Inspire Physics – Grade 10 – General. Academic Year: 2022 - 2023 . . . Term 3
End of Term 3 Questions and Answers.

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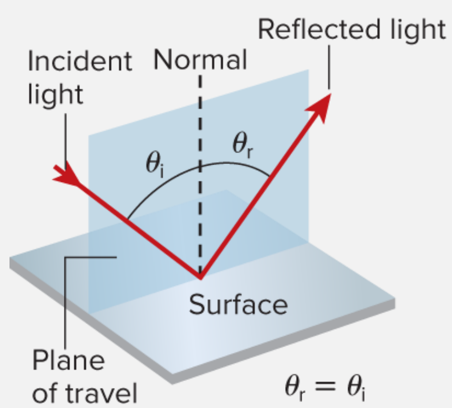
(LO): Learning Objective

PART ONE & TWO – Multiple Choice Questions

LO – 1: The law of Reflection. قانون الانعكاس

As mentioned in the textbook + Figure 2. Page 179.

<table>
<tr><td>LAW OF REFLECTION.</td><td>COPLANAR LAW</td><td>Figure 2: Reflecting light waves have an angle of reflection in the same plane as and equal to the angle of incidence.</td></tr>
<tr><td>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.

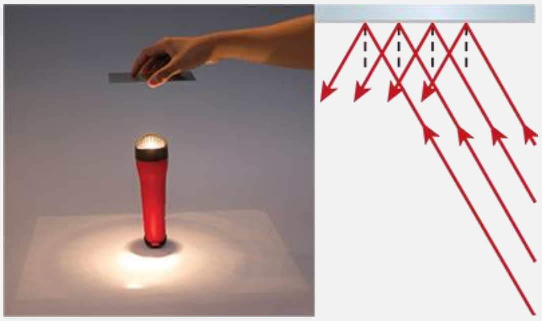
$$\theta_r = \theta_i$$</td><td>The incident ray, the reflected ray, and the normal to the surface ALWAYS will be in the same plane, which is perpendicular to the surface. Although the light travels in three dimensions, the reflection of the light is planar (two – dimensional).</td><td>
</td></tr>
</table>

LO – 2: The difference between specular and diffuse reflection.

الفرق بين الانعكاس المنتظم والانعكاس غير المنتظم.

As mentioned in the textbook + Figure 4. Page 179 +180.

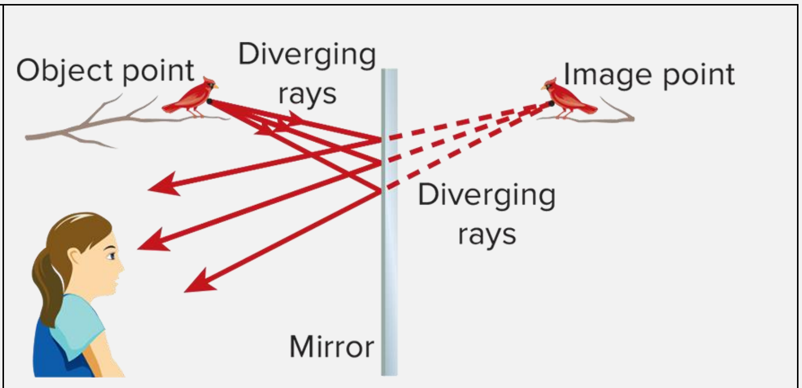
Figure 4: Notice that the image of the light – bulb is reflected on the table by the smooth surface. The surface of the paper only reflects a featureless area of light.

Smooth Surface: Specular Reflection	Rough Surface: Diffuse Reflection
	

Specular reflection happens when parallel light rays reflect in parallel.
Diffuse reflection happens when rays reflected from different parts of the surface go in uncorrelated directions

LO – 3: Images formed by plane mirrors. الصور المتكونة في المرايا المستوية
As mentioned in the textbook + Figure 6. Page 182 +183.

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.



Images formed by a plane mirror are
1. Virtual: Formed by diverging light rays.
2. Located at the same distance from the mirror as the object. $(x_i = - x_o)$, but on the opposite side.
3. Has the same size as the object. $(h_i = h_o)$
4. Upright.

LO – 4: Properties of Plane – Mirror Images. خصائص الصور المتكونة في المرايا المستوية
As mentioned in section 1 review Q 8. Page 184.

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

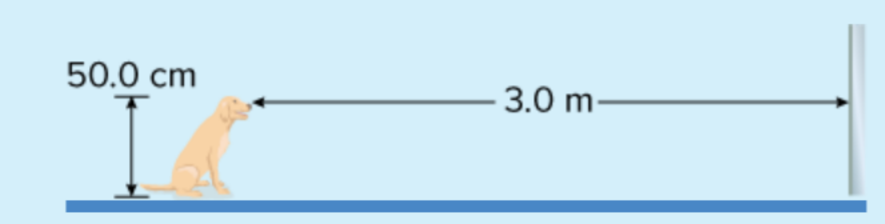


Figure 9

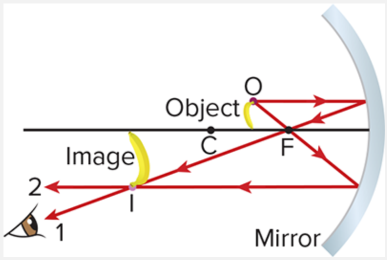
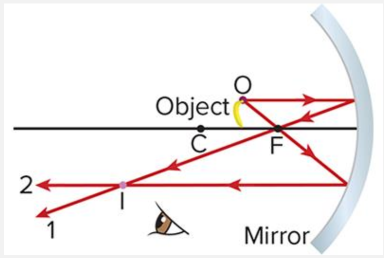
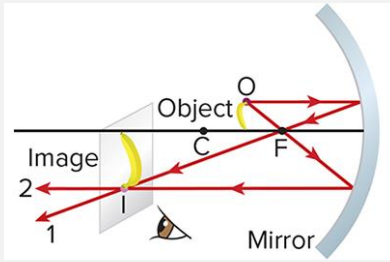
Solutions:

Position	Height	Type
$x_i = -3.0\ m$ 3.0 meters behind the mirror, on the opposite side of the object side.	$h_i = 50.0\ cm$ Same height as the object.	Virtual, as it forms by diverging of light rays.

LO – 5: Properties of Curved – Mirror to solve problems on focal length.

خصائص المرايا الكروية، وحساب البعد البؤري.

As mentioned in the textbook + Figure 12. Page 186.

Figure 12: Ray diagrams can be used to locate an image reflected from a curved mirror.		
		
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.

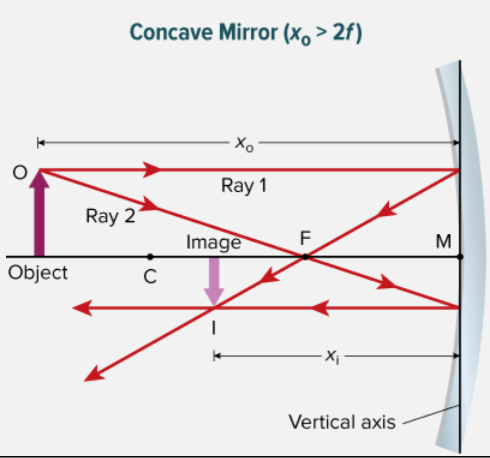
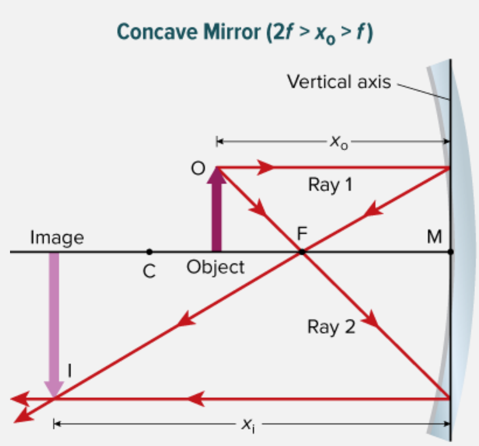
Q 14, Page 193: You place an object 36.0 cm in front of a concave mirror, an image is located a 28.8 cm in front of the mirror. Calculate the mirror focal length.

Solution:

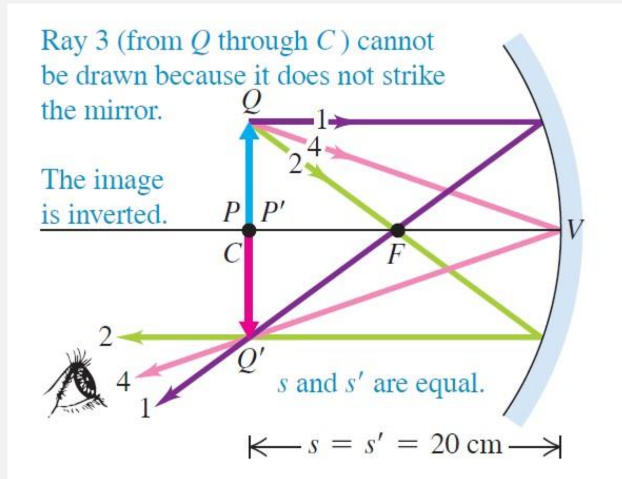
$$\frac{1}{f} = \frac{1}{x_i} + \frac{1}{x_o} \implies f = \frac{x_o x_i}{x_o + x_i} \implies f = \frac{(36.0)(28.8)}{36.0+28.8} = 16.0\ cm$$

LO – 6: Ray Diagrams for Concave Mirrors. الرسوم التخطيطية للمرايا المقعرة.

As mentioned in the textbook + Figure 13. Page 187.

Figure 13: The type of image that results depends on the object's distance from the mirror. A real, inverted image is formed in both of these situations. Remember that f, the focal length, is the distance from M to F.	
	
The image is reduced for an object located a distance greater than $2f$ from the mirror.	The image is enlarged for an object between f and $2f$.

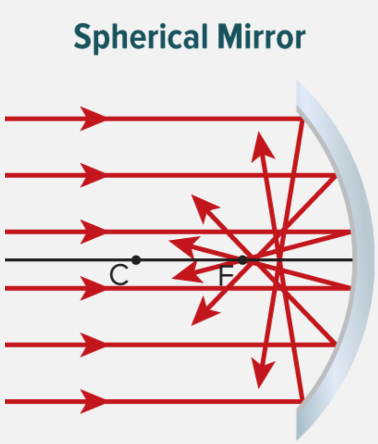
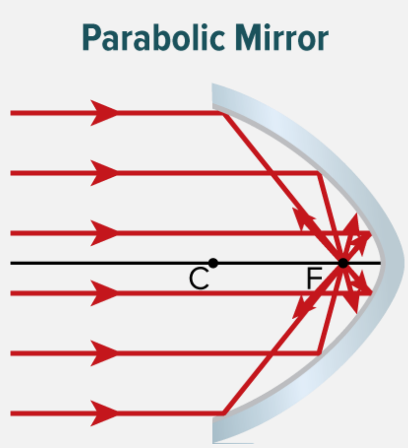
Question 2, P 189: Draw and label a ray diagram showing the location of the object if the image is located twice as far from a concave mirror as the focal point.

Mathematically:	Geometrically
$x_o = \frac{x_i\, f}{x_i - f}$ Given that: $x_i = 2\,f$ $So,\ x_o = \frac{(2f)\,f}{(2f) - f} = 2\,f$ $m = -\frac{x_i}{x_o} \Longrightarrow m = -\frac{2\,f}{2\,f}$ $m = -1$ *, the image is real and inverted.*	

Question 2, P 189: Determine where you should place the object in front of a concave mirror so that no image is formed.
Placing the object right at the focal length of a concave mirror will form no image.
Mathematically:

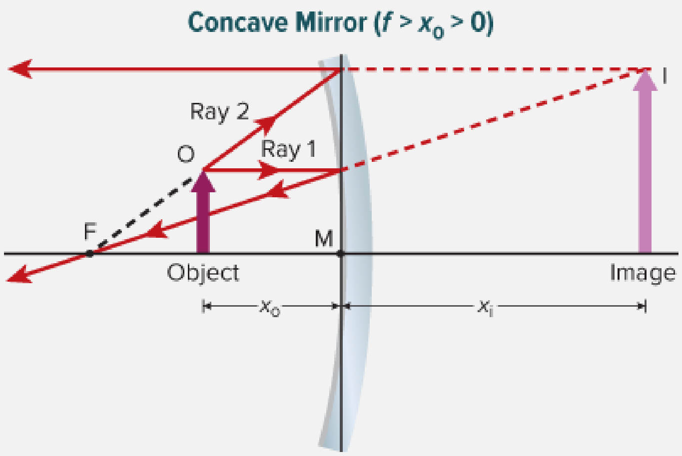
$$x_i = \frac{x_o\, f}{x_o - f} \quad \Longrightarrow \quad x_i = \frac{(f)\,f}{f - f} = \frac{f^2}{0} \quad \underline{\text{Undefined}}$$

LO – 7: Defects in concave mirror (spherical aberration)
As mentioned in the textbook. Page 188 + 189.
Spherical aberration occurs because the light rays do not converge at a focal point, which makes an image look fuzzy.

Figure 15: spherical aberration occurs for spherical mirrors but does not occur for parabolic mirrors.	
	
Spherical aberration can be reduced by reducing the ratio of the mirror's diameter to its radius of curvature.	

LO – 8: Virtual Images with Concave Mirrors. الصور الخيالية المتكونة في المرايا المقعرة.

As mentioned in the textbook. Page 190 + 191.

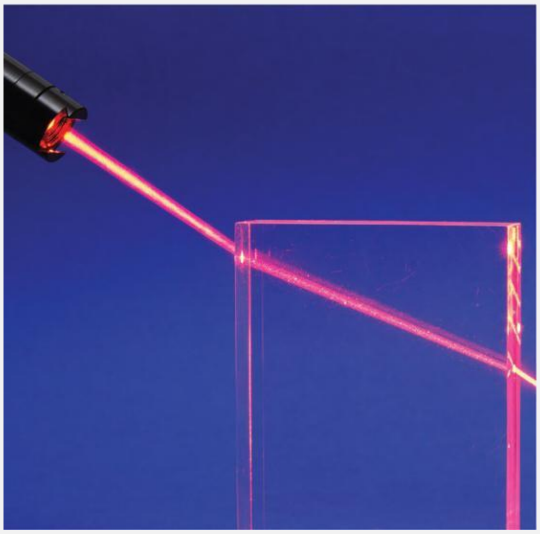
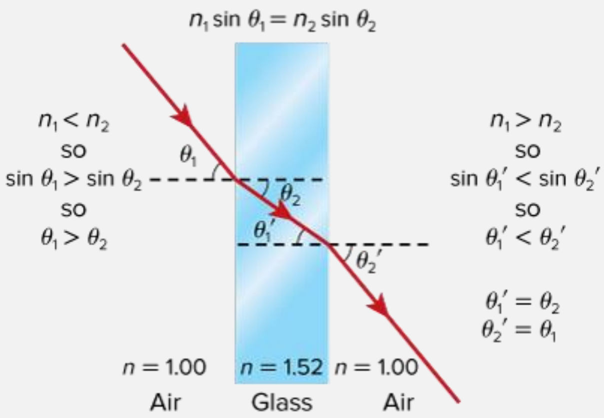
Figure 16: A virtual, upright, enlarged image is formed when an object is placed between the focal point and the surface of a concave mirror.	Mathematically
 	$x_i = \frac{x_o f}{x_o - f}$ Given that: $x_o < f \Longrightarrow x_o - f < 0$ *So,* $x_i = \frac{x_o f}{x_o - f} < 0$ $m = -\frac{x_i}{x_o} \Longrightarrow m > 0$ *the image is virtual, upright and enlarged.*

LO – 9: Light and Boundaries. الضوء والحدود الفاصلة بين الاوساط.

As mentioned in the textbook + Figure 2. Page 206 + 207.

When a light ray travels from a rarer medium to a denser medium, the speed of light reduces, and it bends towards the normal.

When a light ray travels from a denser medium to a rarer medium, it bends away from the normal.

Figure 2: When light travels from air through glass and back to air, it refracts toward and then away from the normal.	Snell's Law of refraction
	

LO – 10: Snell's Law of refraction. قانون سنل للانكسار.

As mentioned in the textbook. Page 207 + 208.

Question 1, P 208: A laser beam in air enters ethanol at an angle of incidence of 37.0°. What is the angle of refraction?

Solution: Apply Snell's Law $n_1 \sin\theta_1 = n_2 \sin\theta_2$

Rearranging: $\theta_2 = \sin^{-1}\left(\frac{n_1}{n_2}\sin\theta_1\right)$

$$\theta_2 = \sin^{-1}\left(\frac{1.0003}{1.36}\sin 37.0°\right) = 26.3\,°$$

Question 2, P 208: As light travel from air into water, the angle of refraction is 25.0 ° to the normal. Find the angle of incidence.

Solution: Apply Snell's Law $n_1 \sin\theta_1 = n_2 \sin\theta_2$

Rearranging: $\theta_1 = \sin^{-1}\left(\frac{n_2}{n_1}\sin\theta_2\right)$

$$\theta_1 = \sin^{-1}\left(\frac{1.33}{1.0003}\sin 25.0°\right) = 34.2\,°$$

Question 3, P 208: Light in air enters a diamond facet at 45.0°. What is the angle of refraction?

Solution: Apply Snell's Law $n_1 \sin\theta_1 = n_2 \sin\theta_2$

Rearranging: $\theta_2 = \sin^{-1}\left(\frac{n_1}{n_2}\sin\theta_1\right)$

$$\theta_2 = \sin^{-1}\left(\frac{1.0003}{2.42}\sin 45.0°\right) = 17.0\,°$$

LO – 11: The Meaning of the Index of Refraction. معنى معامل الانكسار.

As mentioned in the textbook. Page 209 + 210.

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

Consequently, $\left(\lambda = \frac{\lambda_o}{c}\right)$ where:

λ_o is the wavelength of the light in the vacuum

c is the speed of light in vacuum ($c = 3.00 \times 10^3\ m/s$)

λ is the wavelength of the light in a medium.

LO – 12: Solve problems on Total Internal Reflection. حل مسائل على الانعكاس الكلي الداخلي.

As mentioned in the textbook. Page 210 + 211.

Condition of total internal reflection: ($n_1 > n_2$).

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

Question 11, P 213: if you were to use quartz ($n = 1.54$) and float glass ($n = 1.52$) to make an optical fiber, which would you use for the cladding layer? Why?

Solution:

Quartz (n = 1.54)	Float glass (n = 1.52)
$\sin\theta_C = \frac{n_2}{n_1}$ $\sin\theta_C = \frac{1.0003}{1.54}$ $\theta_C = \sin^{-1}\left(\frac{1.0003}{1.54}\right)$ $\theta_C = 40.5°$	$\sin\theta_C = \frac{n_2}{n_1}$ $\sin\theta_C = \frac{1.0003}{1.52}$ $\theta_C = \sin^{-1}\left(\frac{1.0003}{1.52}\right)$ $\theta_C = 41.2°$

Float glass because it has a lower index of refraction and would produce total internal reflection at a greater critical angle.

Question 103, P 232: Find the critical angle for light travelling from ice (n = 1.31) to air. In a very cold world, would fiber optic cables made of ice or those made of glass do a better job of keeping light inside the cable? Explain.

Ice (n = 1.31)	Glass (n = 1.54)
$\sin\theta_C = \frac{n_2}{n_1}$ $\sin\theta_C = \frac{1.0003}{1.31}$ $\theta_C = \sin^{-1}\left(\frac{1.0003}{1.31}\right)$ $\theta_C = 49.8°$	$\sin\theta_C = \frac{n_2}{n_1}$ $\sin\theta_C = \frac{1.0003}{1.54}$ $\theta_C = \sin^{-1}\left(\frac{1.0003}{1.54}\right)$ $\theta_C = 40.5°$

The larger critical angle means that fewer rays would undergo total internal reflection in an ice core than in a glass core. Thus, they would not be able to transmit as much light. So, fiber optics cables made of glass would work better.

LO – 13: types of Lenses. أنواع العدسات.

As mentioned in the textbook. Page 215 – 217.

A lens that is thicker at the center that at the edges is called a convex lens.
A lens that is thinner in the middle that at the edges is called a concave lens.

Convex Lens	Concave Lens

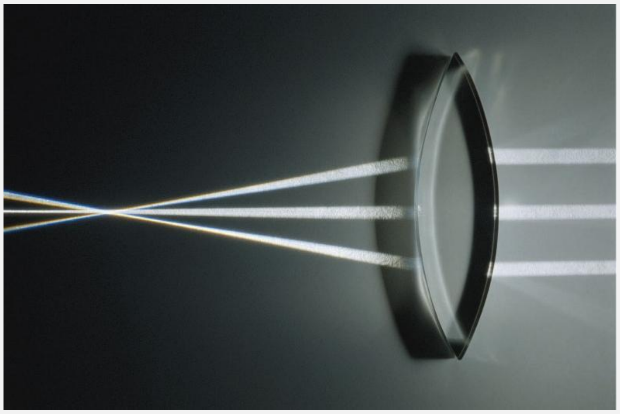
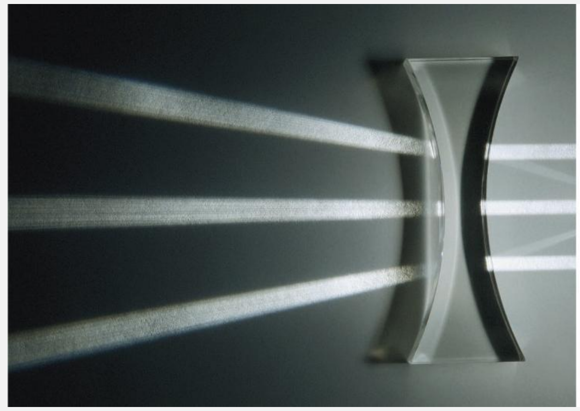

	

Figure 11: Convex lenses refract light so that the rays converge after passing through. The light passing through a concave lens does not meet at the focal point.	

LO – 14: Convex Lenses. العدسات المحدبة.

As mentioned in the textbook + Figures 12, 13 and 14. Pages 215 + 216.

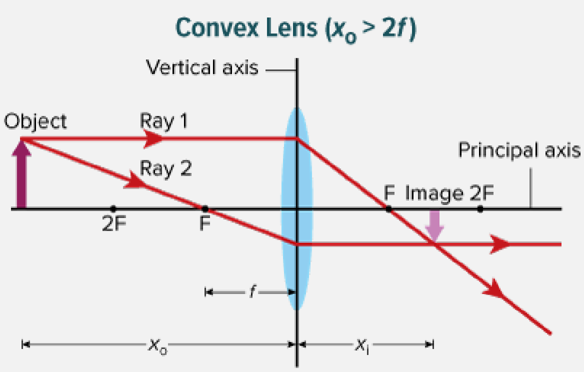
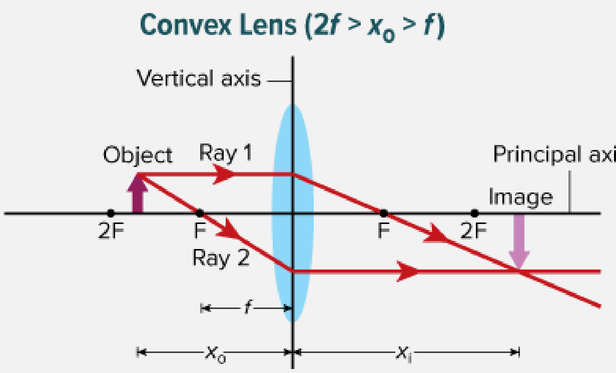
Figure 12: An object placed at a distance greater than twice the focal length from the lens will produce an image that is real, reduced in size, and inverted.	Mathematically (f *is* $+ve$) $x_o > 2f$
	$x_i = \frac{x_o f}{x_o - f}$ Given that: $x_o > 2f \Rightarrow \frac{x_o}{f} > 2$ *So,* $x_i = \frac{x_o f}{x_o - f} = \frac{x_o}{\left(\frac{x_o}{f}\right) - 1} > 0$ $m = -\frac{x_i}{x_o} = -\frac{1}{\left(\frac{x_o}{f}\right) - 1} \Rightarrow m < 0$ $\lvert m \rvert < 1$ *the image is real, inverted and reduced.*

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

Mathematically (f is + ve)

$$2f > x_o > f$$



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

$$2f > x_o > f \quad \Rightarrow \quad 2 > \frac{x_o}{f} > 1$$

$$So,\ x_i = \frac{x_o f}{x_o - f} = \frac{x_o}{\left(\frac{x_o}{f}\right) - 1} > 0$$

$$m = -\frac{x_i}{x_o} = -\frac{1}{\left(\frac{x_o}{f}\right) - 1} \Rightarrow m < 0$$

$|m| > 1$

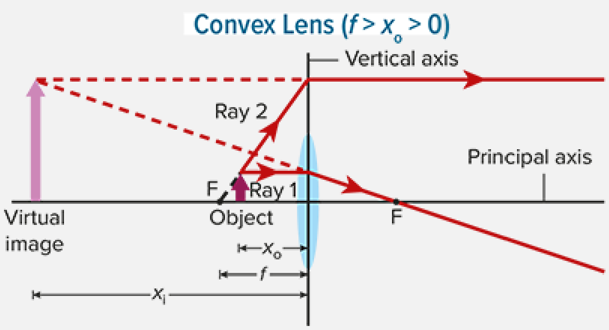
the image is real, inverted and enlarged.

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.

Mathematically (f is + ve)

$$f > x_o > 0$$



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

$$f > x_o > 0 \quad \Rightarrow \quad 1 > \frac{x_o}{f} > 0$$

$$So,\ x_i = \frac{x_o f}{x_o - f} = \frac{x_o}{\left(\frac{x_o}{f}\right) - 1} < 0$$

$$m = -\frac{x_i}{x_o} = -\frac{1}{\left(\frac{x_o}{f}\right) - 1} \Rightarrow m > 0$$

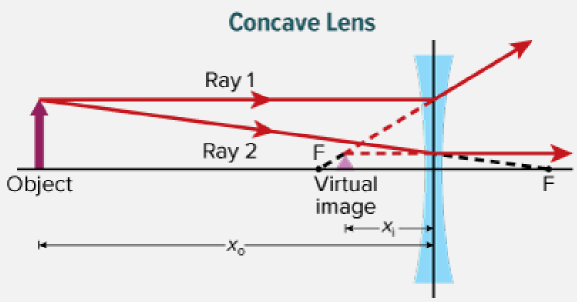
$|m| > 1$

the image is virtual, upright and enlarged.

LO – 15: Images in Convex & Concave Lenses. الصور في العدسات المحدبة والمقعرة.

As mentioned in the textbook + Figures 15. Pages 214 – 218.

<table>
<tr><td>Figure 15: An object placed any distance from a concave lens will always produce an image that is virtual and reduced.</td><td>Mathematically (f $is - ve$)

$f > x_o > 0$</td></tr>
<tr><td>
</td><td>$x_i = \frac{x_o f}{x_o - f}$

$f > x_o > 0 \quad \Rightarrow 1 > \frac{x_o}{f} > 0$

$So,\ x_i = \frac{x_o f}{x_o - f} = \frac{x_o}{\left(\frac{x_o}{f}\right) - 1} > 0$

$m = -\frac{x_i}{x_o} = -\frac{1}{\left(\frac{x_o}{f}\right) - 1} \Rightarrow m < 0$

$|m| > 1$
the image is virtual, upright and enlarged.</td></tr>
</table>

Question 15, P 219: A 2.25 – cm – tall object is 8.5 cm to the left of a convex lens of 5.5 – cm focal length. Find the image position and height.

Solution:

Given	Image position	Image height
$\begin{bmatrix} Given & Unknown \\ h_o = 2.25\ cm & x_i = ? \\ x_o = 8.5\ cm & h_i = ? \\ f = +5.5\ cm & \end{bmatrix}$	$x_i = \frac{x_o f}{x_o - f}$ $x_i = \frac{(8.5)(5.5)}{8.5 - 5.5} = 16\ cm$	$m = -\frac{x_i}{x_o} = \frac{h_i}{h_o}$ $-\frac{x_i}{x_o} = \frac{h_i}{h_o}$ $h_i = \left(-\frac{x_i}{x_o}\right) h_o$ $h_i = \left(-\frac{16}{8.5}\right) 2.25 = -4.1\ cm$

Question 16, P 219: An object near a convex lens produces a 1.8 – cm – tall real image that is 10.4 cm from the lens and inverted. If the focal length of the lens is 6.8 cm, what are the object position and height?

Solution:

Given	Image position	Image height
$\begin{bmatrix} Given & Unknown \\ h_i = 1.8\ cm & \\ x_i = 10.4\ cm & x_o = ? \\ f = +6.8\ cm & h_o = ? \end{bmatrix}$	$x_o = \frac{x_i\ f}{x_i - f}$ $x_o = \frac{(10.4)(6.8)}{10.4 - 6.8} = 20\ cm$	$m = -\frac{x_i}{x_o} = \frac{h_i}{h_o}$ $-\frac{x_i}{x_o} = \frac{h_i}{h_o}$ $h_o = \left\lvert \frac{h_i}{\left(-\frac{x_i}{x_o}\right)} \right\rvert$ $h_o = \frac{1.8}{\left(\frac{10.4}{20}\right)} = 3.4\ cm$

Question 17, P 219: An object is placed to the left of a convex lens with a 25-mm focal length so that its image is the same size as the object. What are the image and object positions?

Solution:

Given		
$\begin{bmatrix} Given & Unknown \\ h_i = h_o & x_i = ? \\ f = +25\ mm & x_o = ? \end{bmatrix}$	$m = -\frac{x_i}{x_o} = \frac{h_i}{h_o}$ $-\frac{x_i}{x_o} = \frac{h_i}{h_o}$ $-\frac{x_i}{x_o} = 1$ $\boldsymbol{x_o = -x_i}$ $\boldsymbol{\lvert x_o \rvert = \lvert -x_i \rvert}$ *The negative sign of the image position means that the image is inverted.*	$x_i = \frac{x_o\ f}{x_o - f}$ $x_i = \frac{(x_i)(25)}{x_i - 25}$ $x_i = \frac{(x_i)(25)}{x_i - 25}$ $x_i^2 - 25\ x_i = 25\ x_i$ $x_i = 50\ mm$ $x_o = 50\ mm$

LO – 16: Properties of Lenses. خصائص العدسات.

As mentioned in the textbook + Figures 11. Pages 214.

A lens that is thicker at the center than at the edges is called a convex lens.

A lens that is thinner in the middle than at the edges is called a concave lens.

Convex Lens	Concave Lens

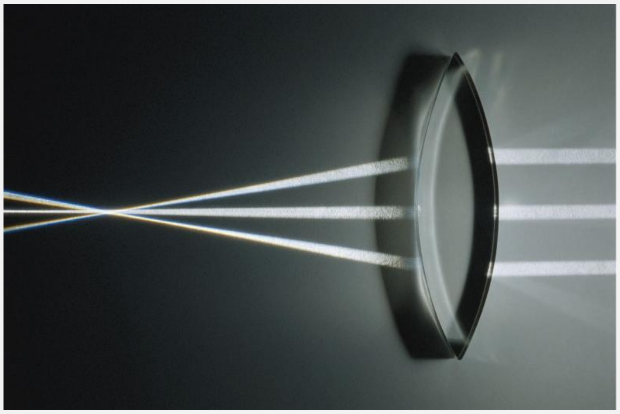
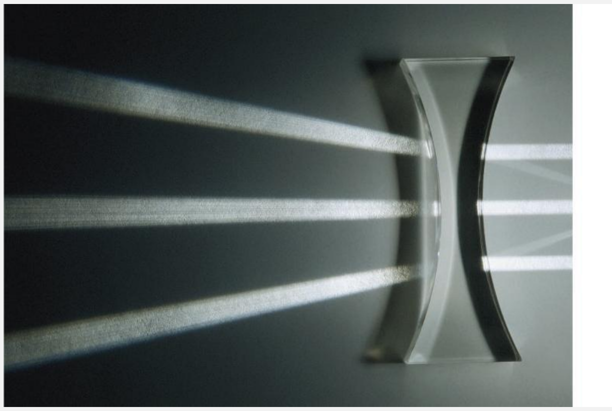

	

Figure 11: Convex lenses refract light so that the rays converge after passing through. The light passing through a concave lens does not meet at the focal point.	

WRITTEN PART

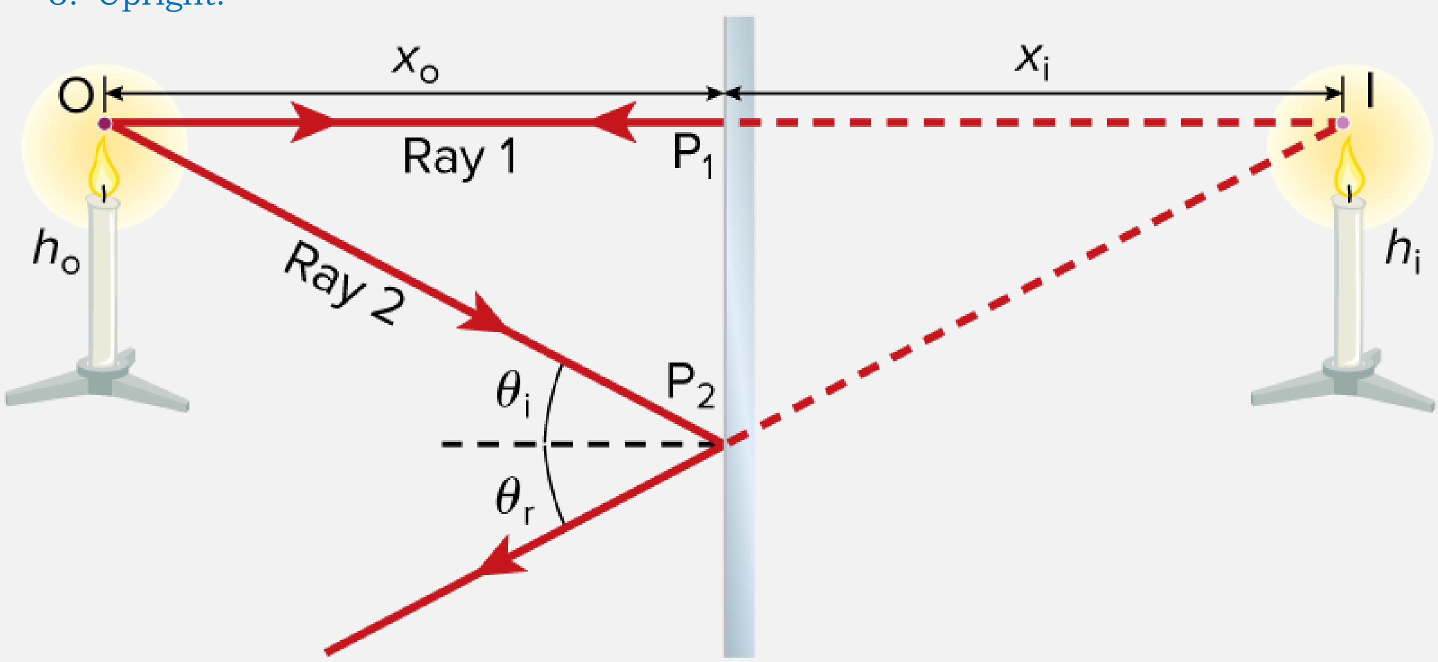
LO – 17: Plane Mirror Images. الصور في المرايا المستوية.

As mentioned in the textbook + Figures 7. Pages 183 & 184.

Figure 7: Reflected light rays from the candle (two rays are shown) strike the mirror. Some of those rays reach the viewer's eye. Sight lines (dashed lines) are dawn from where the rays reflect from the mirror to where they converge. The image is located where the sight lines converge.

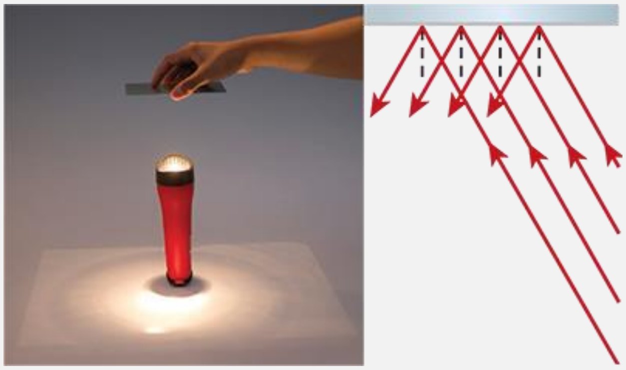
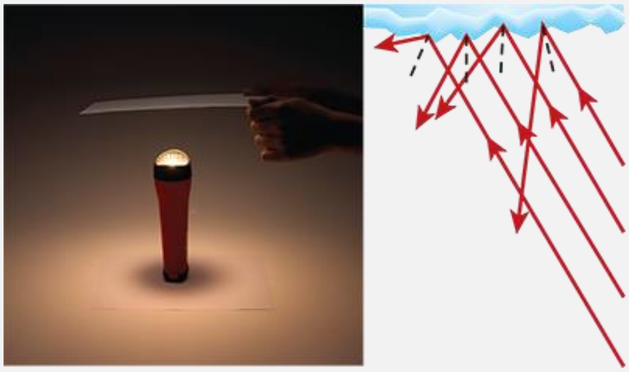
Image properties:

1. $x_i = -x_o$ the negative sign indicates that the image is behind the mirror (virtual).
2. $h_i = h_o \implies m = 1$
3. Upright.



LO – 18: Reflection types. أنواع الانعكاس: منتظم وغير منتظم.

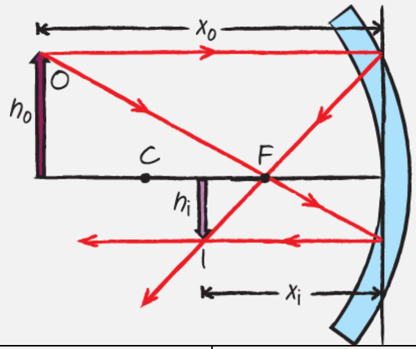
As mentioned in the textbook + Figures 4. Page 180.

Smooth Surface: Specular Reflection	Rough Surface: Diffuse Reflection
	

LO – 19: Calculating Image Position (Mirror Equation). حساب موقع الصور (معادلة المرايا).

As mentioned in the textbook + Example 2. Pages 191 - 193.

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?



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

$$f = \frac{20.0}{2} \implies f = 10.0 \text{ cm}$$

$$x_i = \frac{(x_o)(f)}{x_o - 25}$$

$$x_i = \frac{(30)(10)}{30 - 10}$$

$$x_i = 15.0\ cm$$

Real image, in front of the mirror

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

$$h_i = \left(-\frac{x_i}{x_o}\right) h_o$$

$$h_i = \left(-\frac{15}{30}\right)(2.0) = -1\ cm$$

Inverted, smaller image.

LO – 20: Index of Refraction and light velocity. معاملات انكسار الأوساط وسرعة الضوء.
As mentioned in the textbook + Table 1. Pages 207 – 210.

Question 9, Page 213: What is the speed of light in chloroform (n = 1.51)

Solution:

$$n = \frac{c}{v} \quad \Longrightarrow \quad v = \frac{c}{n} \quad \Longrightarrow \quad v = \frac{3.0 \times 10^8}{1.51} = 1.99 \ m/s$$

Part 3 – Question 21: Undisclosed.
Part 3 – Question 22: Undisclosed.

THE END