شرح
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Section 1

PLANE MIRRORS

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1	The Law of Reflection قانون الانعكاس	As mentioned in the text book +Figure 2	179

reflection law

- Reflection: The bouncing back of light into the same medium.
- Dark bodies: They are the bodies from which light does not pass.. An example of them: If you are holding a book and directing it to the path of light, the light will not penetrate the book.
- The behavior of light depends on: 1- The reflective surface. 2- The angle of incidence of the light on it.
- The law of reflection: the relationship between the angle of incidence and the angle of reflection.
- Law of reflection: angle of incidence i = angle of reflection r.

LAW OF REFLECTION

The angle that a reflected ray makes as measured from the normal to a reflective surface equals the angle that the incident ray makes as measured from the same normal.

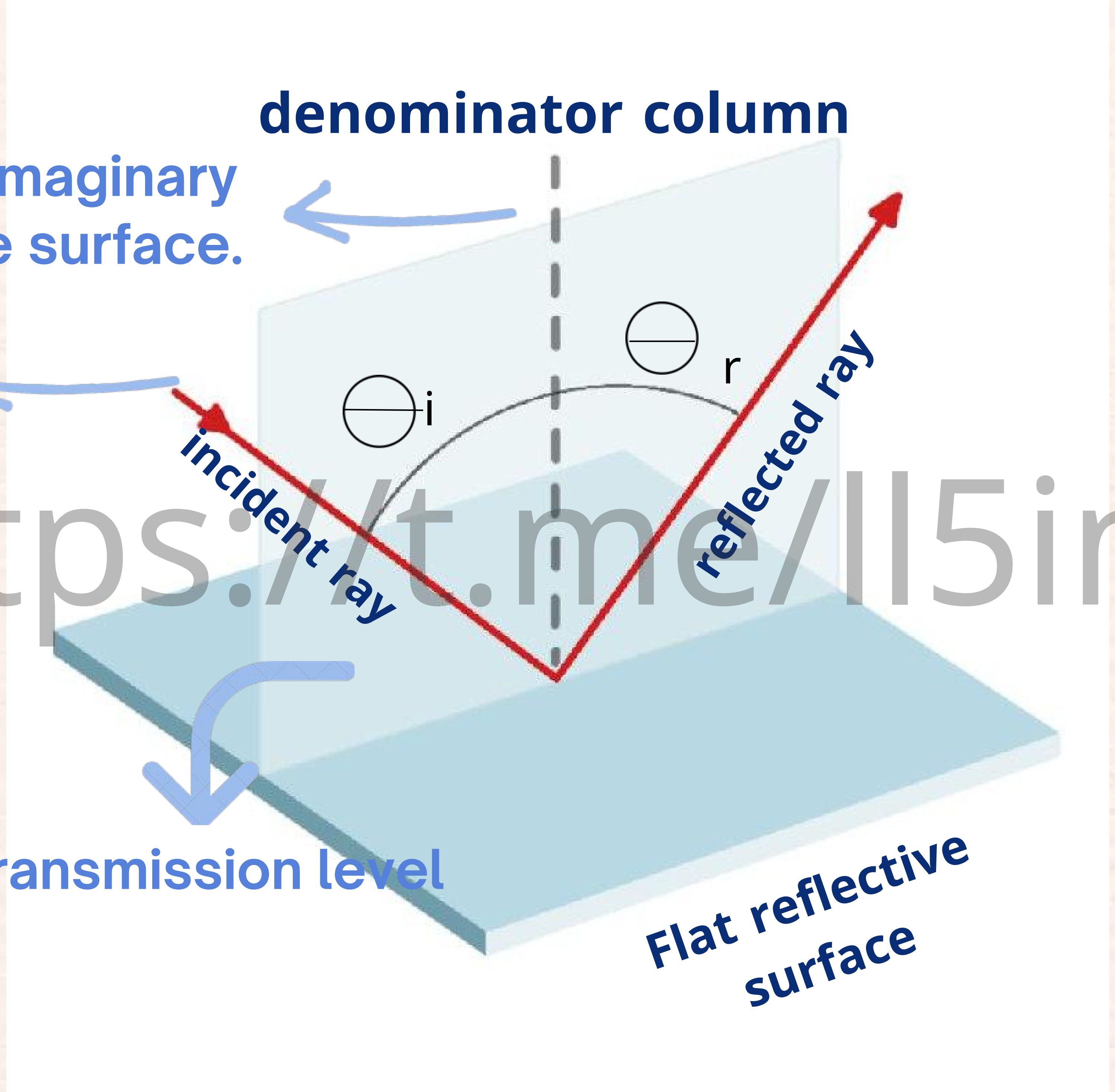
$$\theta_r = \theta_i$$

FIGURE 2

The components of reflection are: the normal, the incident ray, the reflected ray, the angle of incidence, the angle of reflection, and a flat reflecting surface .

The denominator: is an imaginary line perpendicular to the surface.

A ray of light is incident on a flat reflective surface



light transmission level

- The incident ray, the reflected ray, and the normal to the reflective surface lie in one plane perpendicular to the reflecting surface.
- Although light spreads in three dimensions, its reflection is in one plane, i.e. in two dimensions.

2	The difference between specular and diffuse reflection الفرق بين الانعكاس المنتظم والانعكاس غير منتظم	As mentioned in the text book +Figure 4	179-180

The reflection Diffuse Reflection .

- Light rays incident in parallel are reflected in a parallel direction.
- Rays that fall on it are parallel and are reflected from it are also parallel.
- Reflects light in one direction.

$$\theta_r = \theta_i$$

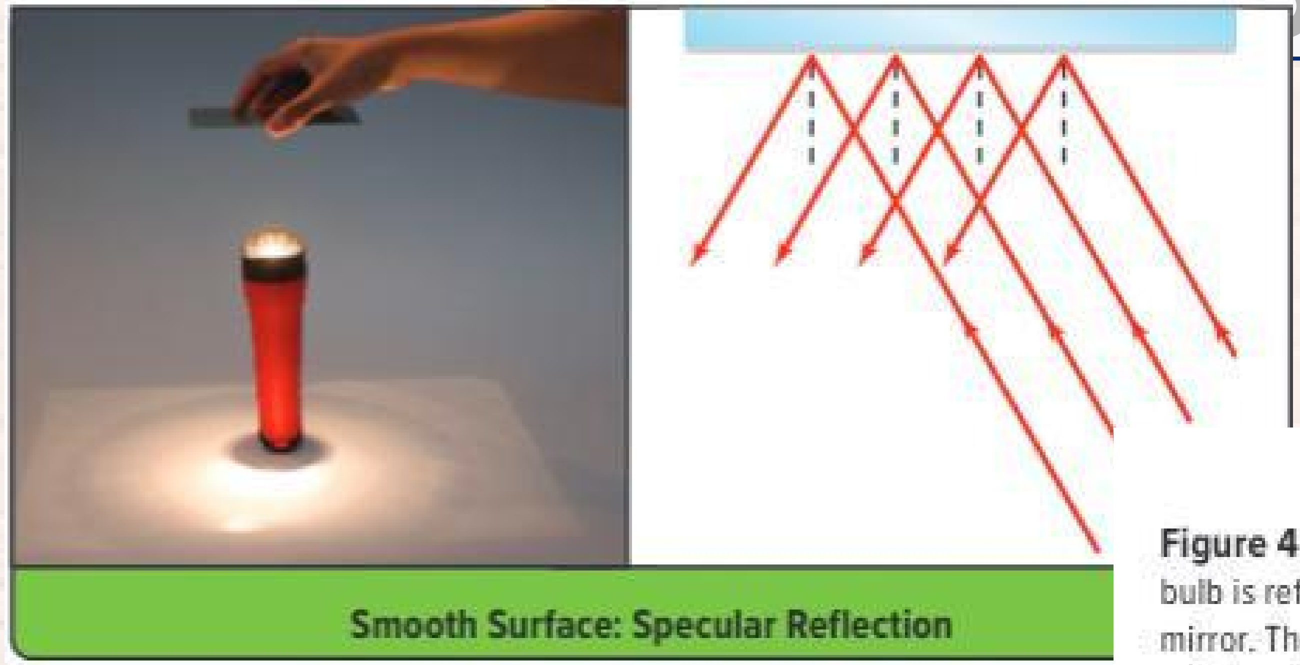


Figure 4 Notice that the image of the light-bulb is reflected on the table by the smooth mirror. The surface of the paper only reflects a featureless area of light.

18	Reflections types أنواع الانعكاس : منتظم و غير منتظم	As mentioned in the text book+Figure 4	180

Reflection rough surface on diffuse

- Rays fall on all rough surfaces in a parallel manner, but they are reflected in a non-parallel manner.
- When the reflected rays are not parallel, it is called scattering of light from a rough surface.
- The incident ray has parallel lines.

The reflected ray has irregular lines $\theta_r = \theta_i$

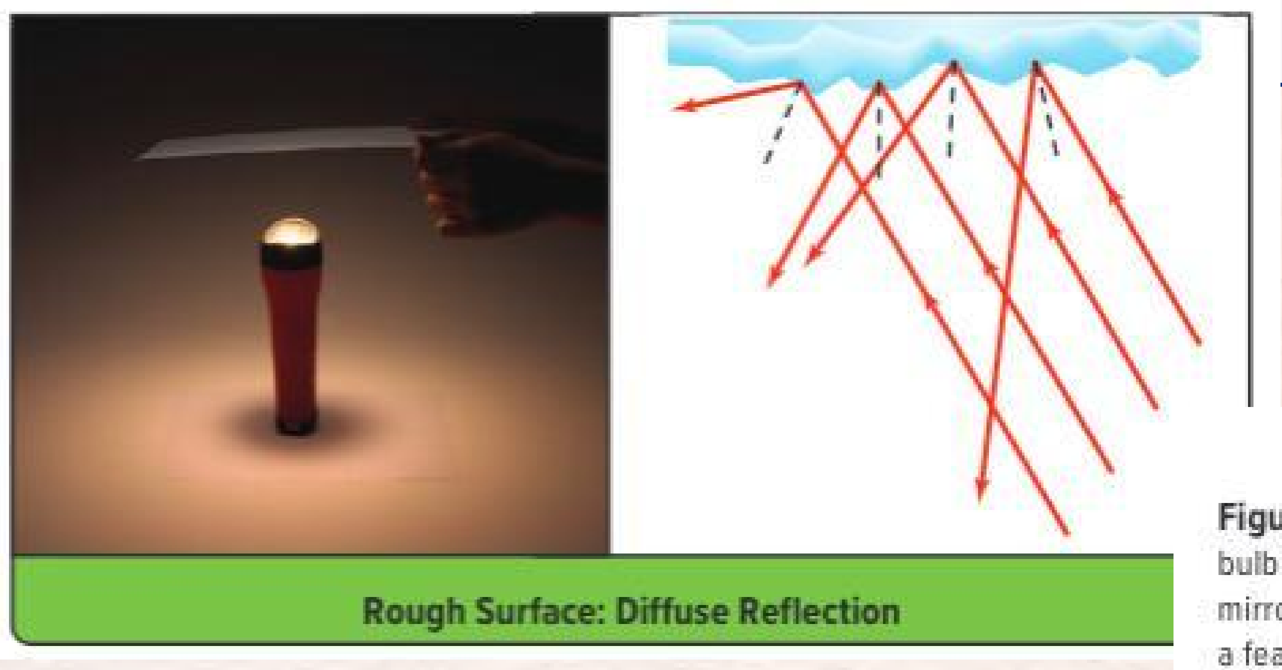


Figure 4 Notice that the image of the light-bulb is reflected on the table by the smooth mirror. The surface of the paper only reflects a featureless area of light.

18	**Reflections types** أنواع الانعكاس : منتظم و غير منتظم	As mentioned in the text book+Figure 4	180

The law of reflection applies to both smooth and rough surfaces. For a rough surface, the angle that each incident ray makes with the normal equals the angle that its reflected ray makes with the normal. On a microscopic scale, however, the normals to the surface locations where the rays strike are not parallel. Thus, the rough surface prevents the reflected rays from being parallel. In this case, the reflected rays are scattered in different directions. With specular reflection, as with a mirror, you can see your face. But no matter how much light reflects off a wall or a sheet of paper, you will never be able to use them as mirrors. Recall that you can only see an object, such as a sheet of paper, if light reflects off that object.

3	Images formed by plane mirrors الصور المتكونة في المرايا المستوية	As mentioned in the text book +Figure 6	182-183

Figure 6

- The bird is a body.. and the light reflects off the body of the bird in an irregular way.
- The light from the bird falls on the mirror and is reflected.
- The light will appear to Mary as shown in the dotted lines shown in the figure, i.e. as if it is coming from a point behind the mirror.
- In Figure 6, Mary will see the rays of light coming from the body of the bird in the same way.. Thus, the image of the bird consists of the union of the images of points resulting from the reflected light rays.. This image is considered imaginary.
- Imaginary image: These images consist of the convergence of the extensions of light rays reflected from the mirror..and they are always located on the other side of the mirror..And the images of real objects formed in plane mirrors are always imaginary because they cannot be collected on a barrier.

Figure 6

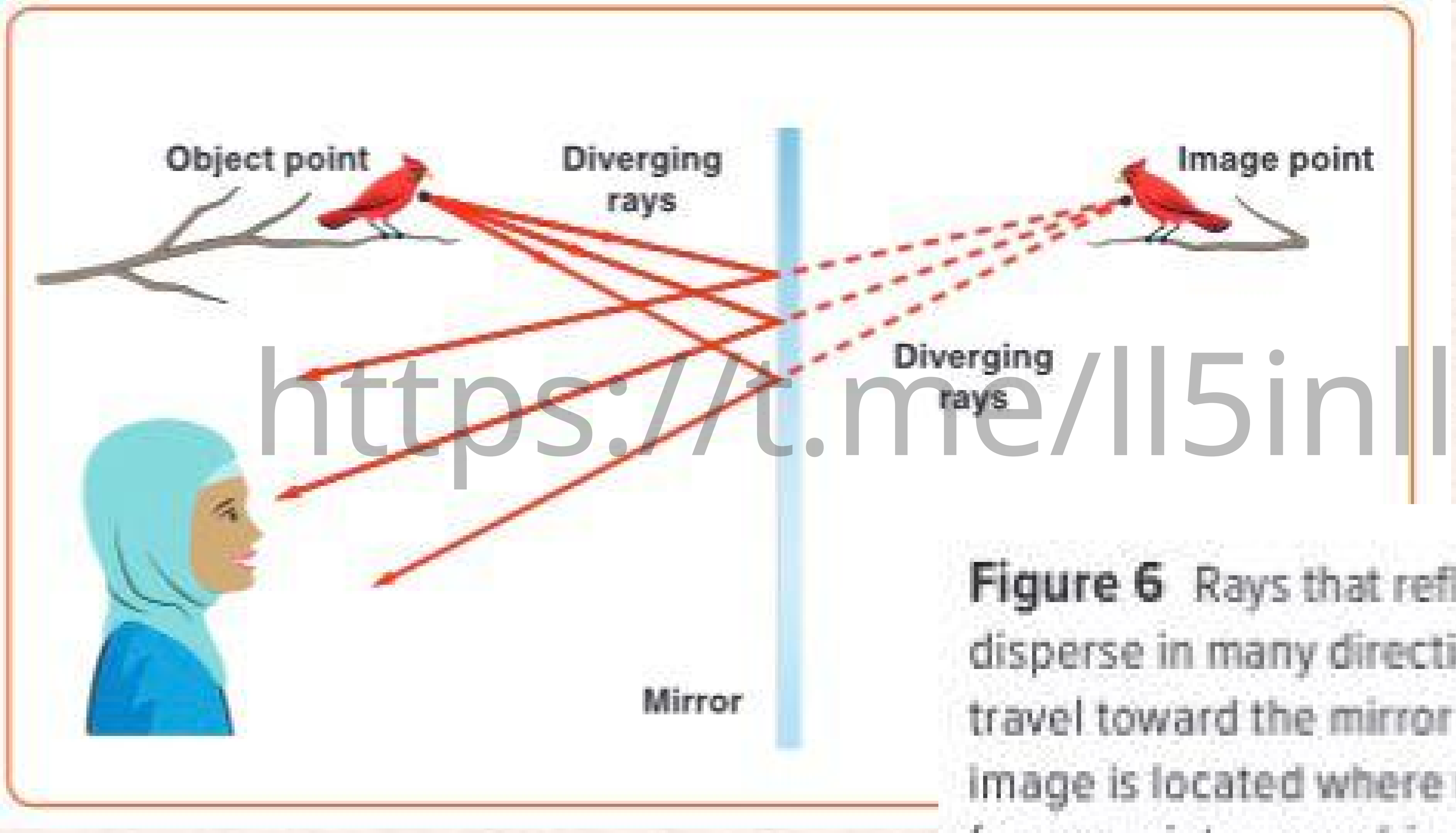


Figure 6 Rays that reflect from the bird will disperse in many directions. Only a few that travel toward the mirror are shown. The image is located where multiple light rays from a point on an object seem to converge.

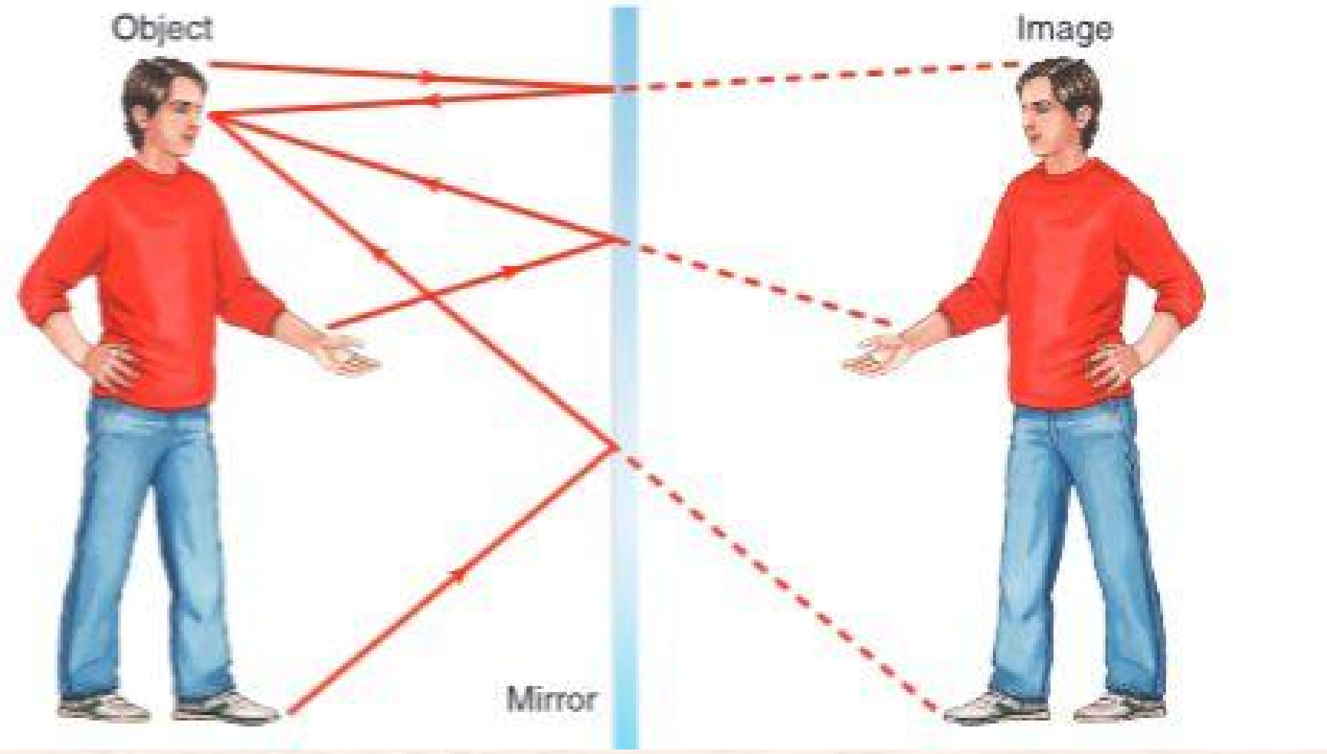
4	Properties of Plane-Mirror Images خصائص الصور المتكونة في المرايا المستوية	As mentioned in section1 review Q8	183-184

- When you see your image reflected, raise your left hand.
- Smooth reflects light from it in a regular way - Plane mirror:
- Characteristics of plane mirrors: Imaginary - have the same size - Moderate - have the same dimension -

It is: body diameter - body length - body height - height: image diameter - image length - image height

xo: the distance of the object from the mirror - xi: the distance of the image from the mirror

Figure 8 Viewed in a mirror, your height and distance from the mirror appear the same. There is, however, a difference. You are facing the opposite direction.



Section 2

SPHERICAL MIRRORS

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- The properties of spherical mirrors and the images they form depend on : the shape of the mirror and the location of the object.
- Concave mirror : It is a reflective surface that is curved inward, and its edge is curved towards the viewer. Its properties depend on the extent of its concavity.
- The concave mirror has: center of curvature c - radius of curvature r - and F focus - and f focal length.
- The principal axis: is a line perpendicular to the surface of the mirror.
- Focus F: It is the point where incident light rays converge parallel to the axis after being reflected from the mirror.
- Focal length f: is the distance between the mirror and the focus. It can be expressed by the equation $f = r/2$.

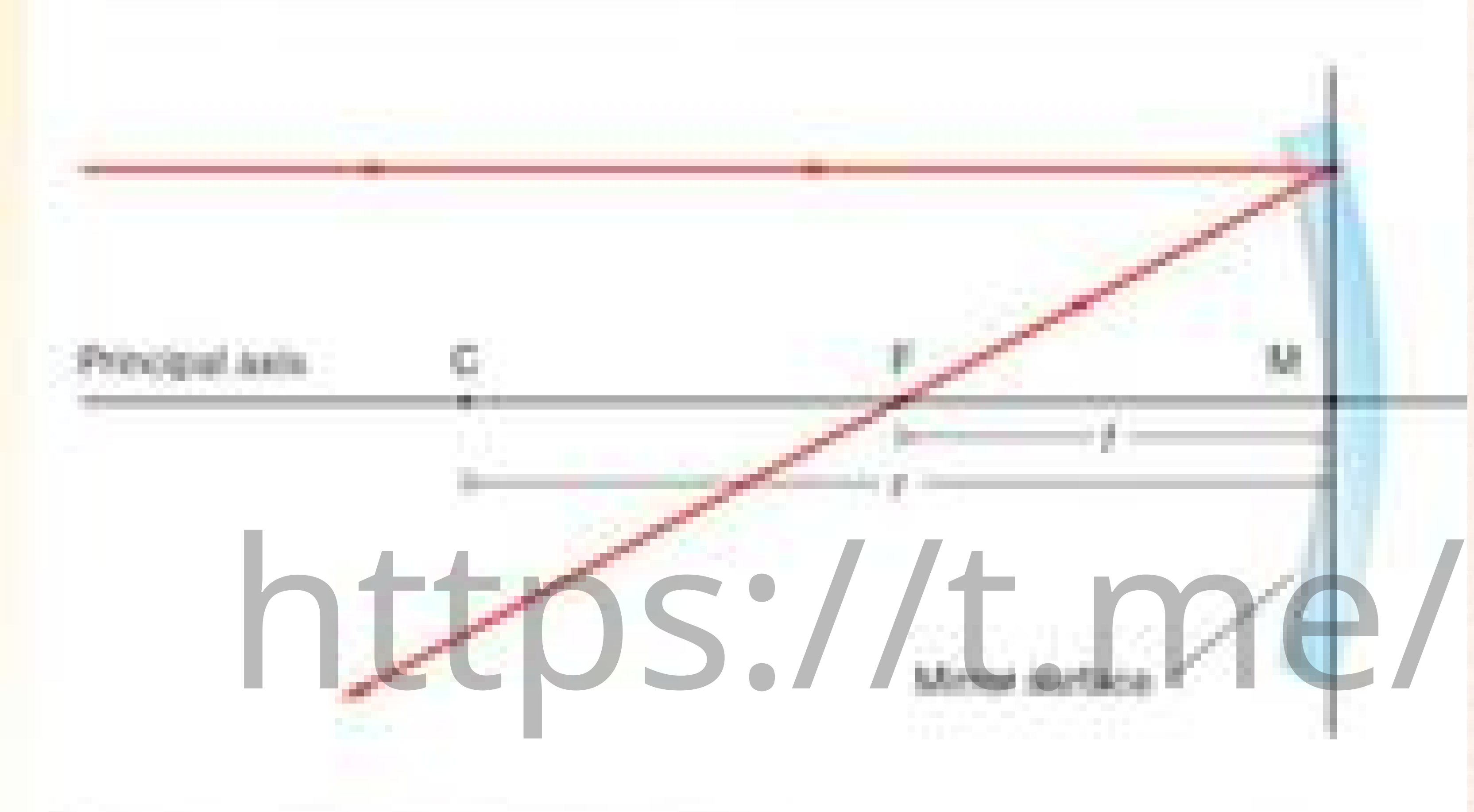
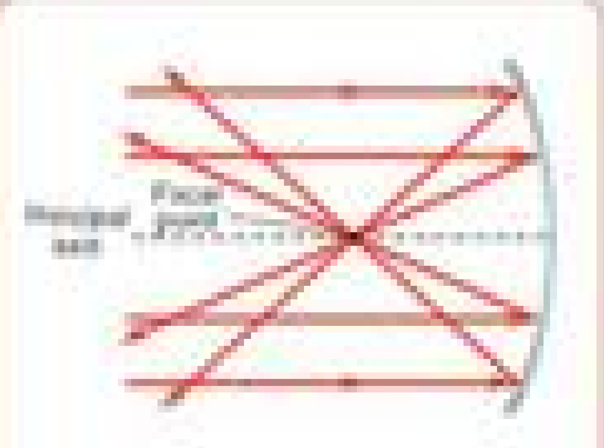


Figure 10 For a concave mirror, the distance from M to the focal point (F) is half the distance from M to C. Light rays that enter parallel to the principal axis converge at the focal point after reflecting off a concave mirror.

The distance between F to M is half the distance between C to M .

If you place a source of light at the focus of a concave mirror, the rays will reflect at the mirror in parallel and form a light beam.



Light rays parallel to the principal axis reflect off a concave mirror and converge at the focal point.

A lightbulb is placed at the focal point of a concave mirror. The parallel reflected rays are evident in this flashlight beam.

Figure 11 If rays are traced from the focal point to a concave mirror, they reflect off the surface as parallel rays.

Diagrams of concave mirrors

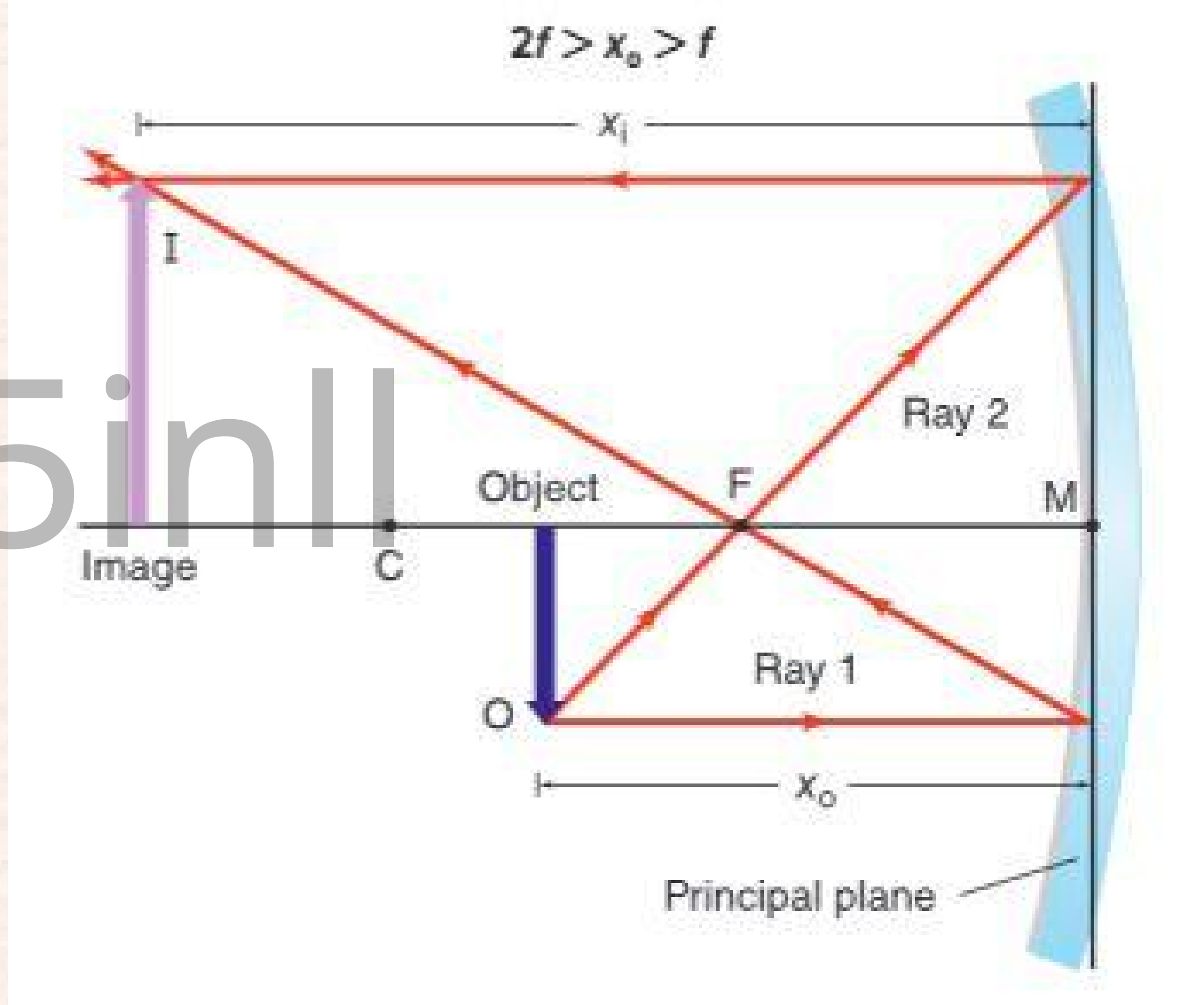
- Figure 12: It shows reflected rays that gather at point I at which the image is formed, and the collected light rays form a real, enlarged and inverted image of the object.

Real picture:
The image that consists of the confluence of reflected rays and can be collected on a barrier.. The real eye does not see it if it is in a location where the reflected rays do not fall on it, and you cannot see the image from behind unless you put a barrier in the location where the image is formed

Real images formed in concave mirrors

- **Figure 13 :**

If the body falls between the center of curvature and the focus , a real , inverted image is formed for it, and its size is larger than the size of the body itself (magnified) .

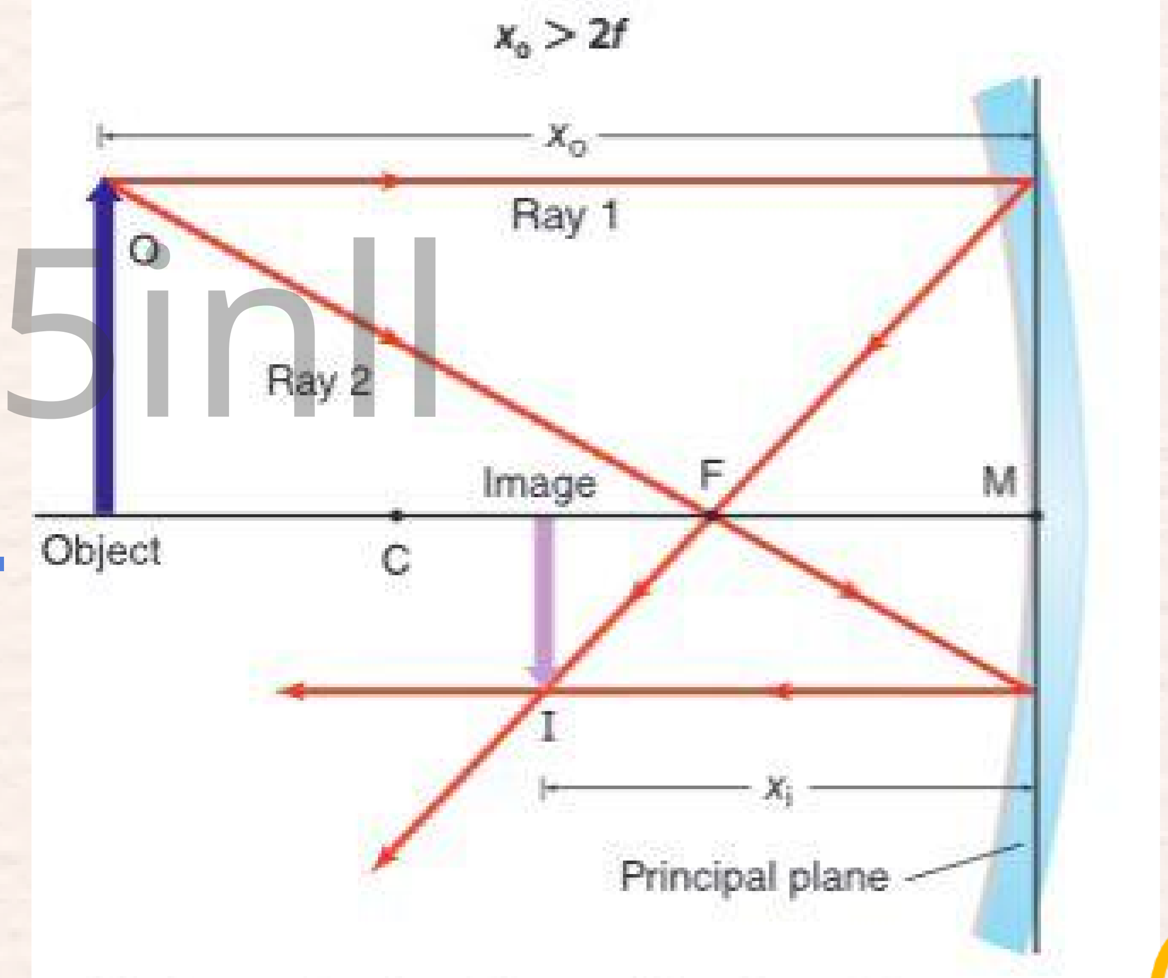


The image is enlarged for an object between f and $2f$.

Real images formed in concave mirrors

- **Figure 13 :**

If the object lies at a distance xo greater than twice the focal length f.. the spherical concave mirror is a real - and inverted - image of the object (miniature).. that is, the object is behind the center of the mirror's curvature.



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

Concave mirror defects

Figure 15:

- Only parallel rays close to the principal axis are reflected passing through the focus.
- The other rays gather at points closer to the mirror, and this defect called spherical aberration occurs.
- This spherical aberration occurs because the reflected light rays do not gather at the focus, which makes the image appear blurry.
- Spherical aberration: A defect in a spherical-concave mirror that does not allow light rays to come into focus.

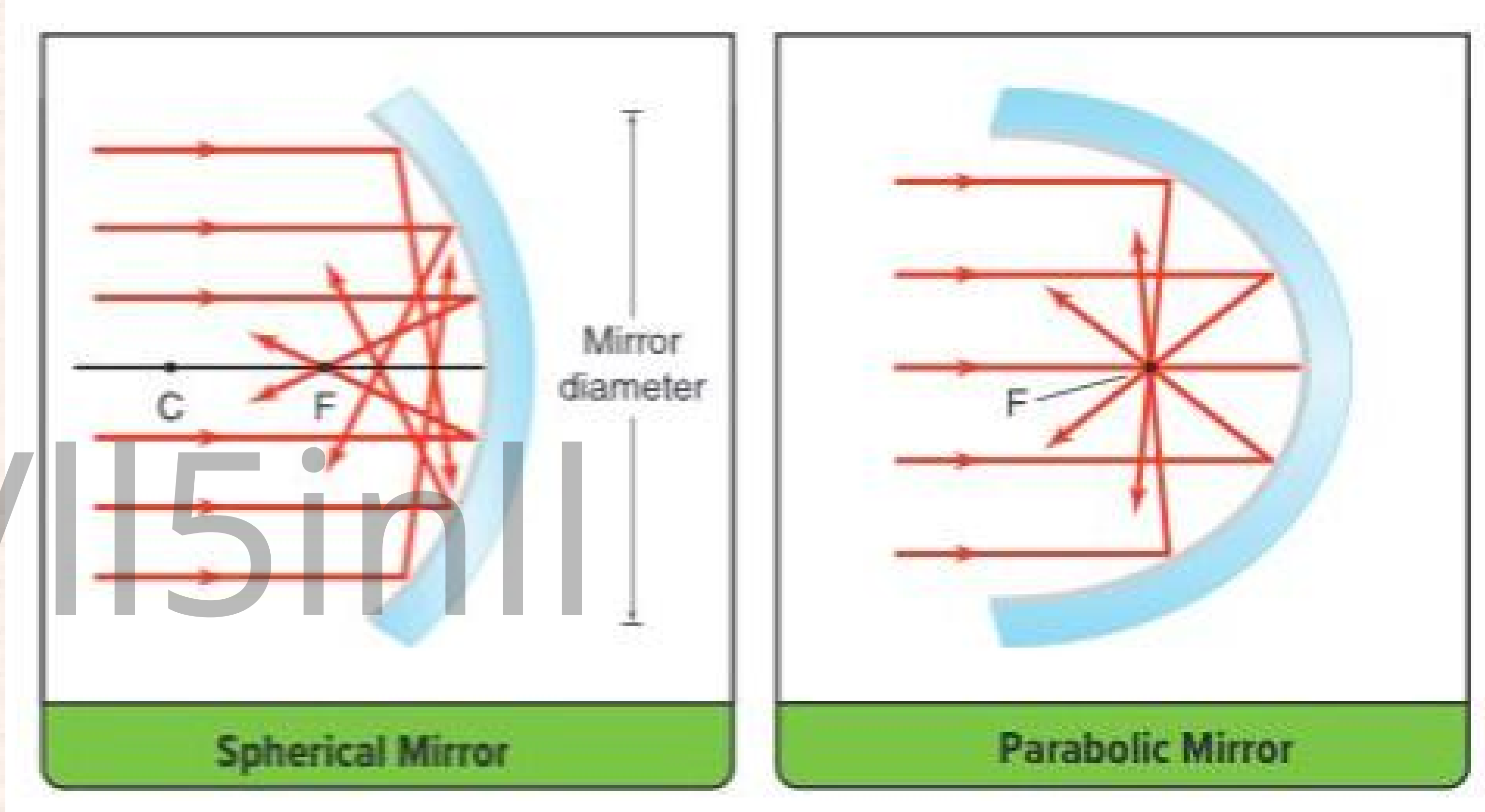


Figure 15 Spherical aberration occurs for spherical mirrors but does not occur for parabolic mirrors.

parabola

Figure 15:

- The parabolic mirror has no spherical aberration.
- We can reduce spherical aberration by reducing the ratio between the diameter of the mirror and the radius of curvature.

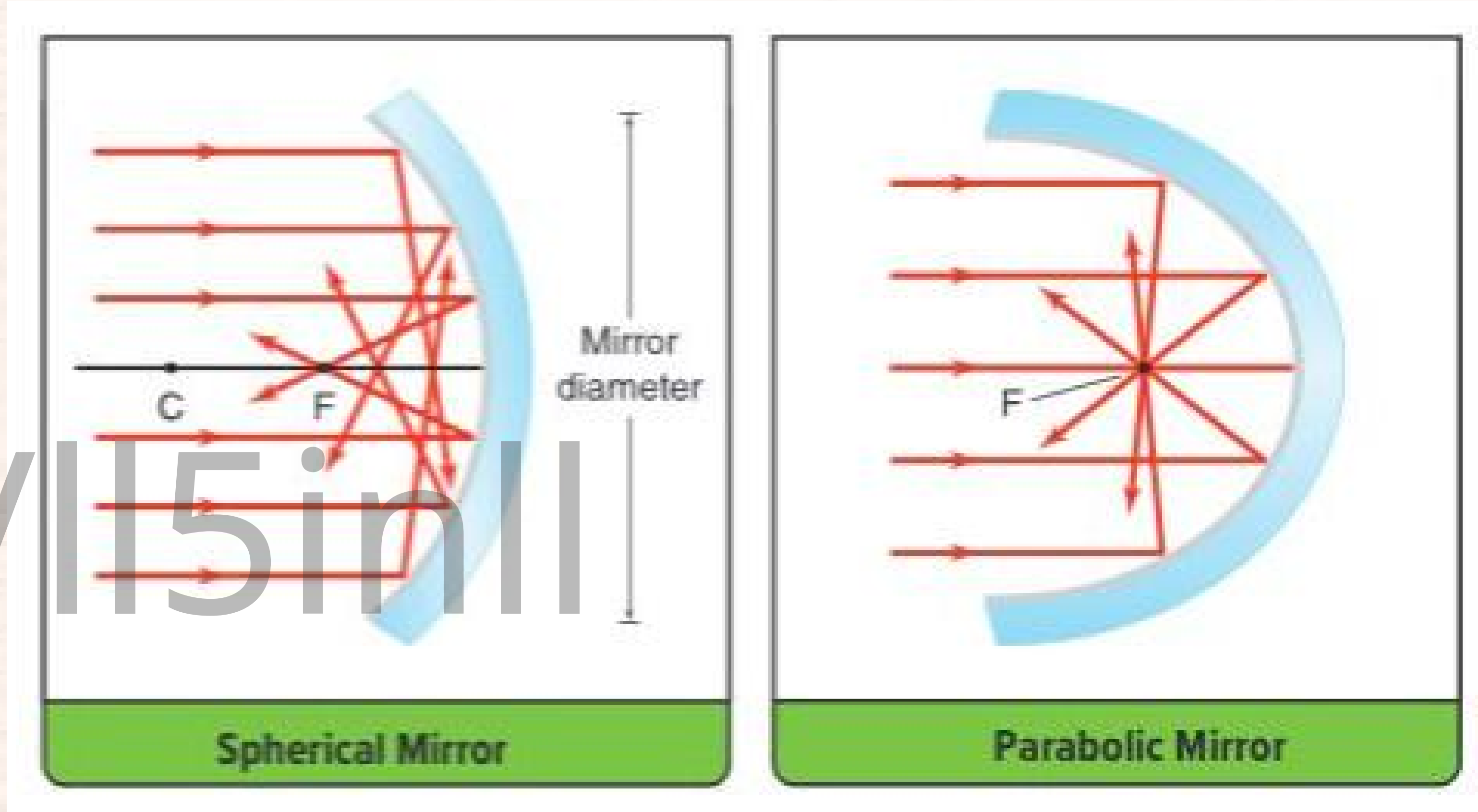


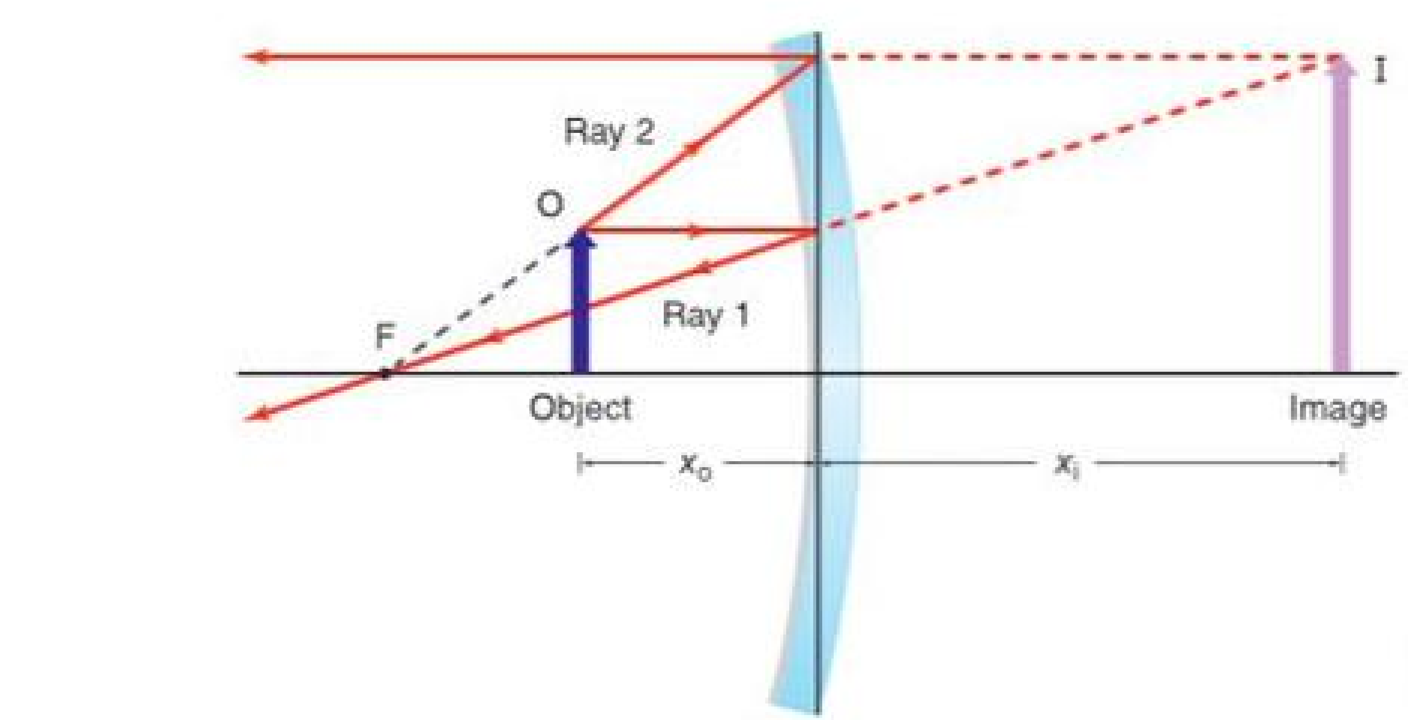
Figure 15 Spherical aberration occurs for spherical mirrors but does not occur for parabolic mirrors.

Imaginary images formed in concave mirrors

- When an object approaches the focus in a concave mirror, the image moves away from the mirror.
- If the body falls into the focus of the mirror, the rays are reflected in parallel, so they do not meet together at all, and the image that was formed is at infinity, and the image can never be seen.

Imaginary images formed in concave mirrors

- When the object is located between the mirror and the focus in the concave mirror, an imaginary image is formed for it, as shown in Figure 16.
- Ray 1: drawn parallel to the principal axis.. and reflected in the focus.
- Ray 2: It is drawn in the form of a line that extends from a point on the body to the mirror.. and is reflected parallel to the main axis.. and its extension passes through the focus.
- Rays 1 and 2 in Figure 16 diverge from the mirror and form an imaginary image, and their extension meets behind the mirror.



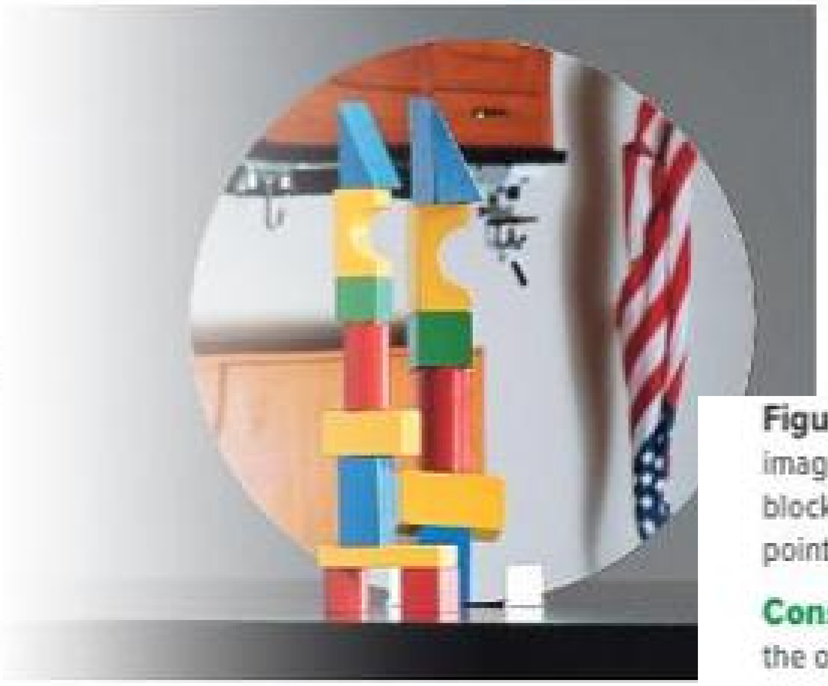


Figure 16 A virtual, upright, enlarged image is formed when an object, such as the block tower, is placed between the focal point and the surface of a concave mirror.

Consider the cause of the appearance of the other images in the mirror.

convex mirrors

- Convex mirror: It is a reflective surface that is curved outwards..and its edges bend away from the observer.
- Characteristics of a convex mirror: It is an imaginary image only (because the rays reflected from it are always dispersed). The focus and the center of curvature are located behind it.

Figure 17:

Ray 1: It reaches the mirror parallel to the main axis.. and is reflected from it, and its extension passes behind the mirror.

- Ray 2: It falls on the mirror and is reflected from it so that its extension passes in the focus behind the mirror, parallel to the principal axis.
- Rays 1 and 2 will disperse and their extensions will meet behind the mirror, and an imaginary, moderate, miniature image will be formed.
- A convex mirror allows the observer to see a large area around him, which is called the field of vision. The field of vision is wide.

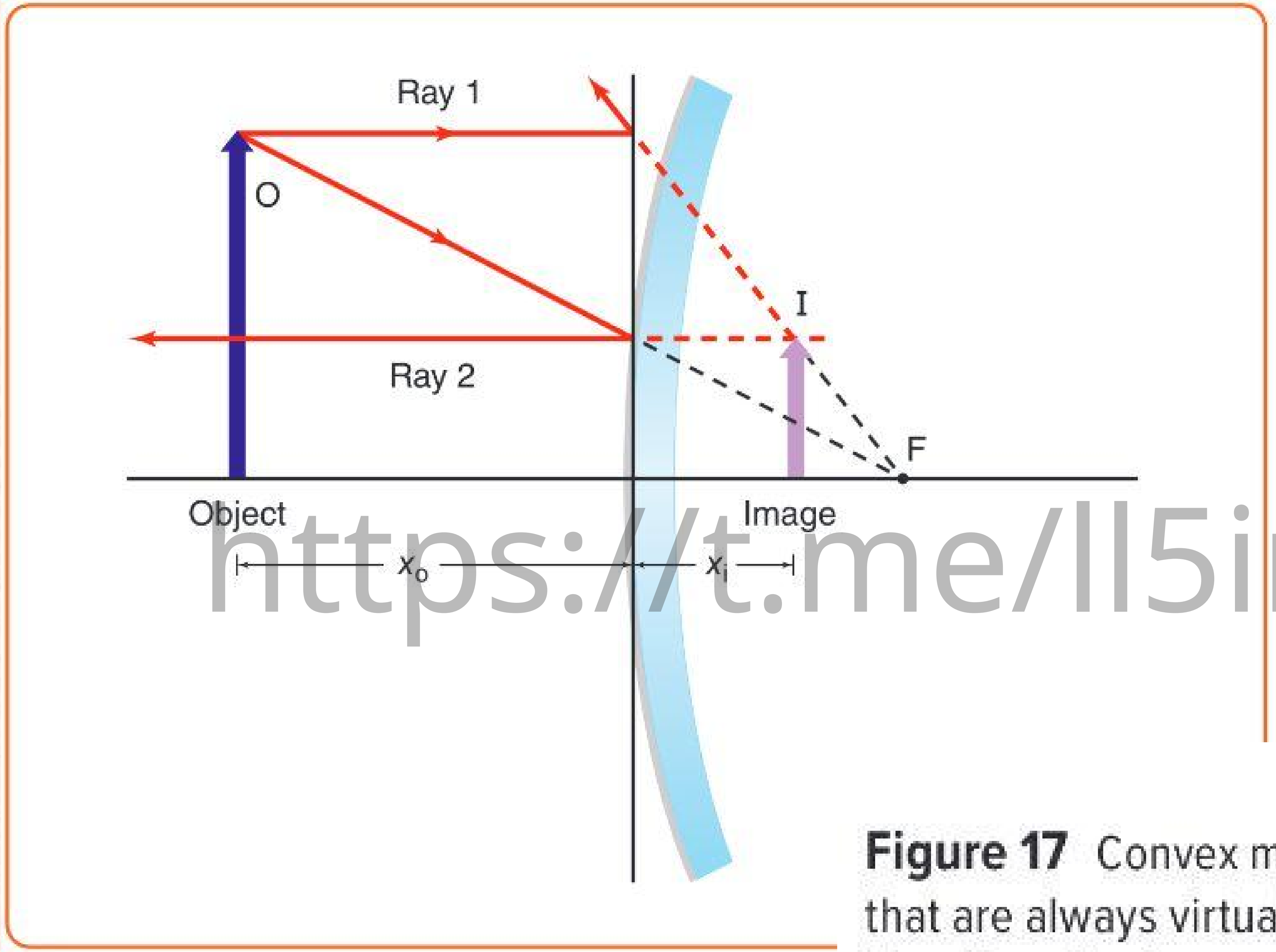


Figure 17 Convex mirrors produce images that are always virtual, upright, and smaller than the object.

uses of convex mirrors

- Convex mirrors are used in the side mirrors of cars to assist in rear vision, as shown in Figure 18. They reduce the size of the images and make them appear farther than they are.

Figure 18 Images from convex mirrors are smaller than the object. This increases the field of view and decreases the driver's blind spot.

spherical mirror equation

MIRROR EQUATION

The reciprocal of the focal length of a spherical mirror is equal to the sum of the reciprocals of the image position and the object position.

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

Focal Length

The distance of the body from the image

The distance of the body from the mirror

Determine the location of the image with accounts

negative values :

- When the image is imaginary, the value of the xi dimension is negative, meaning that it is formed behind the mirror.
- An imaginary image consists of intersecting stretches of reflected rays.
- In concave mirrors, the imaginary image is formed when the object is located between the focus and the mirror, and the focus is in front of the mirror and the focal length is positive.
- In convex mirrors, the focus is behind the mirror and the focal length is negative.
- The equation of spherical mirrors does not correct spherical aberration because it uses the approximation of rays parallel to the axis.

Magnification

Image diameter - length - height

The distance of the body from the image

MAGNIFICATION

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.

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

Body diameter - length - height

The distance of the body from the mirror

Magnification

- Magnification m: One of the properties of spherical mirrors is the ratio of the image length to the body length.
- If the images are imaginary, the value of xi is negative, meaning that the magnification m is positive, and they are moderate, which means that the length is positive.
- If the image is real, then the distance of the image is positive..and the magnification is negative .. and this indicates that the image is inverted..and the length is negative.
- When the body is behind the center of curvature C.. the absolute value of enlarging the real image is less than 1.. and this means that the image is smaller than the body.

- If the object falls between the center of curvature C and the focus F .. then the absolute value of the magnification is greater than 1 .. and this means that the image is larger than the body.

Example 2

1- Find the data

r, the radius of its curve: 20.0 cm.

ho , a body with a length of 2.0 cm

xo, after the body: 30.0 cm.

What is the image length?

After image:

2- Find the focal length

f = r/2

f = 20/2

f = 10

3- We use the equation of spherical mirrors to find the dimension of the image xi

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

$$\frac{1}{10} = \frac{1}{x} + \frac{1}{30}$$

== shift solve

xi = 15 cm

Image attributes:

Real image - inverted - miniature

4- We use the Magnification equation to find the image length hi

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

$$m \equiv \frac{x}{2} = -\frac{15}{30}$$

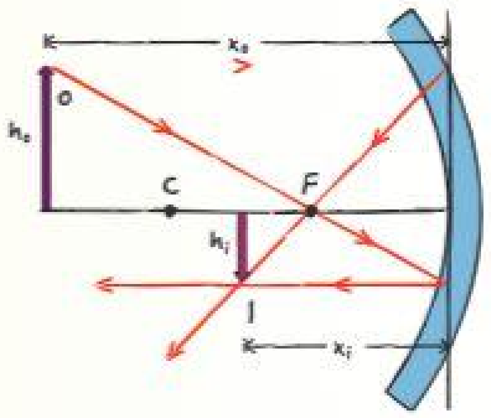
== shift solve

-hi = 1cm

REAL IMAGE FORMATION BY A CONCAVE MIRROR A concave mirror has a radius of curvature of 20.0 cm. You place a 2.0-cm-tall object 30.0 cm from the mirror. What are the image position and image height?

1 ANALYZE AND SKETCH THE PROBLEM

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



KNOWN	UNKNOWN
h_o = 2.0 cm	x_i = ?
x_o = 30.0 cm	h_i = ?
r = 20.0 cm	

2 SOLVE FOR THE UNKNOWN

Focal length is half the radius of curvature.

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

$$= \frac{20.0\text{ cm}}{2} \quad \text{Substitute } r = 20.0\text{ cm}$$

$$= 10.0\text{ cm}$$

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

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

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

$$= \frac{(10.0\text{ cm})(30.0\text{ cm})}{30.0\text{ cm} - 10.0\text{ cm}} \quad \text{Substitute } f = 10.0\text{ cm}, x_o = 30.0\text{ cm}$$

= 15.0 cm (real image, in front of the mirror)

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

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

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

$$= -\frac{(15.0\text{ cm})(2.0\text{ cm})}{30.0\text{ cm}} \quad \text{Substitute } x_i = 15.0\text{ cm}, h_o = 2.0\text{ cm}, x_o = 30.0\text{ cm}$$

= −1.0 cm (inverted, smaller image)

3 EVALUATE THE ANSWER

- **Are the units correct?** All positions and heights are in centimeters.
- **Do the signs make sense?** Positive position and negative height agree with the drawing.

Example applications 2

14. You place an object 36.0 cm in front of a concave mirror with a 16.0-cm focal length. Determine the image position.

15. You place a 3.0-cm-tall object 20.0 cm from a 16.0-cm-radius concave mirror. Determine the image position and image height.

-14

الحل	القانون	المطلوب	المعطيات
$\frac{1}{16} = \frac{1}{x} + \frac{1}{36}$ $x_i = 28.8$ cm	$\frac{1}{f} = \frac{1}{x_i} + \frac{1}{x_o}$	x_i	$x_o = 36$ $F = 16$

-15

الحل		القانون	المطلوب	المعطيات
$\frac{h_i}{h_o} = \frac{-x_i}{x_o}$ $\frac{x}{3} = \frac{-13.3}{20}$ $h_i = -1.995$	$\frac{1}{8} = \frac{1}{x} + \frac{1}{20}$ $x_i = 13.\bar{3}$ cm	$\frac{1}{f} = \frac{1}{x_i} + \frac{1}{x_o}$ $m = \frac{h_i}{h_o} = \frac{-x_i}{x_o}$	x_i h_i	$f = 8$ $h_o = 3$ $x_o = 20$

Example applications 2

16. A concave mirror has a 7.0-cm focal length. You place a 2.4-cm-tall object 16.0 cm from the mirror. Determine the image height.

16-

المعطيات	المطلوب	القانون	الحل
$f=7$	h_i	$m=\frac{h_i}{h_o}=\frac{-x_i}{x_o}$	$\frac{1}{7}=\frac{1}{x}+\frac{1}{16}$
$x_o=16$		$\frac{1}{f}=\frac{1}{x_i}+\frac{1}{x_o}$	$x_i=12.4$
$h_o=2.4$			$\frac{x}{2.4}=\frac{-12.4}{16}$
			-1.86

Example 3

1- Find the data

f, focal length: -0.50cm.

ho , forklift length : 2.0cm .

xo, at a distance of 5.0 cm.

xi , how far is its image from the mirror: ?

hi, how tall is it?

2- We use the equation of spherical mirrors to find the dimension of the image xi

$$\frac{1}{f}=\frac{1}{x_i}+\frac{1}{x_o} \qquad \frac{1}{-0.50}=\frac{1}{x}+\frac{1}{5}$$

== shift solve

xi = -0.45 cm

3- We use the zoom equation to find the image length, hi

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

$$m \equiv \frac{x}{5} = -\frac{2}{-0.45}$$

== shift solve

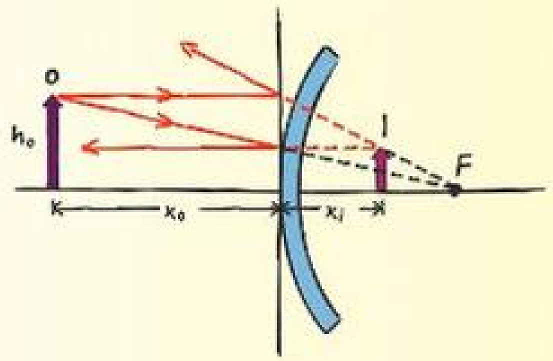
-hi = 0.18 cm

Image attributes : Fictional - moderate - miniature

IMAGE IN A SECURITY MIRROR A 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.

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

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

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

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

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

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

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

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

$= 0.18$ m (upright, smaller image)

3 EVALUATE THE ANSWER

- **Are the units correct?** All positions and heights are in meters.
- **Do the signs make sense?** A negative position indicates a virtual image; a positive height indicates an image that is upright. These agree with the diagram.

Compare mirrors

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

Mirror comparison - plane and convex

- Table 1 summarizes the characteristics of the images formed in a mirror of objects located on its principal axis. Imaginary images are formed behind the mirror and its dimension is always negative.

- When the absolute value of the magnification is between zero and one..the image of the object is reduced..and the negative value of the magnification means that the image is inverted with respect to the body.

- Plane mirrors and convex mirrors are just an imaginary image.

- A flat mirror gives equal images of things.

- Convex mirrors give miniature images, which makes the field of vision wide.

mirror comparison - concave

- A concave mirror is a real image of the object when it is located at a distance greater than the focal length.
- A concave mirror is an imaginary image of an object when it is located at a distance less than the focal length.
- A concave mirror gives enlarged images of an object when it is within the focal length range.
- A concave mirror is an enlarged and upright image of an object when it lies between the focal length and the radius of curvature.
- A concave mirror is an inverted microcosm when the object lies beyond the radius of curvature

THANK YOU

Any questions ? Don't hesitate to ask for our help

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