مؤسسة الإمارات للتعليم المدرسي
EMIRATES SCHOOLS ESTABLISHMENT

وزارة التربية والتعليم
MINISTRY OF EDUCATION

Beda Al Mutawa School

DEPARTMENT OF SCIENCE

EOT3 REVISION

Subject: Physics **Grade: 10G**

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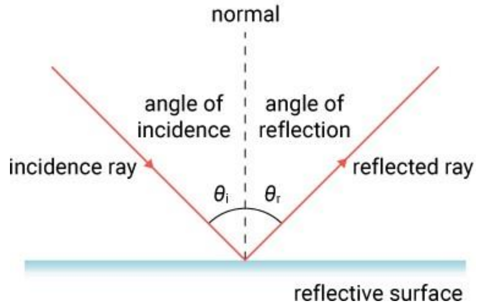
1. **The Law of Reflection.** **P. 179**

Answer:

When a ray of light approaches a smooth polished surface and the light ray bounces back, it is called the reflection of light.



The ray going toward the surface is the **incident ray** and the one moving away from the surface is the **reflected ray**.

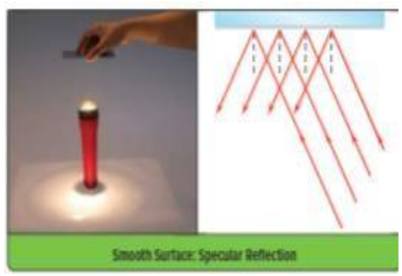
The **law of reflection** states that the angles of incidence and reflection are always equal.

$\theta_i = \theta_r$

2. **The difference between specular and diffuse reflection** **P180**

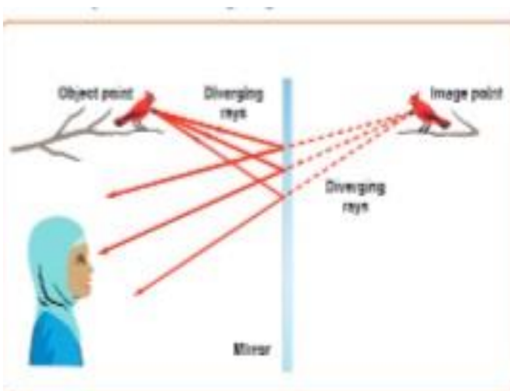
Answer:

A smooth surface, such as a mirror, produces **specular reflection**, in which parallel light rays reflect in parallel.



This scattering of light off a rough surface is called **diffuse reflection**. Diffuse reflection enables you to read this page from various angles. All the light rays are parallel before they strike the surface, but the reflected rays are not parallel.

3. **Images formed by plane mirrors. Fig 6. 182-183**
   Answer:



The combination of light rays reflected from the bird forms the image of the bird. It is a virtual image, which is a type of image formed by diverging light rays.

A virtual image is always on the opposite side of the mirror from the object. The image is virtual because there are no light rays at the image location.

Plane mirrors only produce virtual images

4. **Properties of Plane-Mirror Images. Review Q8 P184**
   Answer:

Image Properties A cat looks at its image, as shown in Figure 9. What is the image position, height, and type?

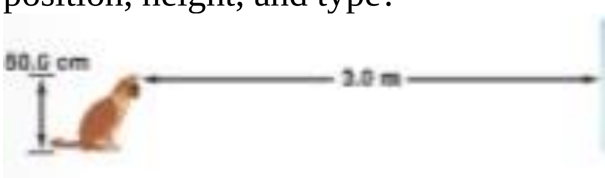


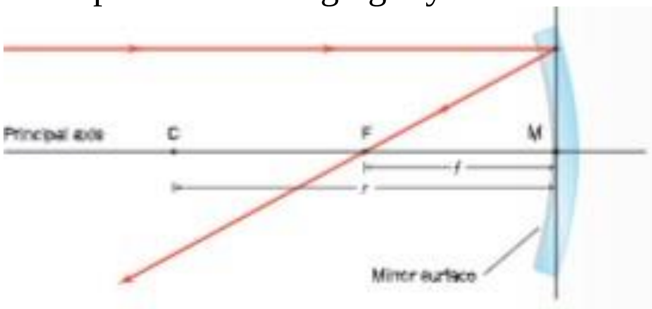
Figure 9

Image position: Appear to see 3.0 m behind the mirror, up-right.
Height: 50.0 cm
Type: Virtual

5. **Properties of Curved Mirrors to Solve problems on focal length. As mentioned in the textbook 186**

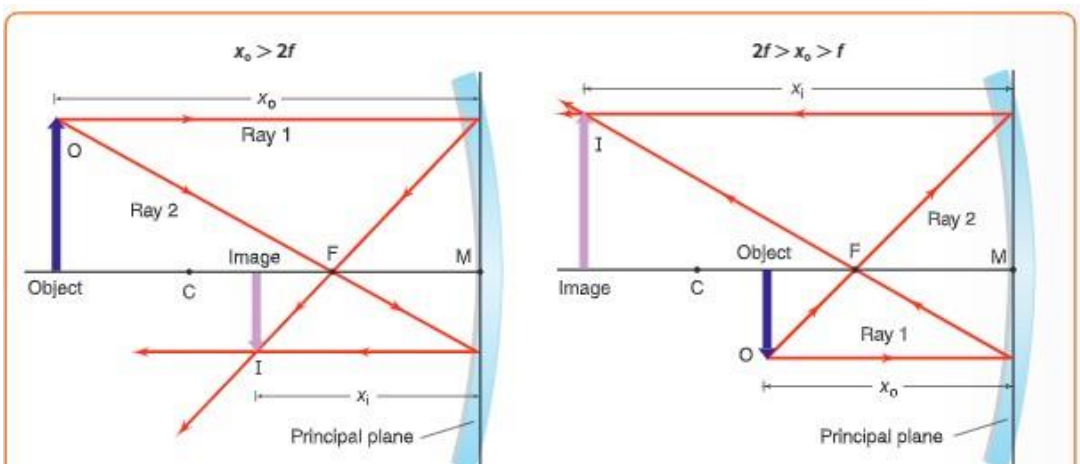
Answer:

The focal length(f) is the distance between the mirror and the focal point and can be expressed as f=r/2. The focal length is positive for a concave mirror, because it is a point of converging rays.



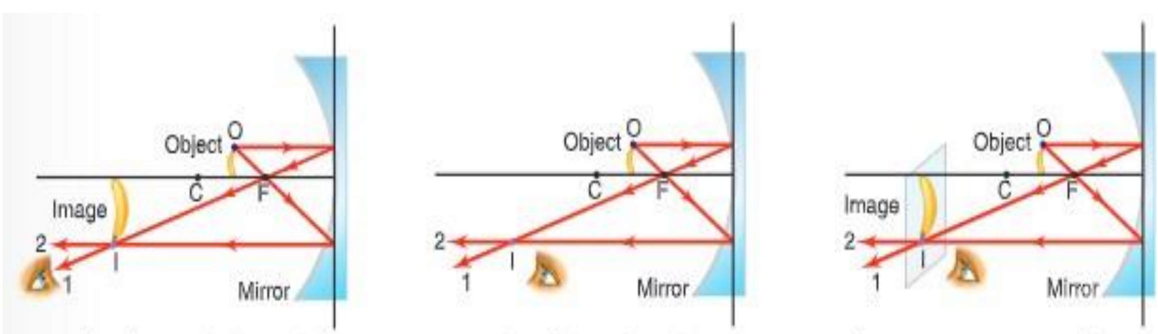
6. Ray Diagrams for Concave Mirrors As mentioned in the textbook + Fig 13 186-187

Answer:



The image is reduced for an object located a distance greater than 2*f* from the mirror.

The image is enlarged for an object between *f* and 2*f*.



The eye is positioned so that the rays that form the real image strike the eye, allowing the image to be seen.

Rays from the object do not reach the eye, and so the image cannot be seen from this position.

The image can be seen when projected on a white opaque screen.

7. **Defects in concave mirrors (spherical aberration) As mentioned in the textbook 188**
   Answer:

   Light rays reflect off the mirror itself. But only parallel rays that are close to the principal axis reflect through the focal point. Other rays converge at points closer to the mirror. This defect is called spherical aberration.

   It occurs because the light rays do not converge at a focal point, which makes an image look fuzzy.

   It produces loss of image resolution.

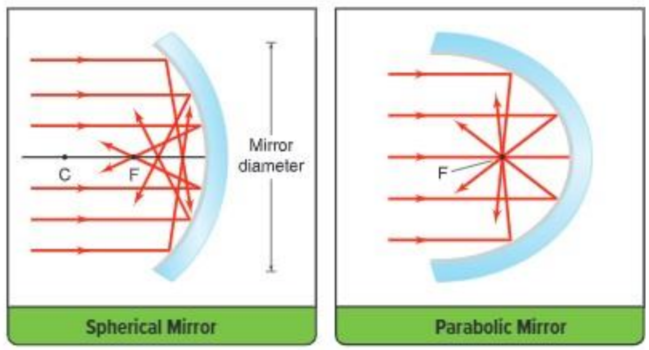
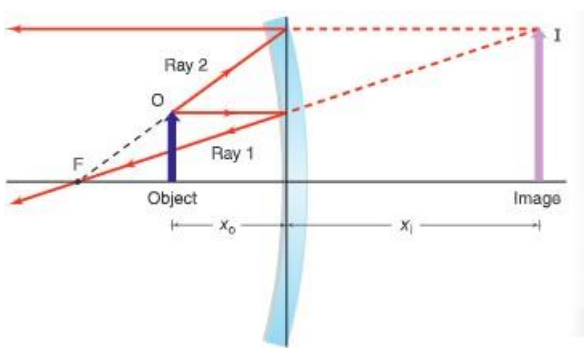


Figure 15 Spherical aberration occurs for spherical mirrors but does not occur for parabolic mirrors.

8. **Virtual Images with Concave Mirrors As mentioned in the textbook 189**
   Answer:

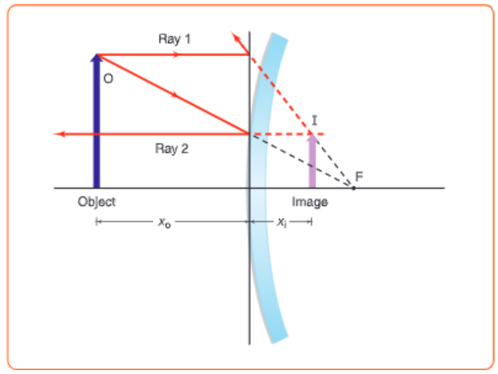


   A **virtual image** is not real because the rays *diverge* rather than *converge*.
   A virtual image cannot be projected on a screen.
   Concave mirrors can form both real and virtual images.

9. **Convex Mirrors As mentioned in the textbook 190**
   Answer:

Convex mirrors are mirrors with an outwardly curving surface.
These rays bounce off the mirror, *diverging* outward.
If you trace the rays back to a single point, they appear to converge at the focal point (F).
The image formed by a convex mirror is,

- behind the mirror
- upright
- smaller than the object
- virtual



10. Convex Mirrors As mentioned in the textbook 191

Answer:

The convex mirrors provide a larger field of view. But, because the reduced image size makes the objects appear farther away than they really are, there is often a warning on passenger-side rearview mirrors of cars stating that objects may be closer than they appear.

11. Magnification of a spherical mirror As mentioned in the text book 192

Answer:

Magnification is a measure of how much larger or smaller the image is than the object.

$$m \equiv \frac{h_I}{h_O} = -\frac{x_I}{x_O}$$

The magnification of an object by a spherical mirror, defined as the image height divided by the object height, is equal to the negative of the image position, divided by the object position.

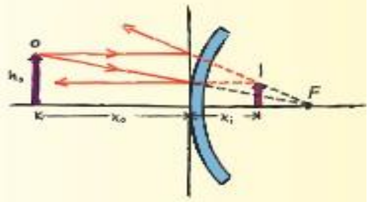
12. Calculating Image Position (Mirror Equation) As mentioned in Example 3 194

Answer:

convex security mirror in a warehouse has a −0.50-m focal length. A 2.0-m-tall forklift is 5.0 m from the mirror. What are the image position and image height?

1 ANALYZE AND SKETCH THE PROBLEM

- Draw a diagram with the mirror and the object.
- Draw two principal rays to locate the image in the diagram.



KNOWN	UNKNOWN
$h_o = 2.0$ m	$x_i = ?$
$x_o = 5.0$ m	$h_i = ?$
$f = -0.50$ m	

2 SOLVE FOR THE UNKNOWN

Use the relationship between focal length and object position to solve for image position.

$$\frac{1}{f} = \frac{1}{x_i} + \frac{1}{x_o}$$

$$x_i = \frac{f x_o}{x_o - f}$$

$$= \frac{(-0.50\text{ m})(5.0\text{ m})}{5.0\text{ m} - (-0.50\text{ m})}$$ ◄ Substitute $f = -0.50$ m, $x_o = 5.0$ m

$= -0.45$ m (virtual image, behind the mirror)

Use the relationship between object height and object and image position to solve for image height.

$$m = \frac{h_i}{h_o} = \frac{-x_i}{x_o}$$

$$h_i = \frac{-x_i h_o}{x_o}$$

$$= \frac{-(-0.45\text{ m})(2.0\text{ m})}{5.0\text{ m}}$$ ◄ Substitute $x_i = -0.45$ m, $h_o = 2.0$ m, $x_o = 5.0$ m

$= 0.18$ m (upright, smaller image)

13.Mirror Comparison As mentioned in Table 1 195

Answer:

Table 1 Single-Mirror System Properties

Mirror Type	f	x_o	x_i	m	Image
Plane	∞	$x_o > 0$	$\lvert x_i \rvert = x_o$ (negative)	Positive $m = 1$	virtual same size laterally inverted
Concave	+	$x_o > r$	$r > x_i > f$	Negative $\lvert m \rvert < 1$	real reduced inverted
		$r > x_o > f$	$x_i > r$	Negative $\lvert m \rvert > 1$	real enlarged inverted
		$f > x_o > 0$	$\lvert x_i \rvert > x_o$ (negative)	Positive $\lvert m \rvert > 1$	virtual enlarged upright
Convex	−	$x_o > 0$	$\lvert f \rvert > \lvert x_i \rvert > 0$ (negative)	Positive $\lvert m \rvert < 1$	virtual reduced upright

- The single plane mirror and convex mirror produce only virtual images.
- A concave mirror produces real images when the object is father than the focal distance.
- A concave mirror produces virtual images when the object is closer than the focal distance.

- Plane mirrors give reflections on scale with the objects, and convex mirrors provide reduced images, expanding the field of view.

- A concave mirror acts as a magnifier when an object is within the focal length of the mirror.
- A concave mirror enlarges and inverts the image when the object is between the focal point and the center of curvature.

- Beyond the radius of curvature, a concave mirror produces a reduced, inverted image

14.Light and Boundaries As mentioned in the text book 206

Answer:

When light encounters a transparent or translucent medium, some light is reflected from the surface of the medium and some is transmitted through the medium.

When light crosses a boundary between two mediums, it bends.
This bending of light when it passes from one medium to another is known as refraction.

Identical rays of light start in air and pass into three different mediums: water, glass, and diamond.

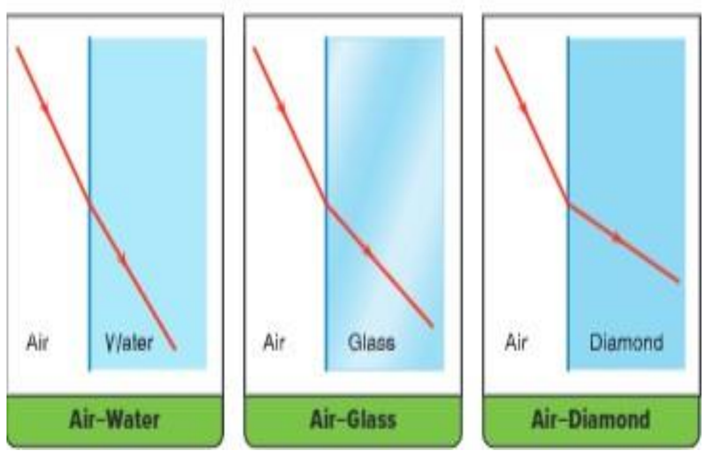
The light hits the surface of each medium at the same angle.

The light rays bend as they cross the boundaries.

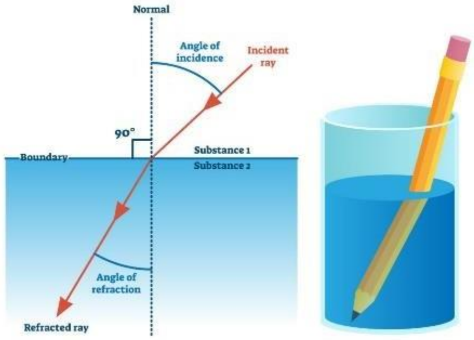
The light rays bend more when traveling from air to diamond than from air to water or air to glass.

This phenomenon depends on properties of the mediums that the light rays are traveling from and into.

Figure 1 Light refracts as it crosses a boundary. The amount of refraction depends on the properties of the mediums. (Angles are not to scale.)



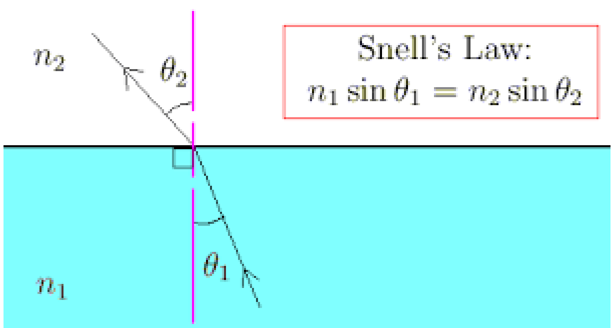
REFRACTION



15.Snell's Law of Refraction As mentioned in the textbook 207

Answer:

Refraction of light at the interface between two media of different **refractive** indices, with n2 > n1. Since the velocity is lower in the second medium (v2 < v1)



SNELL'S LAW OF REFRACTION

The product of the index of refraction of the first medium and the sine of the angle of incidence is equal to the product of the index of refraction of the second medium and the sine of the angle of refraction.

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

16.The Meaning of the Index of Refraction As mentioned in the text book + Fig 5 209-210

Answer:

INDEX OF REFRACTION

The index of refraction of a medium is equal to the speed of light in a vacuum divided by the speed of light in the medium.

$$n = \frac{c}{v}$$

It describes how much light bends as it enters a medium.

This definition of the index of refraction can be used to find the wavelength of light in a medium. In a medium with an index of refraction n, the speed of light is given by $v = \frac{c}{n}$. The wavelength of the light in a vacuum is $\lambda_0 = \frac{c}{f}$. Solve for frequency, and substitute $f = \frac{c}{\lambda_0}$ and $v = \frac{c}{n}$ into $\lambda = \frac{v}{f}$.

$$\lambda = \frac{(c/n)}{(c/\lambda_0)} = \frac{\lambda_0}{n}$$

Note that, as was stated earlier, the wavelength of light in a medium is smaller than its wavelength in a vacuum.

17.Solve problems on Total Internal Reflection As mentioned in the textbook 210, 213

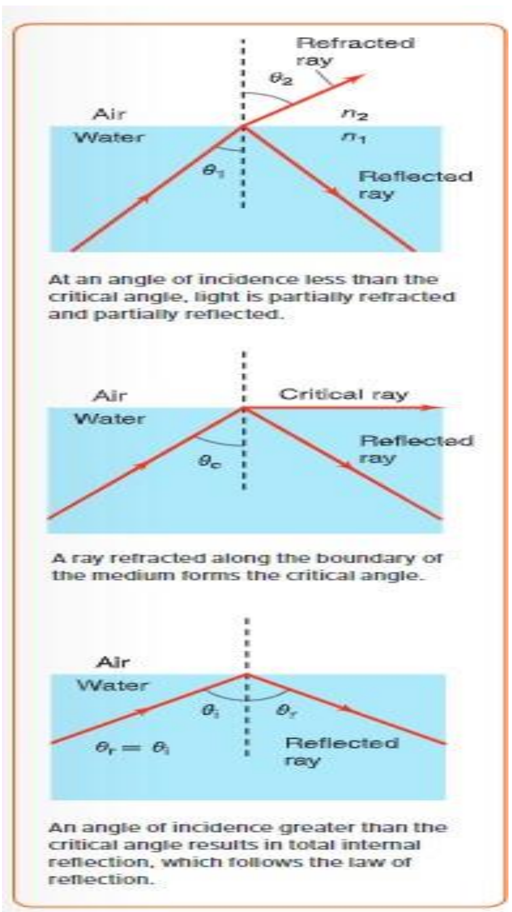


Figure 5 Refraction and reflection of light traveling between mediums depend on the angle of incidence θ_1.

Answer:

At a certain angle of incidence known as the critical angle(θc), the refracted light ray lies along the boundary of the two mediums.

Total internal reflection occurs when light traveling from a region of a higher index of refraction to a region of a lower index of refraction strikes the boundary at an angle greater than the critical angle such that all light reflects back into the region of the higher index of refraction.

This is shown in the bottom diagram of Figure 5.

To construct an equation for the critical angle of any boundary, you can use Snell's law and substitute θ1=θc, and sin θ2= sin 90.0°= 1.

$$\sin \theta_c = \frac{n_2}{n_1}$$

Problem: The index of refraction of air is 1.00, and the index of refraction of water is 1.33. What is the critical angle for light moving from water to air?

Answer:

$$\sin\theta_C = \frac{n_2}{n_1}$$

$$\theta_C = \sin^{-1}\frac{n_2}{n_1}$$

$$\theta_C = \sin^{-1}\frac{1.00}{1.33}$$

$$\theta_C = \sin^{-1}(0.75)$$

$$\theta_C = 48.8^\circ$$

18. Types of Lenses As mentioned in the textbook + Fig 11 214

Answer:

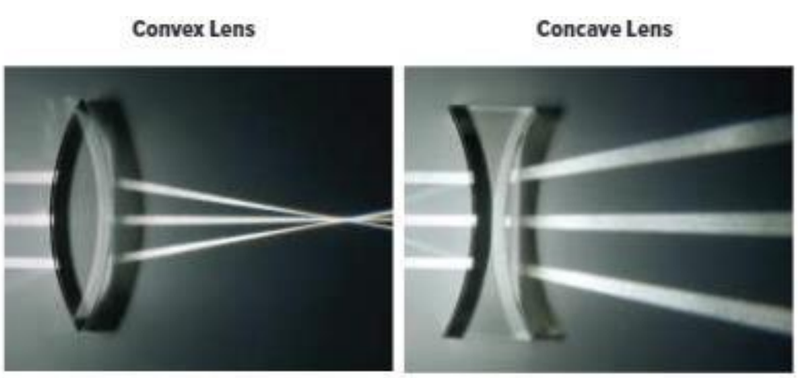
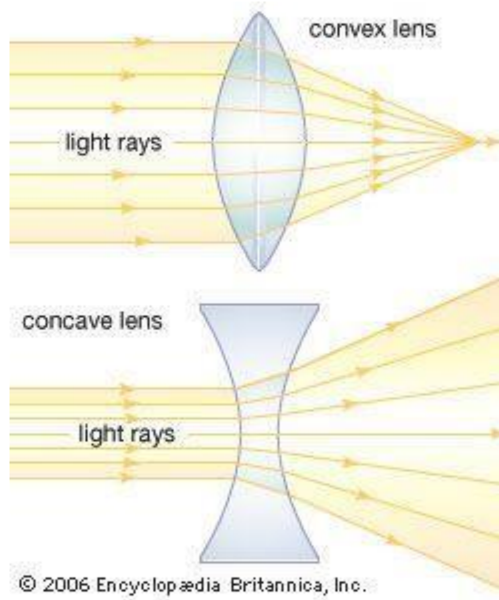


Figure 11 Convex lenses refract light so that the rays converge after passing through. The light passing through a concave lens does not meet at the focal point.

A **lens** is a curved piece of transparent material that focuses or disperses light.

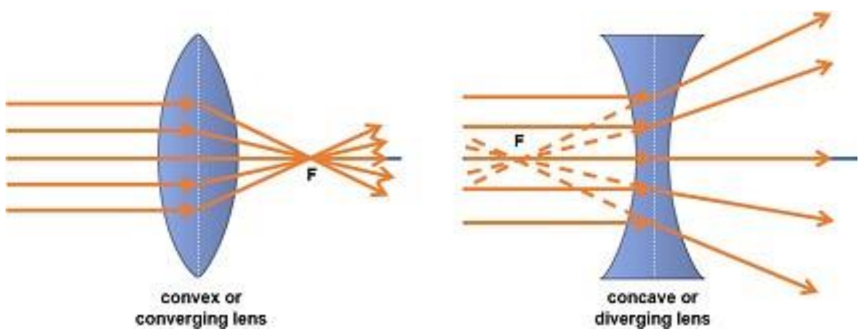
There are two types of lenses:

A convex lens **is thicker at the center than at the edges.** Light rays from a distant object **converge** in a convex lens when they refract out again.



A concave lens **is thinner in the middle than at the edges.** Light rays from a distant object **diverge** in a convex lens when they refract out again.

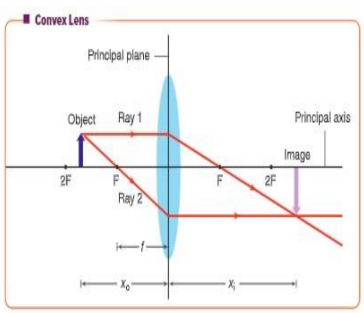
Concave lenses diverge light just like a convex mirror. Divergent rays form virtual, upright images.



19.Convex Lenses As mentioned in the textbook + Fig 13+14 216

Answer:

Figure 13 An object placed at a distance less than twice the focal length but greater than one focal length from the lens will produce an image that is real, enlarged, and inverted.



In this case, the image is also real and inverted.

For an object placed between F and 2F, the image is enlarged.

When an object is placed at the focal point of a convex lens, ray diagrams cannot be drawn. The refracted rays will emerge in a parallel beam and no image will be seen.

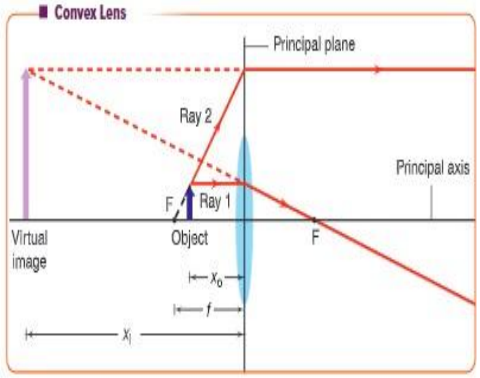


Figure 14 An object placed at a distance less than the focal length from the lens will produce an image that is virtual and enlarged.

Classify an image as virtual or real based on the side of the lens it is on.

This is a virtual image that is upright and larger compared to the object.

No real image is possible.

20.Concave Lenses As mentioned in the textbook + Fig 15 217

Answer:

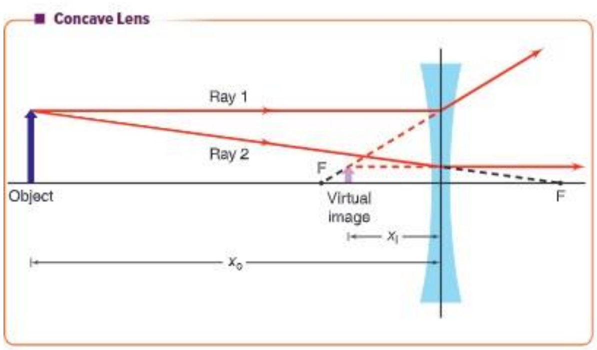


Figure 15 An object placed any distance from a concave lens will always produce an image that is virtual and reduced.

The sight lines of rays 1 and 2 intersect on the same side of the lens as the object.

The image is located at the point from where the two rays appear to intersect, creating a virtual image.

The image is upright and smaller than the object.

This is true no matter how far from the lens the object is located.

The focal length for a diverging lens is negative.

21.Thin lens equation As mentioned in the textbook 217-218

Answer:

The **thin lens equation** relates the focal length of a lens (f) to image position ($\boldsymbol{x}_I$) and object position ($\boldsymbol{x}_o$),

$$\frac{1}{f} = \frac{1}{x_I} + \frac{1}{x_O}$$

Focal length $$f = \frac{x_O x_I}{x_O + x_I}$$

Object distance $$x_O = \frac{f x_I}{x_I - f}$$

Image distance $$x_I = \frac{f x_O}{x_O - f}$$

- Convex lenses have a *positive* focal length (*f*).
- Concave lenses have a *negative* focal length (*f*).
- Object position (x_o) for both lenses is *always positive.*
- Image position (x_I) is *positive* when the image is real and *negative* when the image is virtual.

Table 2
Properties of a Single Spherical Lens System

Lens Type	f	x_o	x_i	m	Image
Convex	+	$x_o > 2f$	$2f > x_i > f$	negative $-1 < m < 0$	real
		$2f > x_o > f$	$x_i > 2f$	negative $\lvert m \rvert > 1$	real
		$f > x_o > 0$	$\lvert x_i \rvert > x_o$ (negative)	positive $m > 1$	virtual
Concave	−	$x_o > 0$	$\lvert f \rvert > \lvert x_i \rvert > 0$ (negative)	positive $0 < m < +1$	virtual

22.Solve problems on lens As mentioned in Example 2 219

Answer:

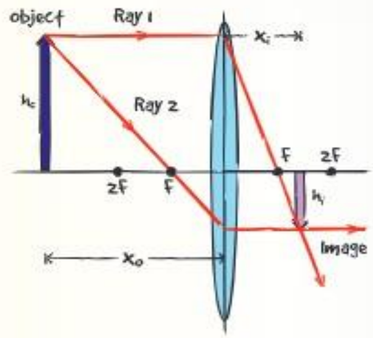
EXAMPLE 2

AN IMAGE FORMED BY A CONVEX LENS An object is placed 32.0 cm from a convex lens that has a focal length of 8.0 cm.

a. Where is the image?

b. If the object is 3.0 cm high, how tall is the image?

c. What is the orientation of the image?



1 ANALYZE AND SKETCH THE PROBLEM

- Sketch the situation, locating the object and the lens.
- Draw the two principal rays.

KNOWN	UNKNOWN
$x_o = 32.0$ cm	$x_i = ?$
$h_o = 3.0$ cm	$h_i = ?$
$f = 8.0$ cm	

2 SOLVE FOR THE IMAGE POSITION AND HEIGHT

a. Use the thin lens equation to determine x_i.

$$\frac{1}{f} = \frac{1}{x_i} + \frac{1}{x_o}$$

$$x_i = \frac{f x_o}{x_o - f}$$

$$= \frac{(8.0\text{ cm})(32.0\text{ cm})}{32.0\text{ cm} - 8.0\text{ cm}}$$ ◄ Substitute $f = 8.0$ cm, $x_o = 32.0$ cm

$= 11$ cm (11 cm away from the lens on the side opposite the object)

b. Use the magnification equation, and solve for image height.

$$m \equiv \frac{h_i}{h_o} = -\frac{x_i}{x_o}$$

$$h_i = -\frac{x_i h_o}{x_o}$$

$$= -\frac{(11\text{ cm})(3.0\text{ cm})}{32.0\text{ cm}}$$ ◄ Substitute $x_i = 11$ cm, $h_o = 3.0$ cm, $x_o = 32.0$ cm

$= -1.0$ cm (1.0 cm tall)

c. The negative sign for the height in part **b** means the image is inverted.

23. Defects of Spherical Lenses (Chromatic aberration) As mentioned in the textbook 220

Answer:

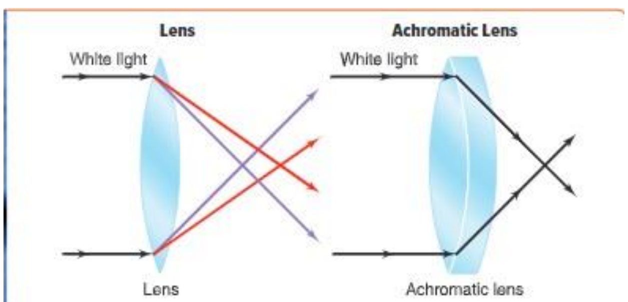


Figure 17 Simple lenses, such as the one shown in the photo on the left, exhibit a rainbow fringing effect called chromatic aberration. Achromatic lenses reduce chromatic aberration.

Explain why the index of refraction is important for achromatic lenses.

Chromatic aberration Lenses have a second defect that mirrors do not have. Because the index of refraction of a medium depends on wavelength.

Different wavelengths of light are refracted at slightly different angles, as you can see in Figure 17.

Light that passes through a lens is slightly dispersed, especially near the edges, causing an effect called chromatic aberration.

This is seen as an apparent ring of color around an object viewed through a lens.

24. Solve problems on Snell's Law of Refraction As mentioned in the Q47 228

Answer:

47. A ray of light travels from air into a liquid, as shown in **Figure 30.** The ray enters the liquid at an angle of 30.0°. The angle of refraction is 22.0°. Using Snell's law, calculate the index of refraction of the liquid. Compare the calculated index of refraction to those in **Table 1.** What might the liquid be?

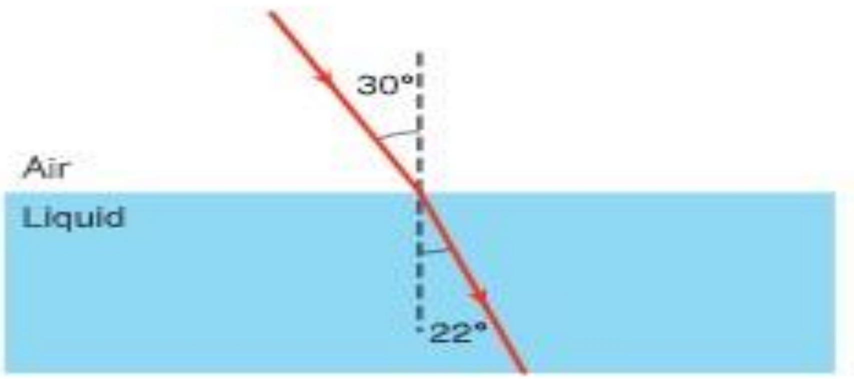


Figure 30

Solution:

$n_1 = 1$

$\theta 1 = 30°$

$\theta 2 = 22°$

$n_2 = ?$

According to Snell's law $n_1 \sin\theta 1 = n_2 \sin\theta 2$

$1 x \sin 30° = n_2 \sin 22°$

$n_2 = 1 x \sin 30° / \sin 22°$

$= 0.5/0.374$

$= 1.33$

The liquid might be water

Table 1

Indices of Refraction for Yellow Light (λ = 589 nm in vacuum)	
Medium	n
Vacuum	1.00
Air	1.0003*
Water	1.33
Ethanol	1.36
Float glass	1.52
Quartz	1.54
Flint glass	1.62
Diamond	2.42

25. Determine what happens to the image in the lens when the object change its position As mentioned in the text book 217-218.

Answer:

When the object changes its position, the image size becomes smaller or bigger than the object, and it may be real or virtual.

Table 2
Properties of a Single Spherical Lens System

Lens Type	f	x_o	x_i	m	Image
Convex	+	$x_o > 2f$	$2f > x_i > f$	negative $-1 < m < 0$	real
		$2f > x_o > f$	$x_i > 2f$	negative $\|m\| > 1$	real
		$f > x_o > 0$	$\|x_i\| > x_o$ (negative)	positive $m > 1$	virtual
Concave	−	$x_o > 0$	$\|f\| > \|x_i\| > 0$ (negative)	positive $0 < m < +1$	virtual

Additional

If the angle of incidence of a ray of light is 42°, what is each of the following?
Answer:

a. the angle of reflection
$\theta_r = \theta_i = 42°$

b. the angle the incident ray makes with the mirror
$\theta_{i,\,mirror} = 90° - \theta_i = 90° - 42° = 48°$

c. the angle between the incident ray and the reflected ray
$\theta_i + \theta_r = 2\theta_i = 84°$

If a light ray reflects off a plane mirror at an angle of 35° to the normal, what was the angle of incidence of the ray?

Answer: $\theta_i = \theta_r = 35°$

ALL THE BEST