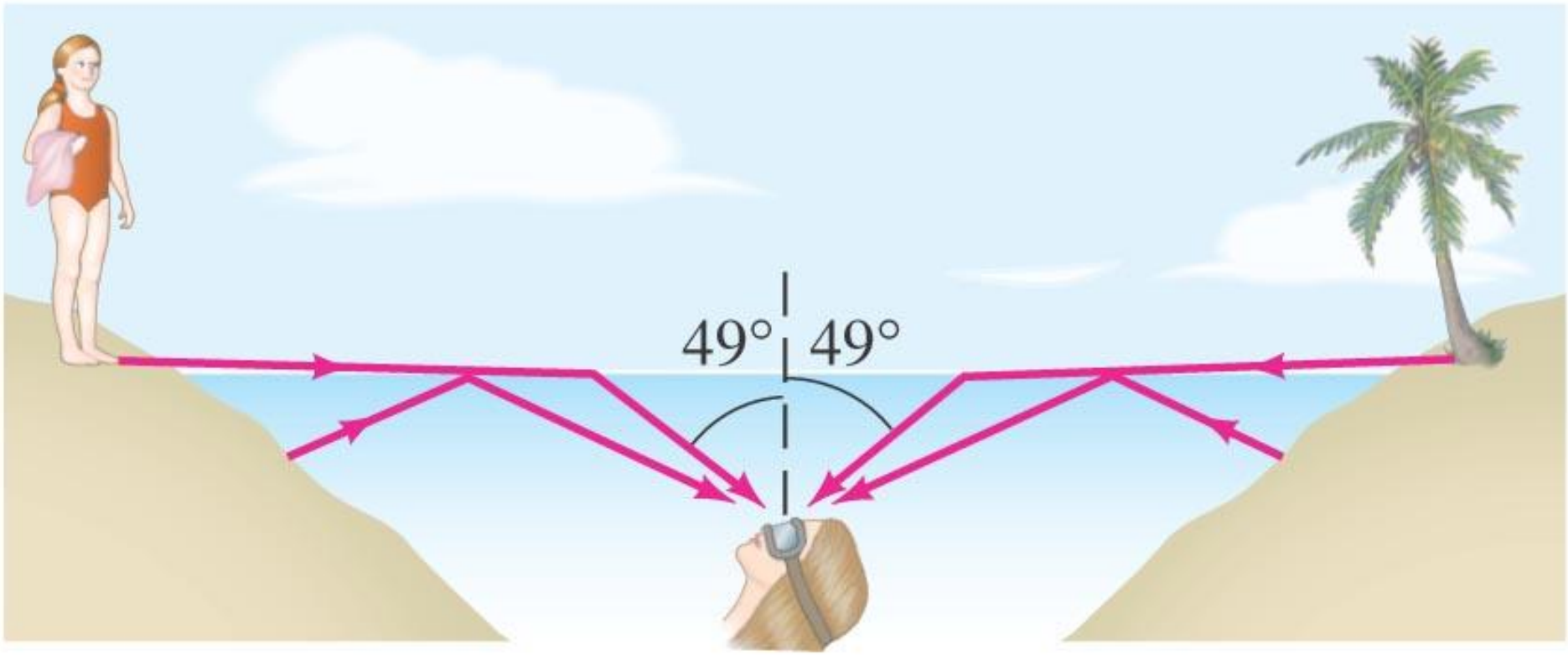


Figure 32.21a

Consequences of Snell's Law

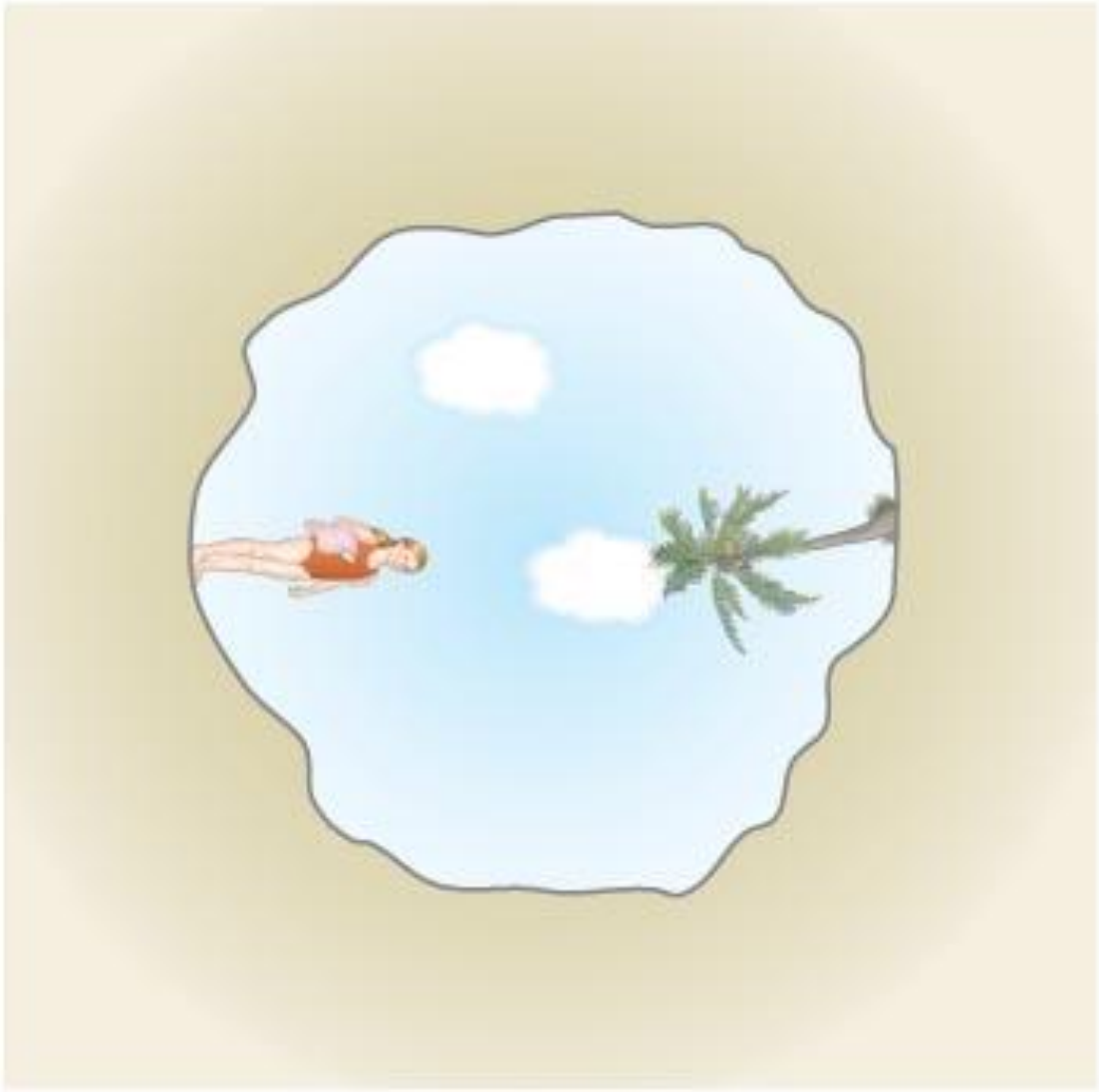
- When light travels into a medium of higher index of refraction, there is a maximum angle for the refracted ray < 90°.
  - The incident light from the first medium (e.g. air) is compressed into a cone in the second medium (e.g. water).





(a)

Figure 32.32a



(b)

Figure 32.32b

Consequences of Snell's Law

- When light travels towards a medium of *lower* index of refraction, no refracted ray will emerge for incident rays with $\theta_i > \theta_c$.
  - *Total Internal Reflection*: When this condition is fulfilled, the light ray is completely reflected back into the original medium.

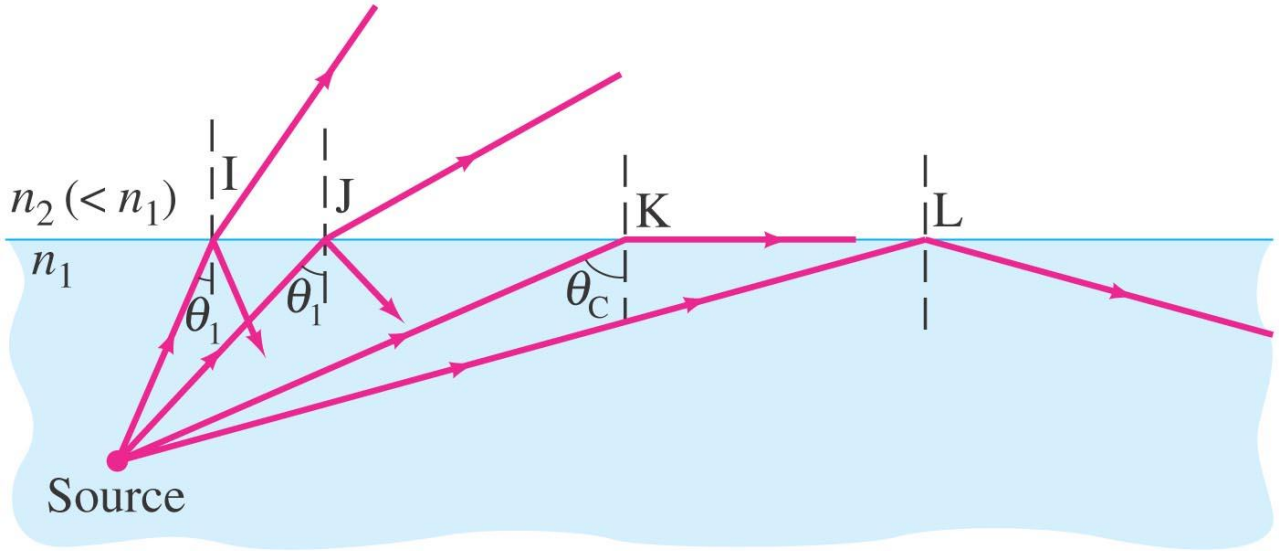
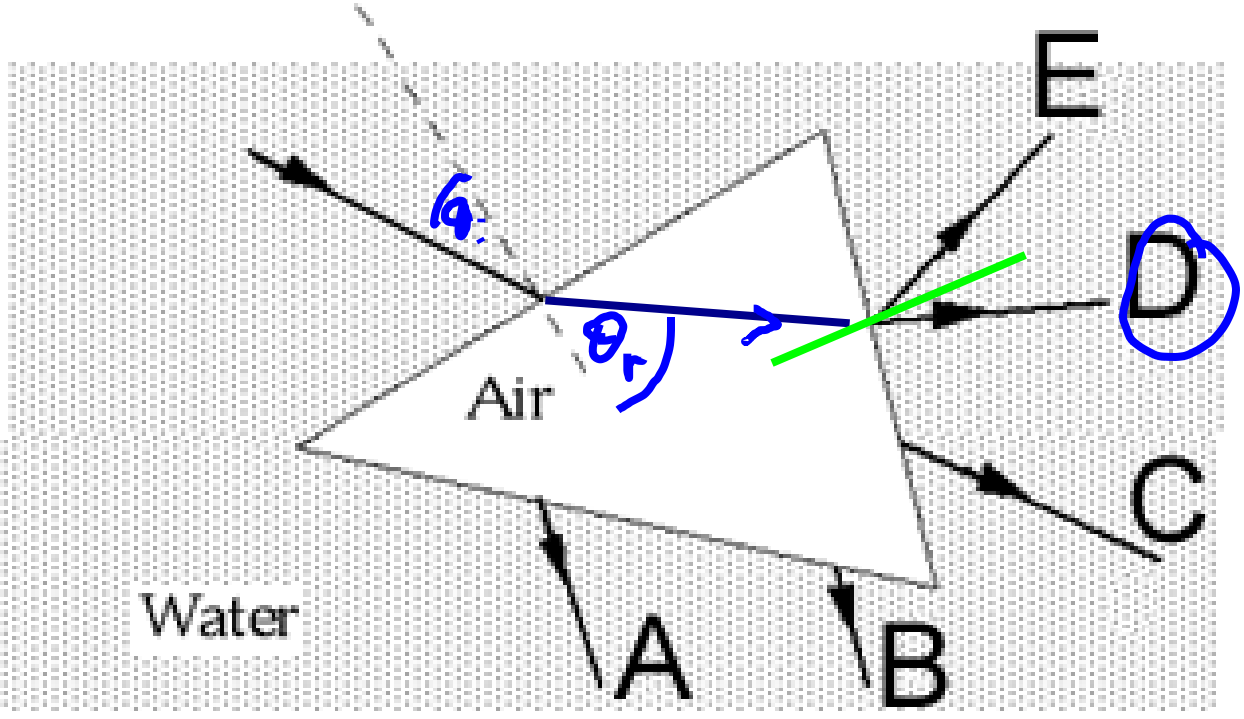


Figure 32.31

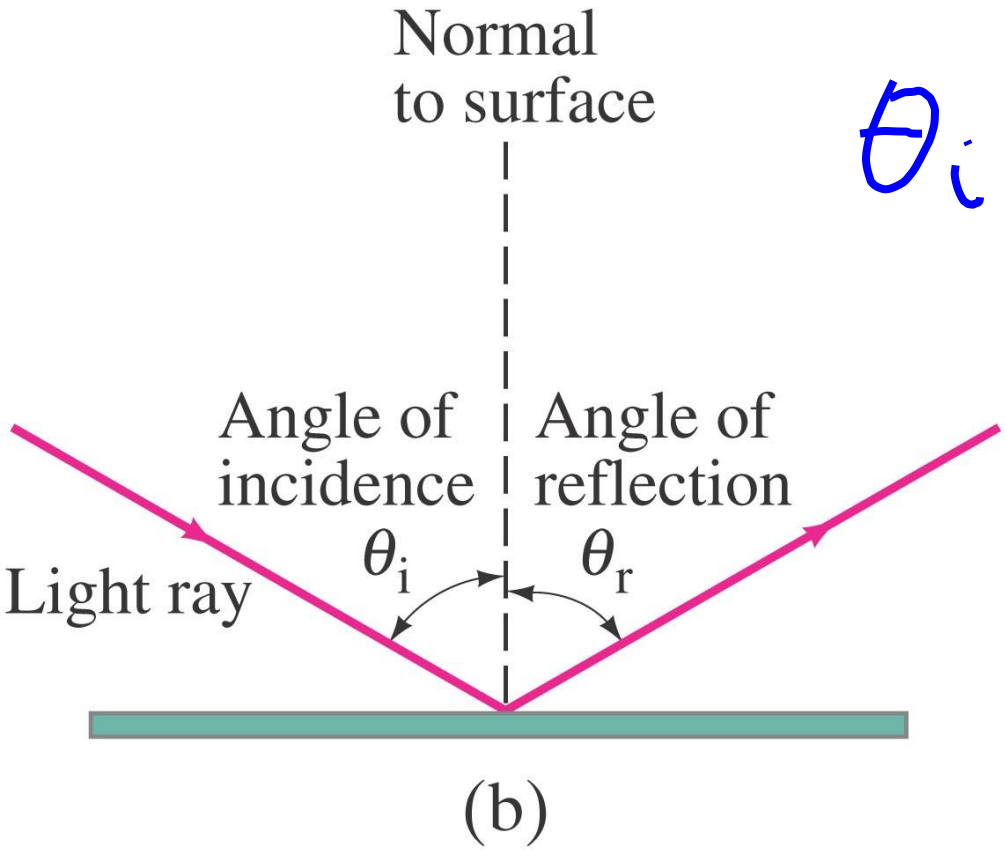

Dave Knight

An air prism is immersed in water. A ray of monochromatic light strikes one face as shown. Which arrow shows the emerging ray?



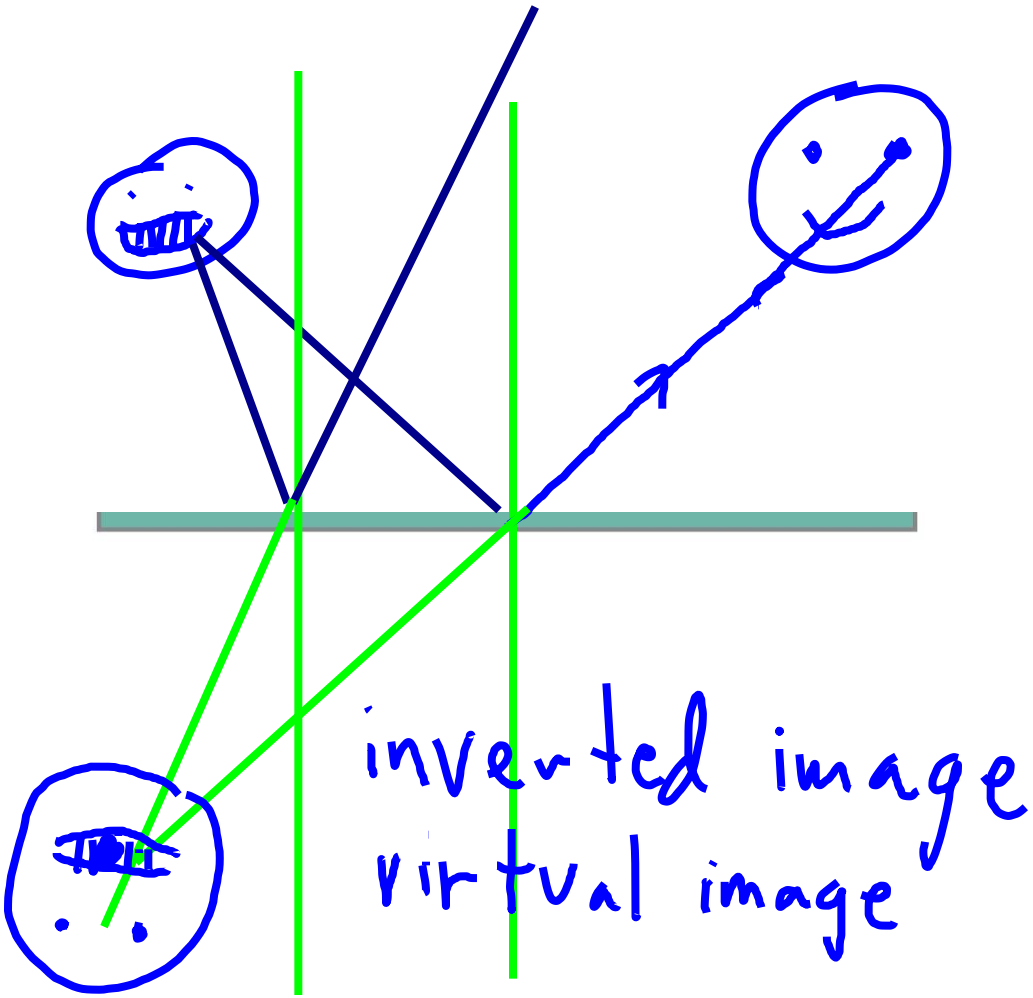
Law of Reflection

- When a ray of light hits a reflective surface (e.g. mirror), the incident and reflected rays make the same angle with respect to the normal to the surface.



$\theta_i = \theta_r$

Figure 32.2b


inverted image
virtual image

Spherical Mirrors

- A reflective "portion of a sphere".
- If the mirror is a small enough portion, all light rays parallel to the principal axis (which passes through center C and the middle of the mirror A), will converge on a single focal point F.
- The focal length *f* (distance from mirror to F) is half the radius of the sphere *r*.

$$f = \frac{r}{2}$$

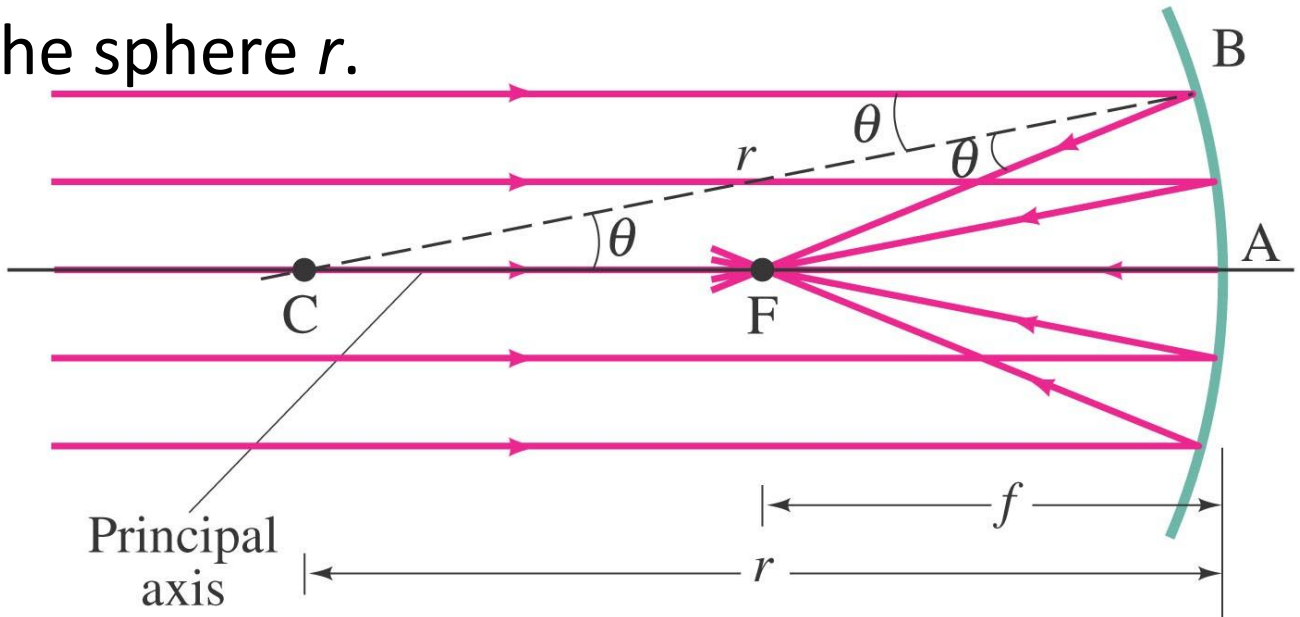


Figure 32.14

Ray diagrams

- Three rays leave one point on an “object”.

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

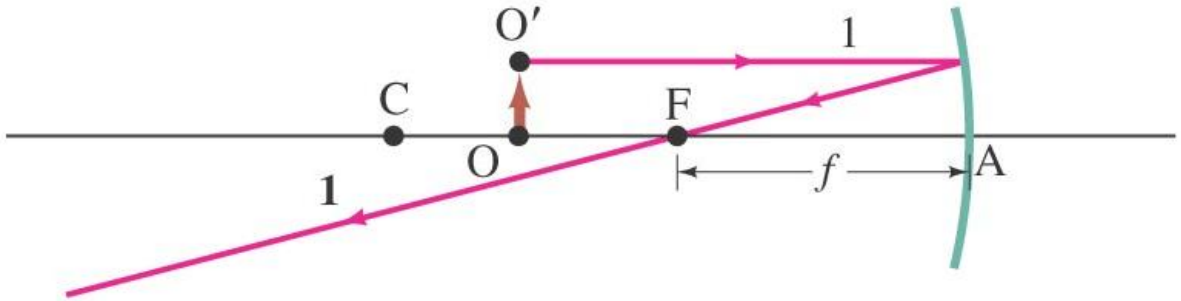


Figure 32.15a

Ray diagrams

- Three rays leave one point on an “object”:

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

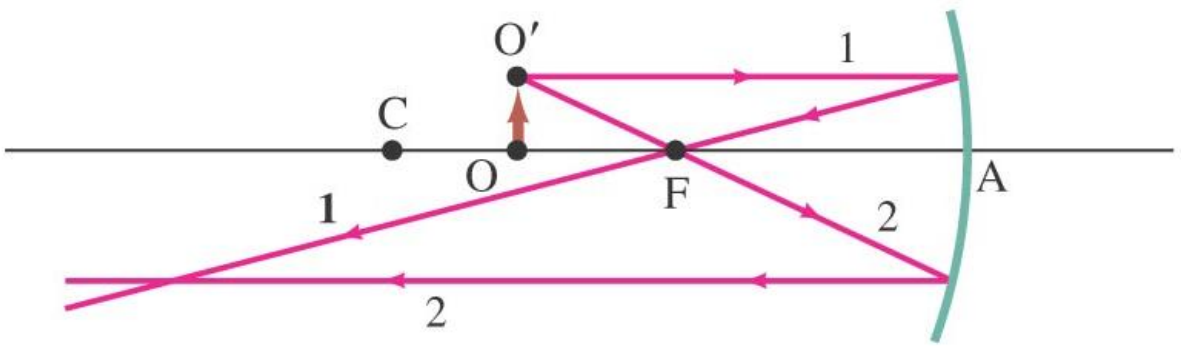


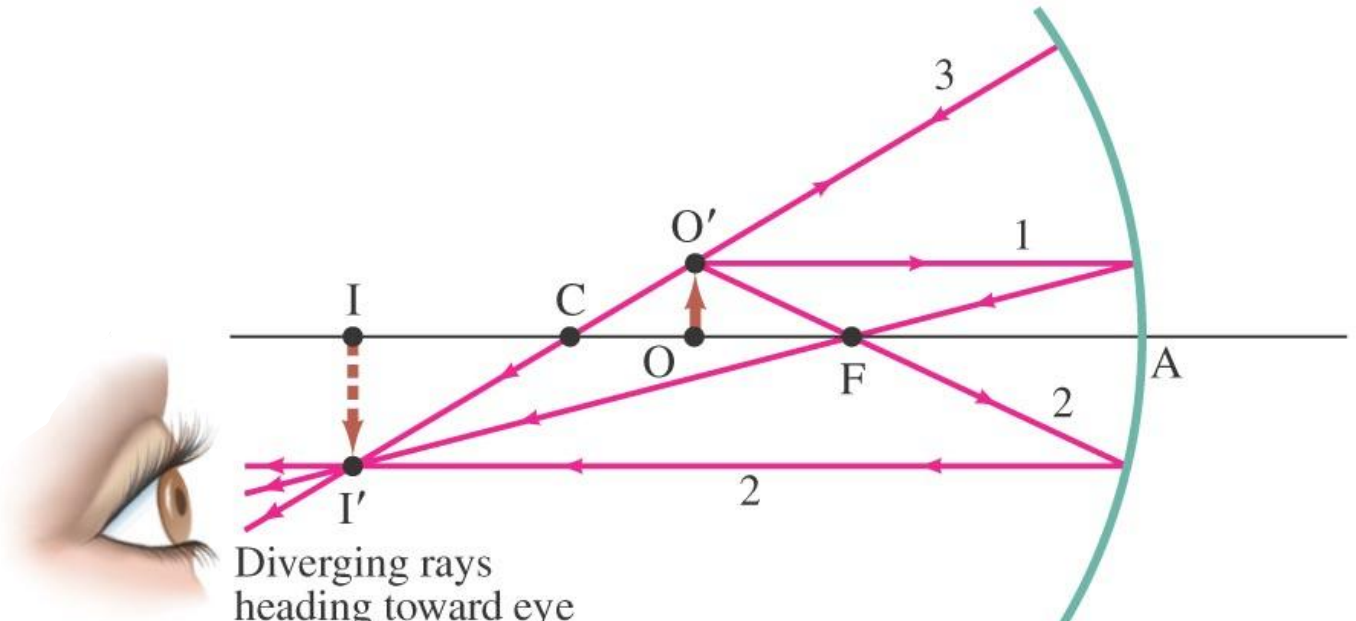
Figure 32.15b

Ray diagrams

- Three rays leave one point on an “object”:

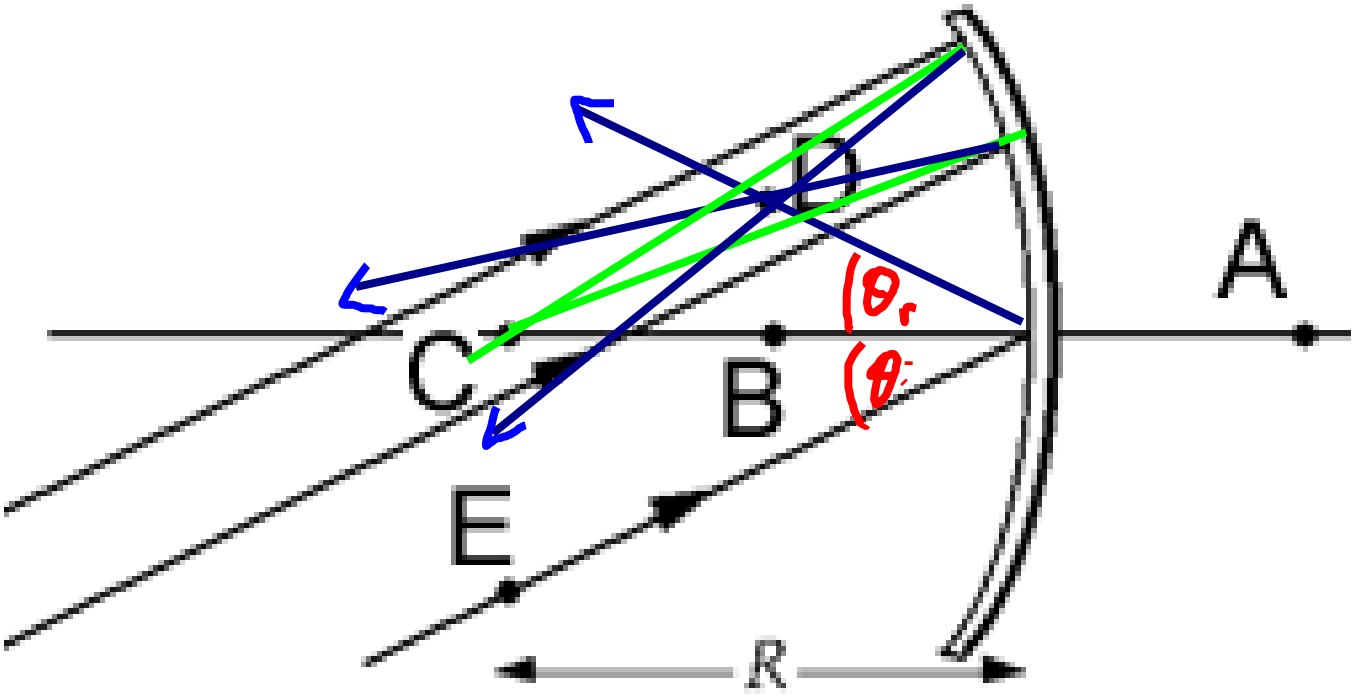
1) A ray parallel to the principal axis (aka optic axis), will pass through the focal point F.
2) A ray that passes through F, will end up parallel to the principal axis.
3) A ray that passes through C, will reflect back upon itself.

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



Fig

The parallel rays incident on the surface of the concave spherical mirror in the figure converge to which point?



Object and Image distances

- d_0 = “object distance” = distance of object from mirror .
- d_i = “image distance” = distance of image from mirror .
- f = “focal length” = distance of F from mirror .

- d_0 is positive if the object is on the same side of the mirror as the incident rays.
- d_i is positive if the image is on the same side of the mirror as the reflected 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.
  - if F is on the side of the mirror where the reflected rays actually go.

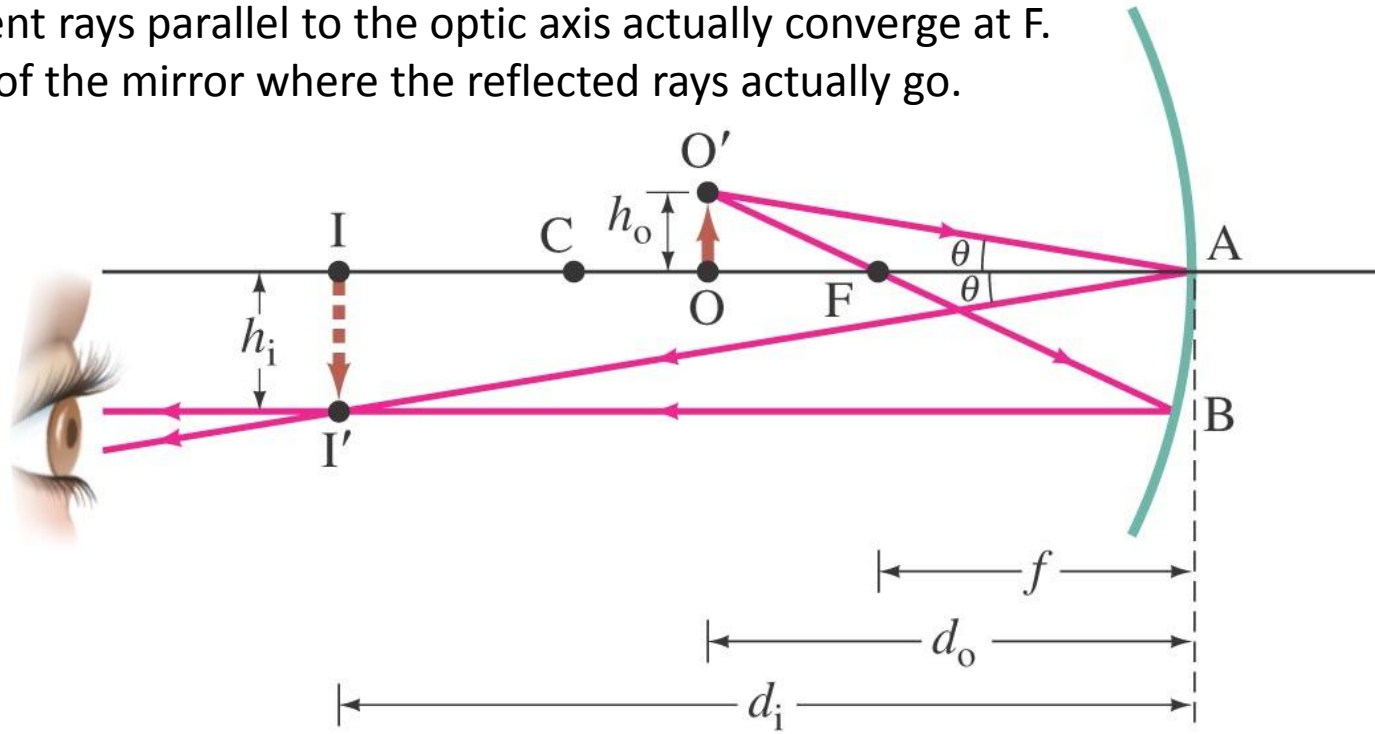


Figure 32.16