THE GARDEN ACADEMY

Your Guide to Success

هيـكل 12 ADV
حكومي (English)

EOT Term 1
2025/2026

المادة: الفيـزياء

المدرس: أحمد التـميـمي

تحــــــذير

إعلان هام من الأكاديمية

تنوه أكاديميتنا إلى ضرورة الحفاظ على حقوق الملكية الفكرية الخاصة بالمحتوى التعليمي الذي نقدمه في بطاقاتنا التعليمية من فيديوهات، أوراق عمل واختبارات وغيره .

في هذه الفترة الخاصة بمراجعات "الهياكل" لمادة الفصل الدراسي الأول، نود التأكيد على التالي:

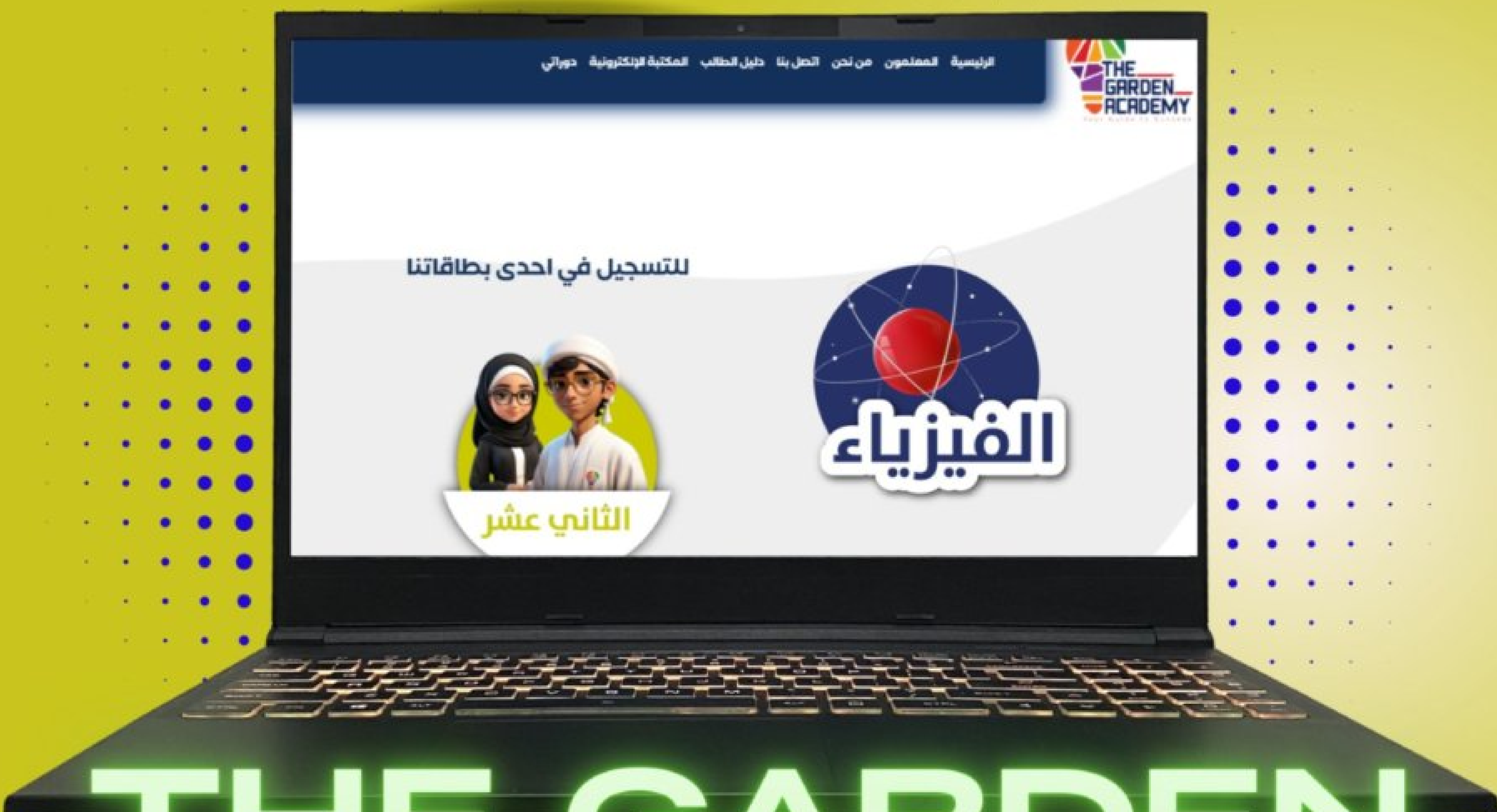
يمنع منعاً باتاً نشر أوراق الشرح المحلولة أو تصوير فيديوهات الشرح الخاصة بنا أو إعادة توزيعها بأي شكل من الأشكال إذ يُعتبر نشر أي من هذه المواد دون إذن مسبق مخالفة قانونية، ويعرض الفاعل للمساءلة والملاحقة القانونية، لكن يسمح فقط بنشر ملزمة الهيكل (غير المحلولة)

نشكركم على تفهمكم وتعاونكم في حماية حقوق الجميع ودعم الأكاديمية في توفير محتوى تعليمي آمن وموثوق.

THE GARDEN ACADEMY

Your Guide to Success

بطاقة الفيزياء
صف 12 متقدم
شرح أ. أحمد التميمي



THE GARDEN ACADEMY

جاهز للنجاح وإطلاق إبداعاتك

فيديوهات ملازم شرح أوراق عمل اختبارات

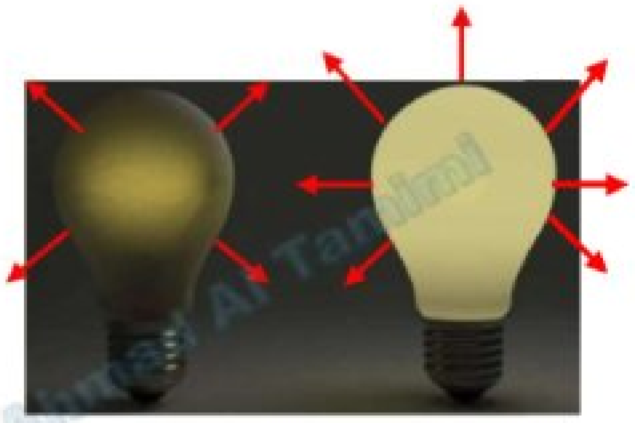
مراجعة تفصيلية شاملة للهيكل

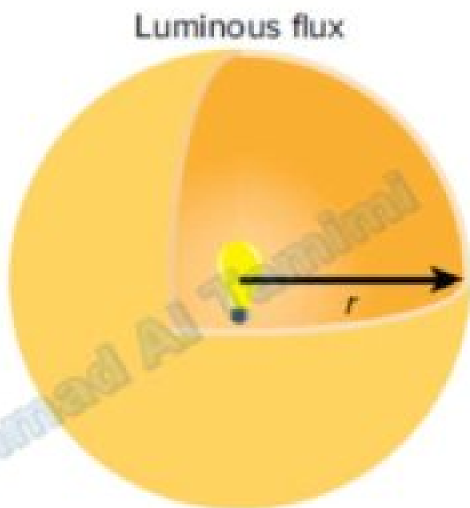
للاشتراك في البطاقة واتساب الدعم
الفني للأكاديمية 0569174493

الجزء الإلكتروني

1	**Define quantities of light like luminous flux and illuminance, specifying their SI units.**	**Student Textbook**	**5,6**

Quantity	Symbol	Definition	Unit
Luminous Flux	(P)	The rate at which light energy is emitted from a luminous source.	lumen (lm)
Illuminance	(E)	The luminous flux falling on a given surface area at any instant.	lux (lx) = lumen/m^2
Luminous Intensity	(I_v)	the luminous flux that falls on 1 m^2 of the inside of a 1-m radius sphere.	candela (cd)





$$\boxed{E = \frac{P}{4\pi r^2} = \frac{I_v}{r^2}}$$

$$\boxed{I_v = \frac{P}{4\pi}}$$

Question 1

What is luminous flux (P)?

A	The rate at which light energy is emitted from a luminous source	B	The total number of photons emitted per second
C	The brightness perceived by the human eye	D	The light intensity on a given area

Question 2

The unit of illuminance (E) is:

A	lumen (lm)	B	candela (cd)
C	lux (lx)	D	watt (W)

Question 3

The luminous flux that falls on 1 m^2 of the inside of a 1-m radius sphere is called:

A	Luminous flux	B	Luminous power
C	Luminous intensity	D	Illuminance

Question 4

Two light sources A and B are placed at the same distance from a wall. Source A appears brighter than source B. This means that:

A	The luminous flux (P) of A is smaller than B	B	The illuminance on the wall from A is greater than that from B
C	Both sources have equal illuminance	D	The luminous intensity (I_v) of A is less than B

Question 5

In the equation: $E = \frac{x}{4\pi r^2}$. What does x represent?

A	Luminous flux	B	Luminous intensity
C	Power	D	Luminous density

Question 6

In the equation: $E = \frac{I_v}{x^2}$. What does x represent?

A	Luminous flux	B	Luminous intensity
C	Area of the surface	D	Distance from the light source to the surface

Question 7

The given equation is used to calculate the luminous flux: $P = x \cdot 4\pi$. What does x represent?

A	Luminous flux	B	Luminous power
C	Luminous intensity	D	Illuminance

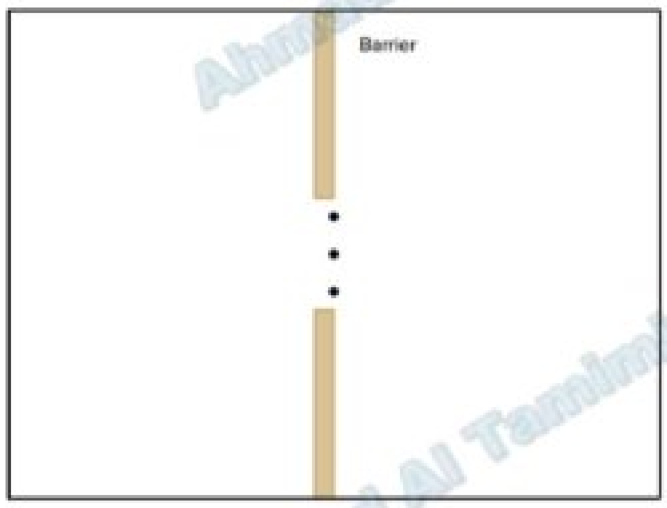
Question 8

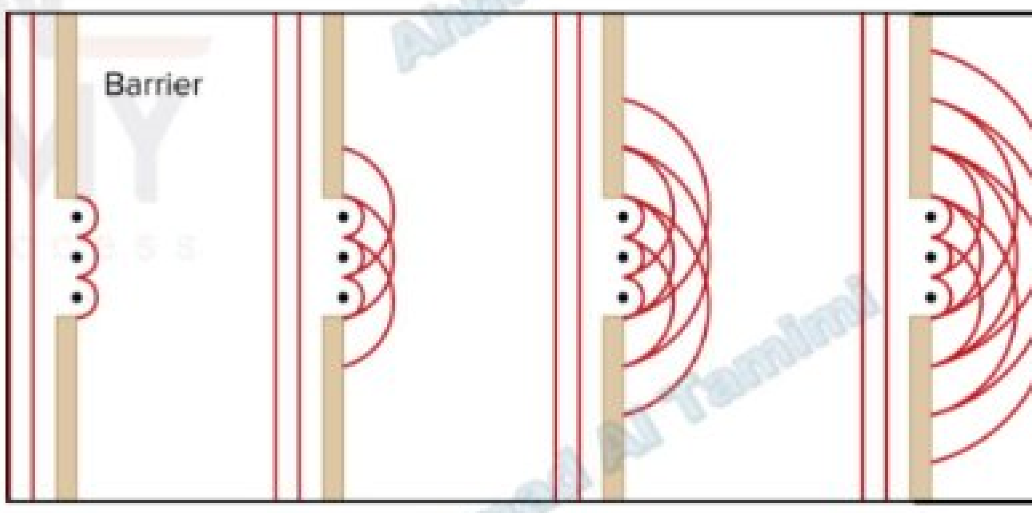
In the equation: $E = \frac{P}{x}$. What does x represent?

A	Surface area of a sphere	B	Distance between the source and the object
C	Luminous intensity	D	Luminous flux

2	**Define diffraction as the bending of a wave as it passes the edge of a barrier.**	**Student Textbook**	**12**

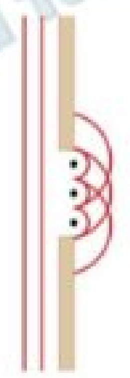
- Diffraction is the **bending or spreading of a wave** as it passes the **edge of a barrier** or through a **narrow opening**.
- In **1678**, Christiaan Huygens explained diffraction using the **wave model of light**.
- He proposed that **every point on a wavefront (جبهة الموجة) acts as a new source of tiny secondary waves (wavelets مويجات)**.
- These wavelets **spread in all directions** and remain **in step (coherent متسقة)** with each other.
- A **plane wavefront** can thus be seen as an <u>infinite line of point sources</u>.
- When the wavefront meets a **barrier (عائق) or an edge (حافة)**, the wavelets near the edge spread out in circular arcs, creating <u>**diffraction**</u>.





Question 9

What is the name of the wave phenomenon represented by the adjacent figure, which shows the propagation of waves before and after passing the barrier? Also, which principle explains this phenomenon?



A	Refraction of light / Huygens' principle	B	Diffraction of light / Huygens' principle
C	Reflection of light / Newton's principle	D	Polarization of light / Newton's principle

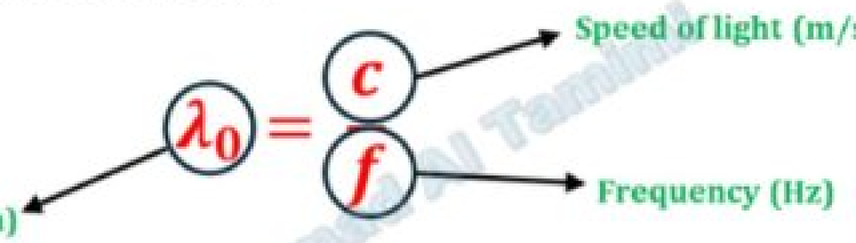
Question 10

Which of the following best describes the diffraction of light?

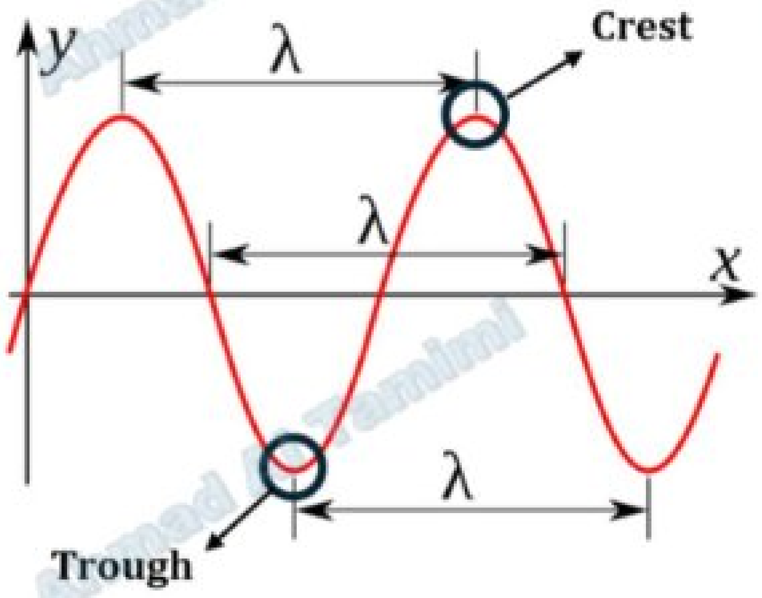
A	The change in direction of light waves when they travel from one medium to another.	B	The bouncing back of light waves when they strike a smooth surface.
C	The interference of light waves from two or more coherent sources, producing bright and dark fringes.	D	The bending and spreading of light waves when they pass through a narrow slit or around the edge of an obstacle.

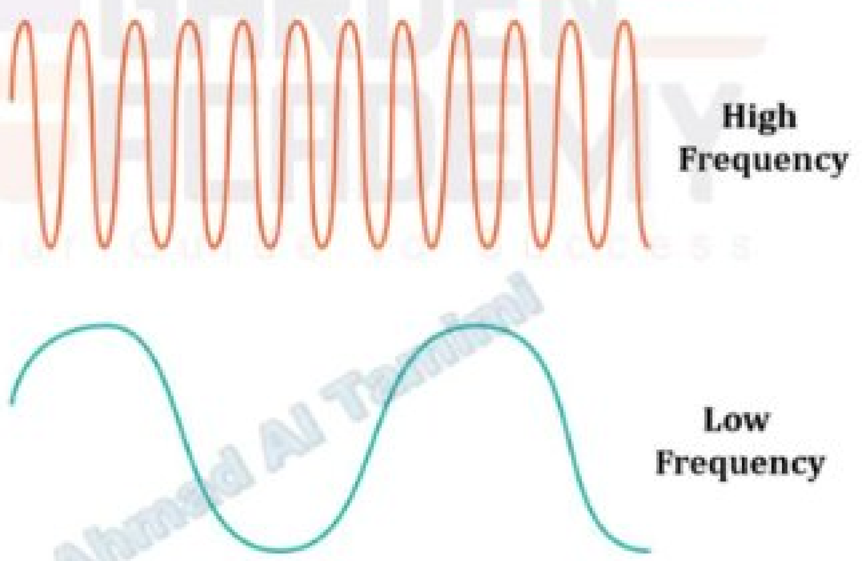
3	-Describe that the colour of light is related to its wavelength and frequency. -Describe primary and secondary pigments and the effects of mixing pigments or dyes.	Student Textbook	13-15

- **Wavelength الطول الموجي (λ)**: the shortest distance between points of a wave where the wave pattern repeats itself.
- **Frequency التردد (*f*)**: the number of complete cycles of waves passing a point in unit time
- **Wavelength and frequency have an inverse relationship (علاقة عكسية):**



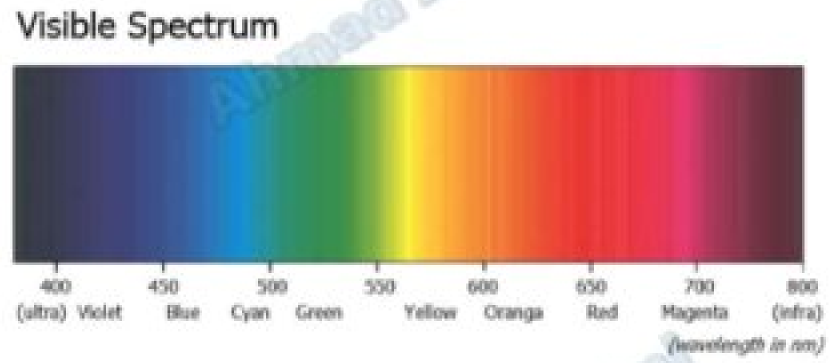
$$\lambda_0 = \frac{c}{f}$$





Color and Wavelength

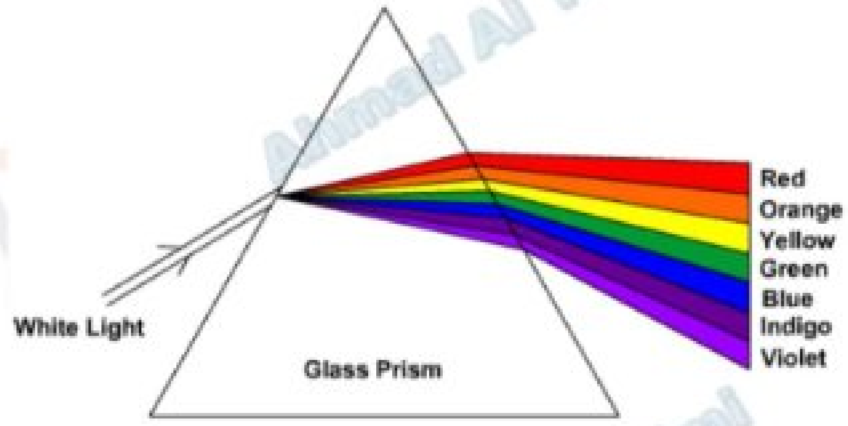
- **Visible light (الضوء المرئي) wavelength range from 400 nm (4.00×10^{-7} m) to 700 nm (7.00×10^{-7} m).**



  - **Red light** → longest wavelength and lowest frequency.
  - **Violet light** → shortest wavelength and highest frequency.

- **When white light passes from air → glass → back to air:**

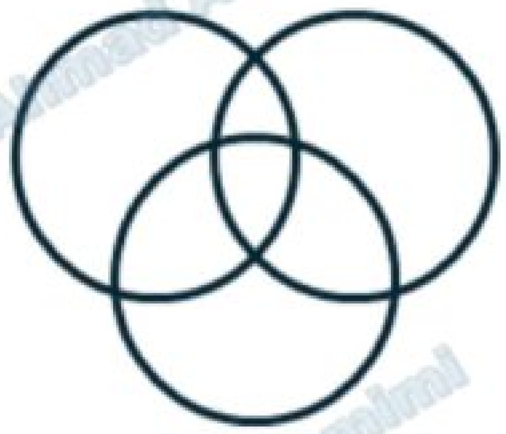
  - Each wavelength bends differently due to the **wave nature of light**.
  - **Shorter wavelength = bends more.**
  - **Longer wavelength = bends less.**



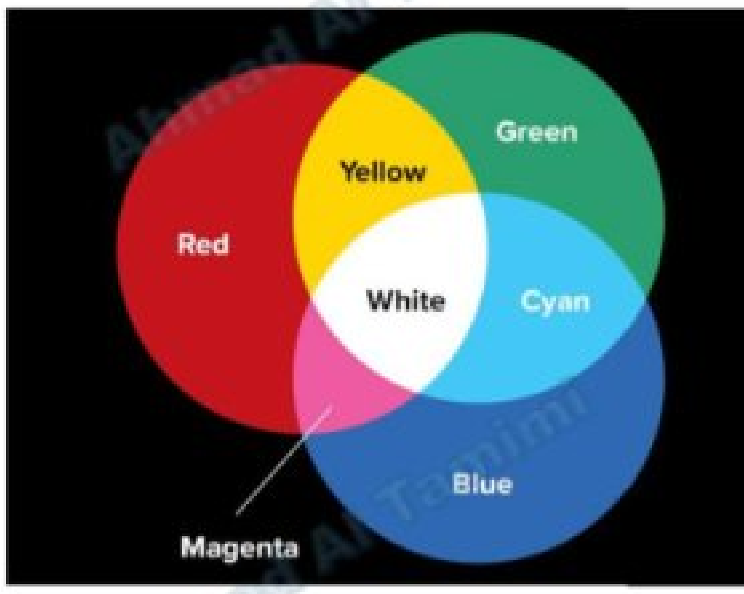
- This **unequal bending** spreads white light into a **spectrum (dispersion of light)**.

Color by Addition of Light

- When **red, green, and blue** lights are projected with correct intensities, **white** light is formed.
- ***Used in television and computer screens.***
- Screens use three colors: **red**, **green**, **blue** (**RGB**).



Primary Colors of Light	Secondary Colors of Light	Complementary Colors of Light
The primary colors of light are: **red, green, blue**. When combined in correct intensities, they form **white light**. By mixing them in pairs, three **secondary colors** are formed: • Red + Green = **Yellow** • Blue + Green = **Cyan** • Red + Blue = **Magenta**	A **secondary color** is formed by combining two primary colors. The secondary colors are: **Yellow, Cyan, Magenta**. These are different from the primary/secondary colors in art (paint/dyes).	**Complementary colors**: two colors of light that combine to make **white light**. Examples: • Yellow + Blue = White • Cyan + Red = White • Magenta + Green = White Practical example: bluish detergents make yellowish clothes appear whiter.



Color by Subtraction of Light

- Objects can **reflect (يعكس), transmit (ينفذ), or absorb (يمتص)** light.
- The color of an object depends on:
  1. Wavelengths present in the light source.
  2. Wavelengths absorbed or reflected by the object.
- It's called color by subtraction because pigments/dyes **absorb** (subtract) parts of white light, and the reflected remainder is the color you see.

A red object reflects red absorbs other colors of white light

A white object reflects all colors of white light equally

An object is seen as black if it absorbs all colors of white light

- **Dyes are used to color cloth and other materials.**
- Sources of dyes:
  - **Plants** (e.g., mulberry tree → purple dye, saffron → yellow dye).
  - **Insects** (e.g., cochineal insect → red dye).
- A dye is a molecule that **absorbs some wavelengths** and **reflects or transmits others**.

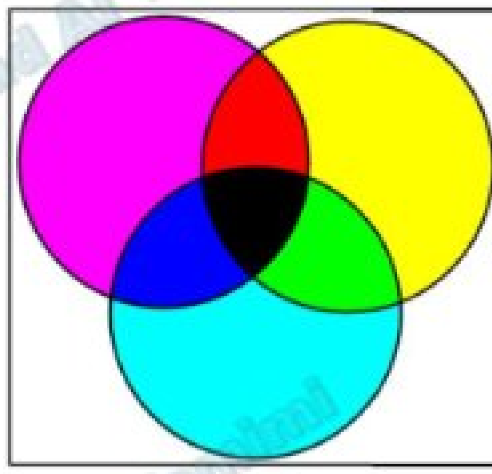
- **Pigments** are usually made of **crushed minerals** (not plants/insects).

Examples:

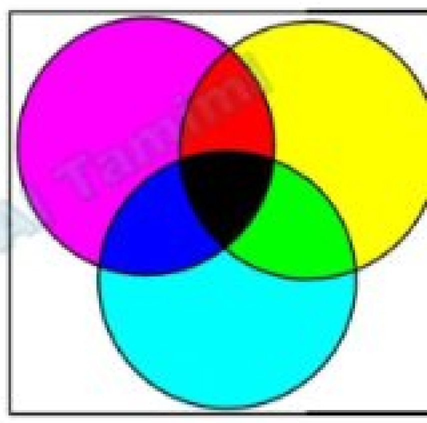
- Hematite → red pigment.
- Azurite → blue pigment.
- Pigment particles can be seen under a microscope.

Color by Subtraction of Light

Primary Pigments/Dyes الملوّنات ولأصباغ الأساسية	Secondary Pigments/Dyes الملوّنات والأصباغ الثانوية	Complementary Pigments/Dyes الملوّنات والأصباغ المتممة
Absorbs **one primary color of light** and reflects the other two. **Primary pigments**: Yellow, Cyan, Magenta. Examples: • Yellow pigment absorbs blue, reflects red + green. • Cyan pigment absorbs red, reflects blue + green. • Magenta pigment absorbs green, reflects red + blue.	A pigment that absorbs **two primary colors** and reflects only **one**. **Secondary pigments**: Red, Green, Blue. Examples: • Red pigment absorbs blue + green, reflects red. • Green pigment absorbs red + blue, reflects green. • Blue pigment absorbs red + green, reflects blue.	**When pigments are mixed, they absorb more wavelengths.** Examples: • Yellow + Cyan → Green (yellow absorbs blue, cyan absorbs red). • Yellow + Blue → Black (all primary colors absorbed). **Complementary pigment pairs**: • Yellow & Blue • Cyan & Red • Magenta & Green



Pigment /Dye Color	Absorbs	Reflects	Under White Light	Under Red Light	Under Green Light	Under Blue Light	Under Magenta Light	Under Yellow Light	Under Cyan Light
Red (R)	G + B	R	R	R	BLK	BLK	R	R	BLK
Green (G)	R + B	G	G	BLK	G	BLK	BLK	G	G
Blue (B)	R + G	B	B	BLK	BLK	B	B	BLK	B
Magenta (M)	G	R + B	M	R	BLK	B	M	R	B
Yellow (Y)	B	R + G	Y	R	G	BLK	R	Y	G
Cyan (C)	R	G + B	C	BLK	G	B	B	G	C
White (W)	Nothing	R + G + B	W	R	G	B	M	Y	C
Black (BLK)	R + G + B	Nothing	BLK	BLK	BLK	BLK	BLK	BLK	BLK



Question 11

Why white light splits in a prism?

A	Because all wavelengths bend equally in the prism	B	Because different wavelengths bend differently
C	Because most of the light will be reflected by the prism	D	Because most of the light will be absorbed by the prism

Question 13

A white T-shirt has yellowed slightly with age. A laundry additive gives the fabric a faint bluish tint, so it looks whiter under normal lighting. Why does the shirt appear whiter?

A	Polarization removes yellow	B	Blue and yellow are complementary and combine to appear white
C	Diffraction spreads blue more than yellow	D	Cotton absorbs only yellow

Question 12

When the red and green sub-pixels in a phone screen are lit at equal brightness and the blue is off, the pixel appears a single color. What color does the pixel show?

A	Cyan	B	White
C	Yellow	D	Magenta

Question 14

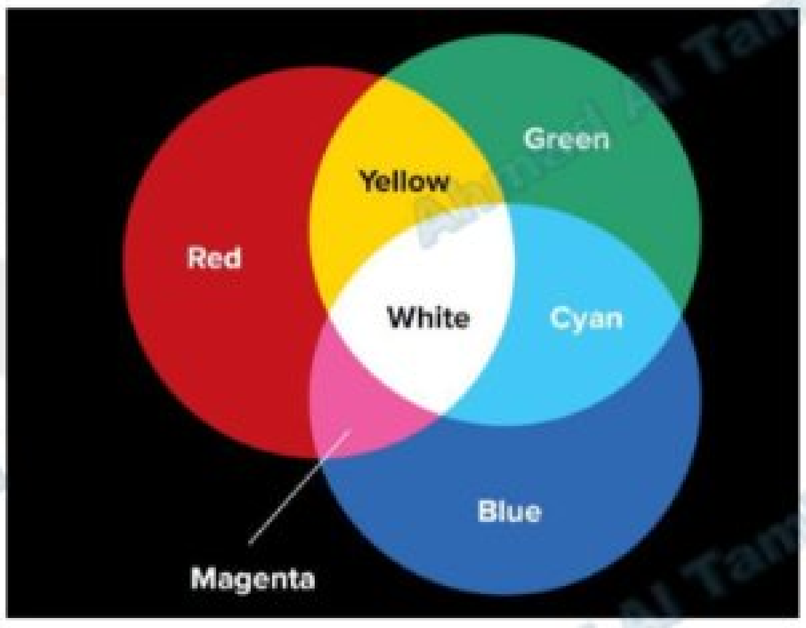
A lighting designer wants to stock only secondary colors of light—each one formed by mixing two primaries. Which set should she buy?

A	Red, Green, Blue	B	Orange, Green, Violet
C	Red, Yellow, Blue	D	Yellow, Cyan, Magenta

Question 15			
Which color of light must be combined with blue light to produce white light?			
A	Red	B	Green
C	Yellow	D	Magenta

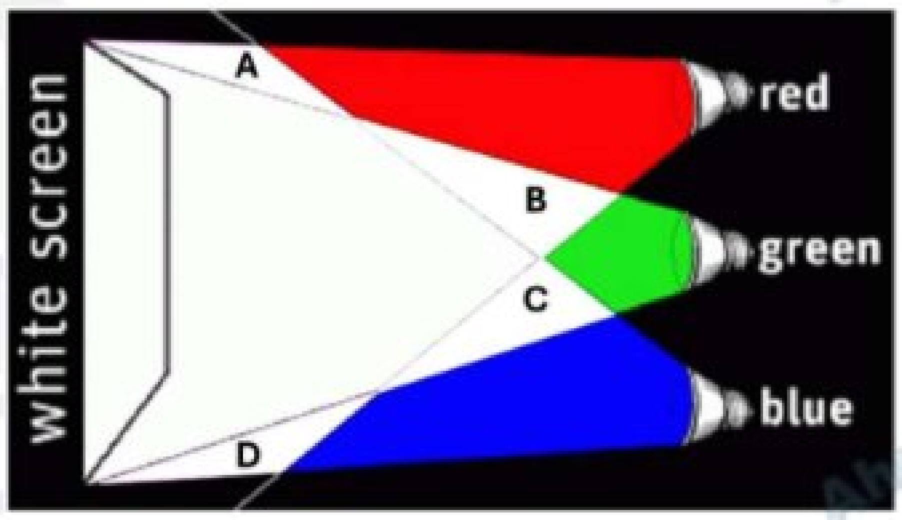
Question 16			
Which of the following pairs of colors of light will combine to form white light?			
A	Red and blue	B	Green and cyan
C	Blue and magenta	D	Red and cyan

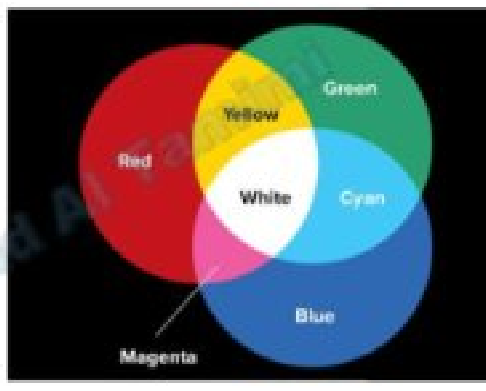
Question 17			
Which color bends most in a glass prism?			
A	Red	B	Yellow
C	Green	D	Violet



Question 18

The diagram represents overlapping areas of light with different intensities of illumination. Which of the following shows the resulting colors in the regions (A, B, C, D)?

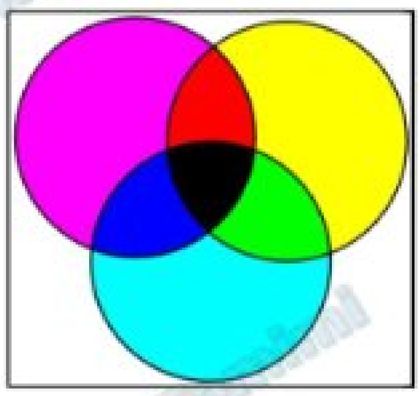




	Region A	Region B	Region C	Region D
A	Cyan	Yellow	Cyan	Magenta
B	Yellow	Cyan	Magenta	Yellow
C	Magenta	Yellow	Cyan	Magenta

Get It?

Distinguish the difference between color by subtraction and color by addition.



Check Your Progress — Page 21

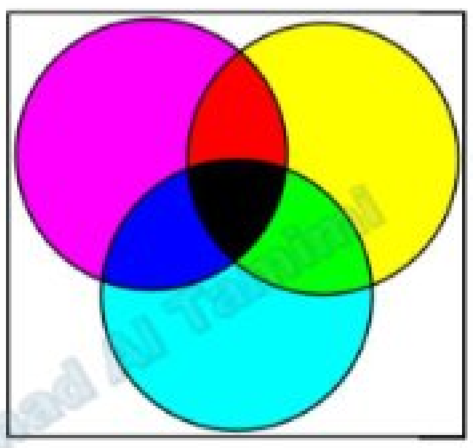
22. **Light and Pigment Interaction** What color will a yellow banana appear to be when illuminated by each of the following?
    a. white light
    b. green and red light
    c. blue light

23. **Pigment Colors** What are the secondary pigment colors, and why do they give objects the appearance of those colors?

Check Your Progress — Page 21

24. **Combination of Pigments** What primary pigment colors must be mixed to produce red? Explain your answer in terms of color subtraction for pigment colors.

Question 19
Explain why a yellow dice in white light appears red when placed under red light. 

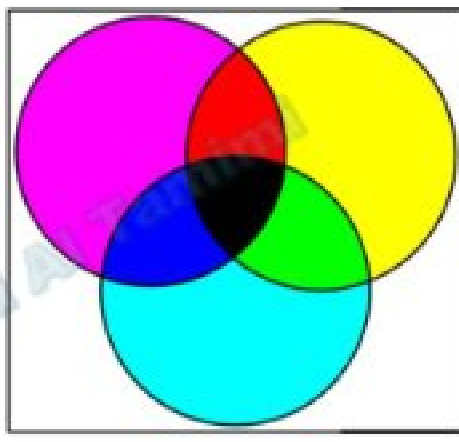


Question 20

A toy car that looks **magenta** in white light is placed under **green** light only. What color will it appear, and why?

Question 21

A book with a **red** cover is illuminated only by green light in a dark room. What color will the book appear, and why?



Question 22

Explain why mixing **cyan** and **yellow** pigments produces green under white light.

CHEMISTRY Connection

- Color printers use **yellow, magenta, and cyan pigments** to create images.
- These pigments are usually made from finely ground compounds, such as:
  - Titanium(IV) oxide → **white**
  - Chromium(III) oxide → **green**
  - Cadmium sulfide → **yellow**
- Pigments form **suspensions** (not solutions).
- Their chemical form does not change when mixed, so they still absorb and reflect the same wavelengths.

BIOLOGY Connection

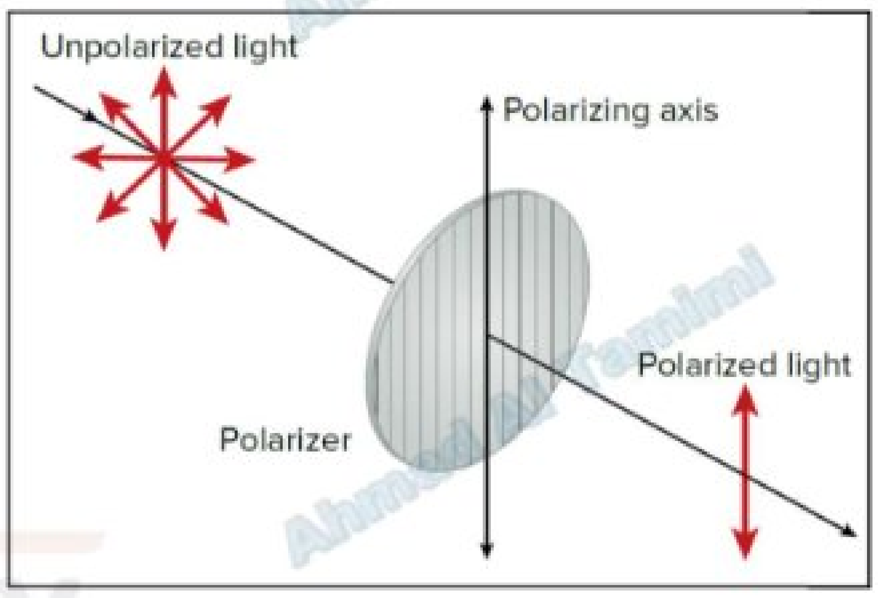
- Plants look **green** because of **chlorophyll**.
- There are two types of chlorophyll:
  - One absorbs mostly **red light**.
  - The other absorbs mostly **blue light**.
- Both types reflect **green light**, making plants appear green.
- The absorbed red and blue light provides **energy for photosynthesis**, helping plants make food.

Question 23

White light (which consists of the seven rainbow colors) falls on a green leaf, as shown in the figure. Which of the following statements best describes what actually happens?

A	The eye sends a ray towards the leaf, which reflects back, making the leaf appear green.	B	The pigment particles in the green leaf absorb the green color and reflect all the other colors.
C	The pigment particles in the green leaf absorb all colors and reflect only the green color.	D	The pigment particles absorb all colors and the leaf appears colorless.

4	**Apply Malus's law to light filtered by polarizer and analyser filters.**	**Student Textbook** **Physics Challenge**	**16,17** **18**



- In **unpolarized light**, these vibrations occur in **all directions randomly**.
- In **polarized light**, the vibrations are restricted to **just one direction**.

- **Polarization** is the production of light with a specific pattern of oscillation.

- Key idea: Polarization does not change the **speed** or **color** of light — it only changes the **direction of vibration** of the electric field.

- The lines in the polarizer represent a **polarizing axis**.

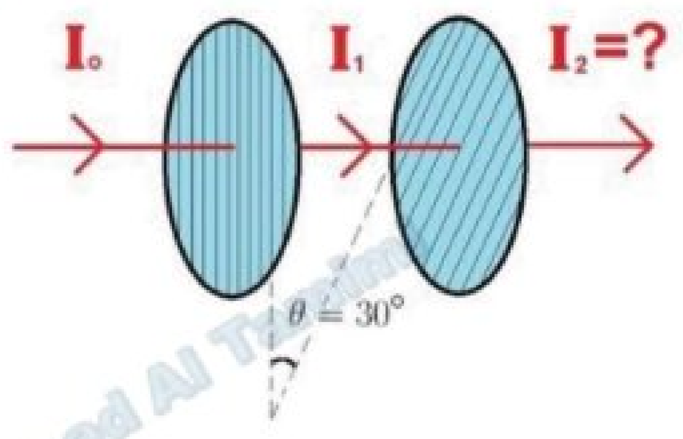
- The light with the portion of the electric field that oscillates parallel to the polarizing axis passes through.

- The light with the portion of the electric field that oscillates perpendicular to the axis is absorbed.

- **The intensity of unpolarized light as it emerges from the first polarizer reduces to half.**

Polarization by Reflection

- **Polarization can also occur when light is reflected, such as from a sheet of glass or from a road.**
- Polarized reflected light causes **glare**. Polarizing sunglasses reduce glare from the polarized light reflected off roads.
- Photographers can use polarizing filters over camera lenses to block reflected light.



Polarization by Filtering

- If you place a second polarizing filter in the path of the polarized light from the first filter, the amount of light transmitted through the second filter depends on the an**gle** between the two filters.
- The law that explains the reduction of light intensity as **light** passes through a second polarizing filter is **Malus's law.**

$$\boxed{I_1 = \frac{1}{2} I_0}$$

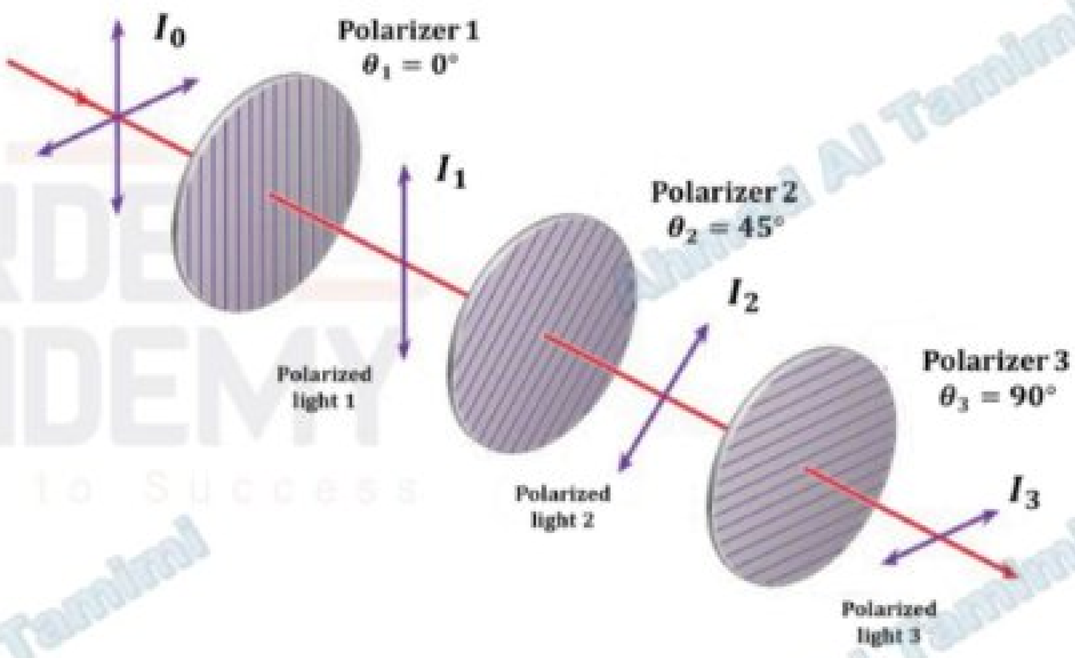
$$\boxed{I_2 = I_1 cos^2(\Delta\theta)}$$

where:

- I_1 =intensity after first filter (W/m^2)
- I_2 =intensity after second filter (W/m^2)
- θ= angle between filter axes (degrees)

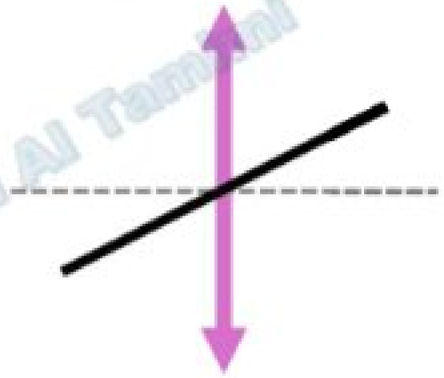
Question 24

Suppose that unpolarized light with intensity I_0 is initially incident on the first of three polarizers in a line. The first polarizer has a polarizing direction that is vertical. The second polarizer has a polarizing angle of $45.0°$ with respect to the vertical. The third polarizer has a polarizing angle of $90°$ with respect to the vertical. What is the intensity of the light after passing through all three polarizers, in terms of the initial intensity?



Question 25

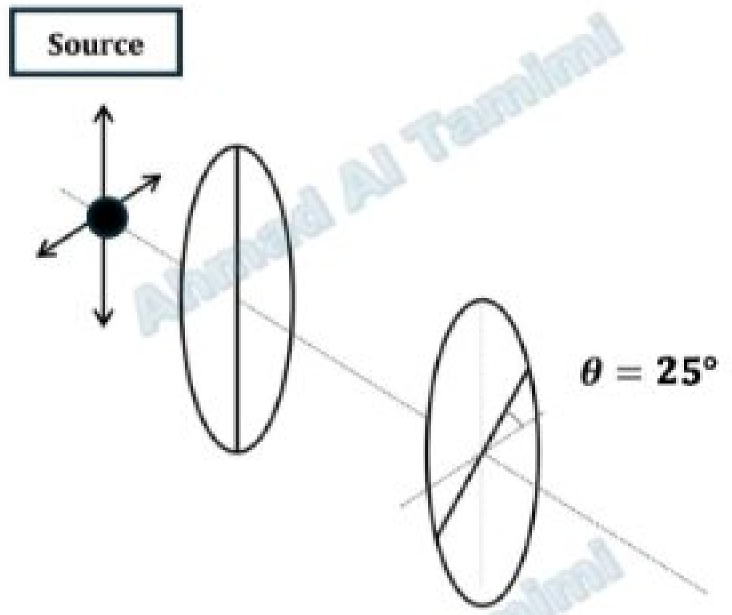
A vertically polarized laser beam passes through a polarizer whose polarizing angle is 30.0° from the horizontal. What is the intensity of the laser beam when it emerges from the polarizer?



Question 26

In the adjacent figure the light is transmitted through the second filter with an intensity of 100 W/m^2 . What is the intensity of the light emitted by the source? Th polarizing axis of the second filter makes an angle of $\theta = 25°$ from the horizontal.

A	121 W/m^2	B	325 W/m^2
C	560 W/m^2	D	1120 W/m^2



Question 27

The figure shows unpolarized light incident on polarizer 1 with polarizing angle $\theta_1 = 0°$ and then on polarizer 2 with polarizing angle $\theta_2 = 90°$, which results in no light passing through. If polarizer 3 with polarizing angle $\theta_3 = 50°$ is placed between polarizers 1 and 2, which of the following statements is true?

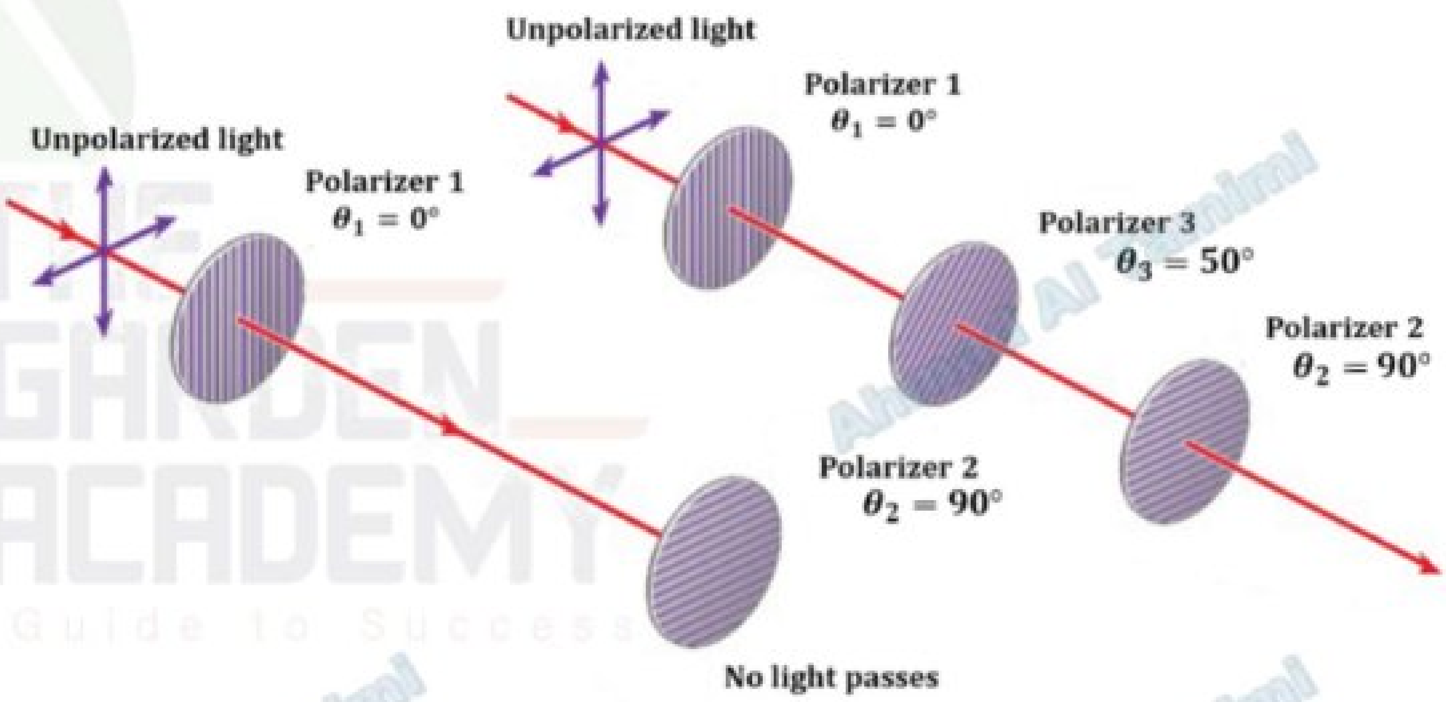
a) No light passes through the three polarizers.

b) Less than half, but more than zero, of the light passes through the three polarizers.

c) Exactly half of the light passes through the three polarizers.

d) More than half, but not all, of the light passes through the three polarizers.

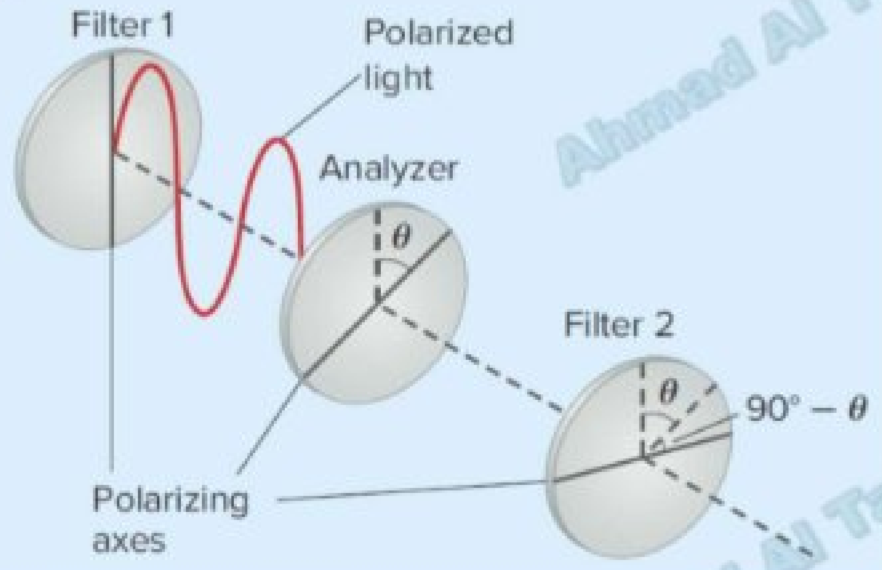
e) All of the light passes through the three polarizers.



PHYSICS Challenge

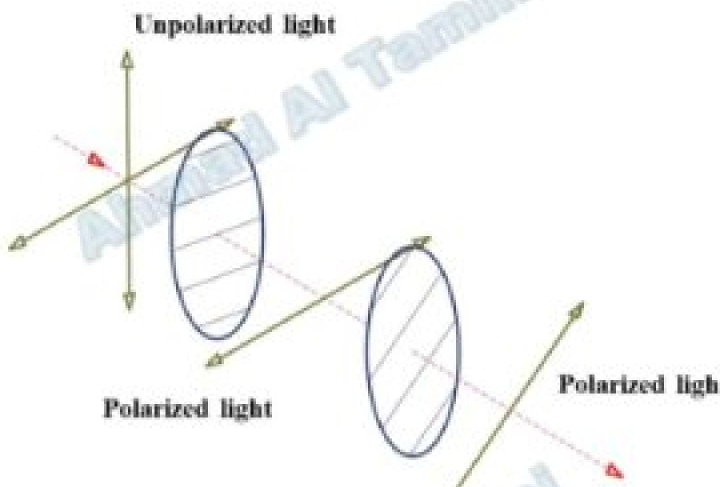
You place an analyzer filter between the two cross-polarized filters, such that its polarizing axis is not parallel to either of the two filters, as shown in the figure to the right.

1. You observe that some light passes through filter 2, though no light passed through filter 2 before you inserted the analyzer filter. Why does this happen?
2. The analyzer filter is placed at an angle of θ relative to the polarizing axis of filter 1. Derive an equation for the intensity of light coming out of filter 2 compared to the intensity of light coming out of filter 1.



Question 28

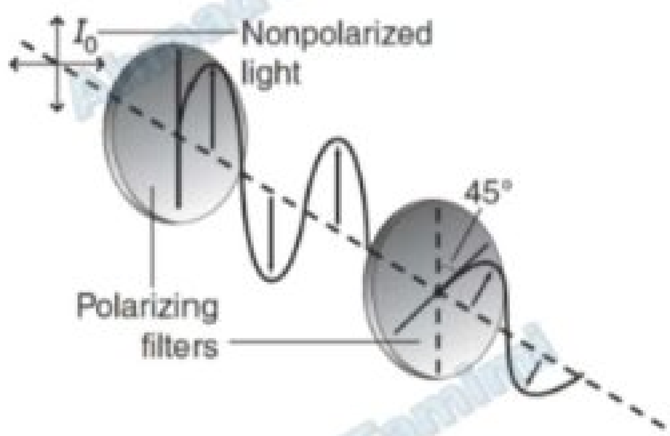
Unpolarized light with intensity $I_0 = I$ passes through two ideal polarizers. The emerging polarized light has intensity $I_{out} = 0.30\,I$. What is the angle θ between the two polarizers?



Question 29

Unpolarized light of intensity I_0 is incident on a polarizing filter, and the emerging light strikes a second polarizing filter, as shown. What is the light intensity emerging from the first polarizer and the second polarizer?

A	$I_1 = \frac{1}{4}I_0 \| I_2 = \frac{1}{4}I_0$	B	$I_1 = \frac{1}{2}I_0 \| I_2 = 0.35\,I_0$
C	$I_1 = \frac{1}{2}I_0 \| I_2 = \frac{1}{8}\,I_0$	D	$I_1 = \frac{1}{2}I_0 \| I_2 = \frac{1}{4}I_0$



5	-Apply mathematical equations to calculate unknown physical quantities (wavelengths, frequencies, or speeds) when light waves are doppler shifted based on the relative speed of the observer and the light source.	Student Textbook Practice problems	20

Concept	Formula	When Applied	Meaning
Observed Frequency	$F_{obs} = f\left(1 \pm \frac{v}{c}\right)$	Use when finding the frequency seen by an observer if the source/observer is moving.	"+" → moving **toward each other** → λ ↓ (blue shift). "−" → moving **away each other** → λ ↑ (red shift).
Observed Wavelength (Doppler Shift)	$\Delta\lambda = \lambda_{obs} - \lambda = \pm\left(\frac{v}{c}\right)\lambda$	Use when comparing the observed wavelength with the emitted one.	"+" → moving **away each other** → λ ↑ (red shift). "−" → moving **toward each other** → λ ↓ (blue shift).
Red Shift	$\lambda_{obs} > \lambda$ (wavelength increases) $f_{obs} < f$ (frequency decreases)	Occurs when the source moves **away** from the observer.	Light shifts toward the **red end** of spectrum.
Blue Shift	$\lambda_{obs} < \lambda$ (wavelength decreases) $f_{obs} > f$ (frequency increases)	Occurs when the source moves **toward** the observer.	Light shifts toward the **blue end** of spectrum.
Key Relationship	$c = f\lambda$	Speed of light is constant	If λ increases → f decreases. If λ decreases → f increases.

Question 30			
If a distant galaxy emits light in the green region of the visible spectrum. Will the observed wavelength shift toward the red light or the blue light?			
A	Toward blue	B	Toward red
C	Toward red and blue	D	None of the above

Question 31			
Which of the following expresses the observation of waves with a frequency different from their original frequency?			
A	Polarization phenomenon	B	Diffraction phenomenon
C	Doppler effect	D	Huygens' principle

PRACTICE Problems Page 20

16. Oxygen can be made to produce light with a wavelength of 513 nm. What is the frequency of this light?

17. A hydrogen atom in a galaxy moving with a speed of 6.55×10^{6} m/s away from Earth emits light with a frequency of 6.16×10^{14} Hz. What frequency of light from that hydrogen atom would be observed by an astronomer on Earth?

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18. A hydrogen atom in a galaxy moving with a speed of 6.55×10^{6} m/s away from Earth emits light with a wavelength of 486 nm. What wavelength would be observed on Earth from that hydrogen atom?

19. CHALLENGE An astronomer is looking at the spectrum of a galaxy and finds that it has an oxygen spectral line of 525 nm, while the laboratory value is measured at 513 nm. Calculate how fast the galaxy would be moving toward or away from Earth and how you know.

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Question 32			
A man is piloting a spacecraft on a mission from Earth toward the nearest star to our solar system. The star is a red dwarf, but it appears green to the observer. If you know that ($\lambda_{\text{Red}} = 680$ nm, $\lambda_{\text{Green}} = 535$ nm) What is the speed at which the man must be piloting the spacecraft so that the star appears to him in green color?			
A	$6.4 \times 10^7\ m/s$	B	$5.45 \times 10^7\ m/s$
C	$7.5 \times 10^7\ m/s$	D	$3.2 \times 10^6\ m/s$

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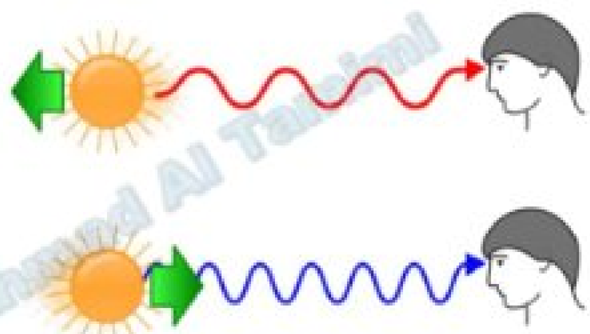
Question 33			
An astronomer observes a distant galaxy that normally emits **blue light** with a wavelength of **470 nm**, but due to its motion, the light appears **yellow** with a wavelength of **590 nm**. What **fraction of the speed of light in vacuum (c)** is the galaxy moving relative to Earth?			
A	$0.12\ c$	B	$0.18\ c$
C	$0.26\ c$	D	$0.31\ c$

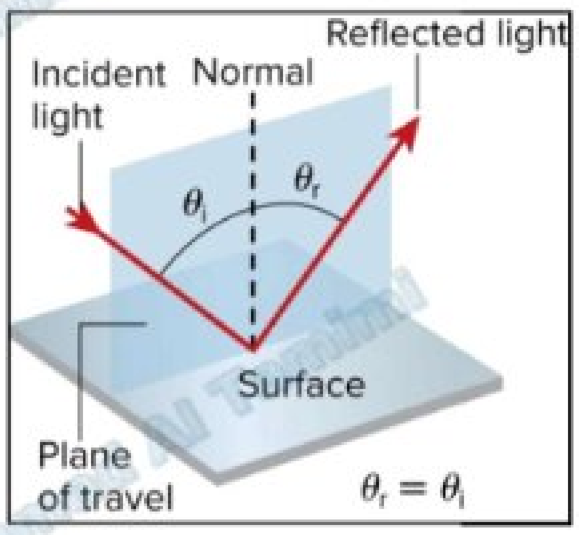
Question 34			
A distant star emits light with a frequency of $f = 6.00 \times 10^{14}\ Hz$. However, an observer on Earth measures the frequency as $f_{obs} = 5.40 \times 10^{14}\ Hz$. Find the velocity of the star relative to Earth. State whether the light is **red-shifted** or **blue-shifted**.			
A	$3 \times 10^{7} km/s. (red - shefted)$	B	$3 \times 10^{4}\ km/s. (blue - shefted)$
C	$3 \times 10^{4}\ km/s. (red - shefted)$	D	$3 \times 10^{7} km/s. (red - shefted)$



Question 35
A monochromatic source emits light of frequency $f = 6 \times 10^{14}\ Hz$. The source moves toward an observer at 250 km/s, and the observer moves toward the source at 170 km/s (same line). a) Find the **observed frequency.** b) Find the **observed wavelength** and the **wavelength shift.**

Question 36
Assume a red source emits light of frequency $f = 4.3 \times 10^{14}\ Hz$. The source moves away from an observer at $6.8 \times 10^{6}\ km/hr$, and the observer moves away from the source at $1.2 \times 10^{6}\ m/s$ (same line).   a) Find the **observed frequency.**   b) Find the **observed wavelength** and the **wavelength shift.**

6	**-Apply the law of reflection in drawing ray diagrams and solving numerical problems.**	**Student Textbook Example problem1 Practice problems**	**29,30 31**



- **Normal**: an imaginary line drawn **perpendicular** to the surface at the point of incidence.
- **Ray (شعاع)**: a line drawn at a right angle to a wavefront; represents the direction of wave travel.
- **Incident Ray (شعاع ساقط)**: the incoming ray of light that strikes a surface.
- **Reflected Ray (شعاع منعكس)**: the ray of light that bounces off the surface after reflection.
- **Incident ray, reflected ray, and normal** all lie in the **same plane (2D plane)** even though light travels in 3D.
- **Law of Reflection**: The angle of incidence (θ_i) is always equal to the angle of reflection (θ_r), both measured from the normal to the reflective surface.

$$\boxed{\theta_i = \theta_r}$$

- θ_i : angle of incidence (degrees).
- θ_r: angle of reflection (degrees).

PRACTICE Problems Page 31

1. Explain why the reflection of light off ground glass changes from diffuse to specular if you spill water on it.

2. What is the angle of incidence of a light ray reflected off a plane mirror at an angle of 35° to the normal?

3. Suppose the angle of incidence of a light ray is 42°.
   a. What is the angle of reflection?
   b. What is the angle the incident ray makes with the mirror?
   c. What is the angle between the incident ray and the reflected ray?

4. Light from a laser strikes a plane mirror at an angle of 38° to the normal. If the angle of incidence increases by 13°, what is the new angle of reflection?

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5. You position two plane mirrors at right angles to each other. A light ray strikes one mirror at an angle of 60° to the normal and reflects toward the second mirror. What is its angle of reflection off the second mirror?

6. **CHALLENGE** You are asked to design a retro-reflector using two mirrors that will reflect a laser beam by 180° independent of the incident direction of the beam. What should be the angle between the two mirrors?

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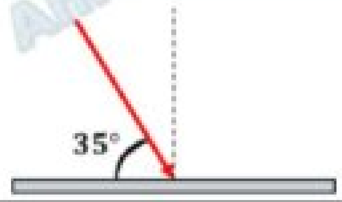
Question 37

A light ray strikes a plane mirror and makes an angle of **35°** **with the plane of the mirror**. **What is the angle of reflection**?



A	35°	B	45°
C	55°	D	90°

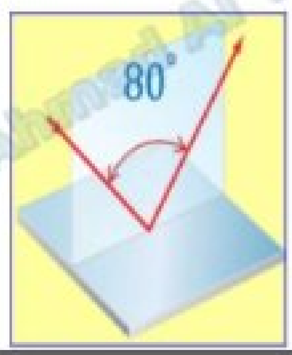
Question 38

Suppose the angle of reflection of a light ray is **45°**. **What is the measure of the angle between the incident ray and the reflected ray?**

A	45°	B	90°
C	120°	D	130°

Question 39

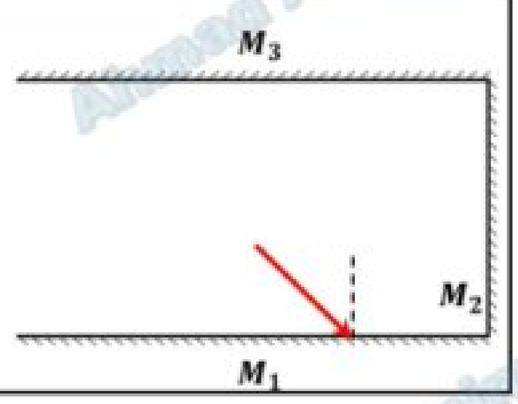
As shown in the figure, which of the following expressions correctly represents the relationship between the angle of incidence $\boldsymbol{\theta_i}$ and the angle of reflection $\boldsymbol{\theta_r}$?



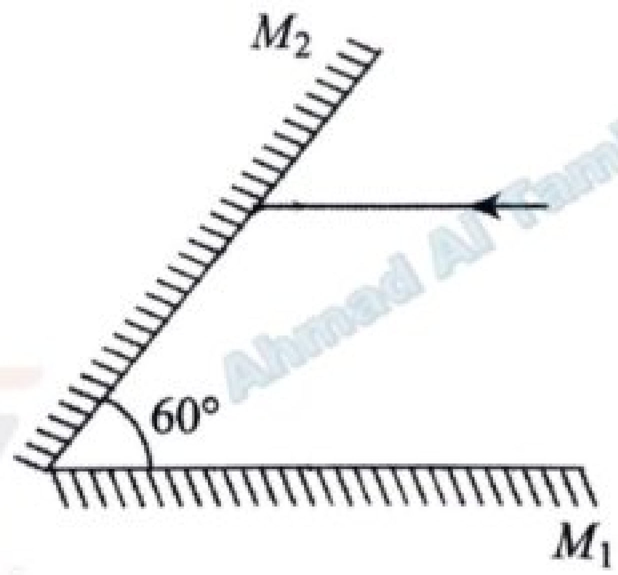
A	$\theta_i = \theta_r = 80°$	B	$\theta_i = \theta_r = 40°$
C	$\theta_i = 50°, \theta_r = 30°$	D	$\theta_i = 30°, \theta_r = 50°$

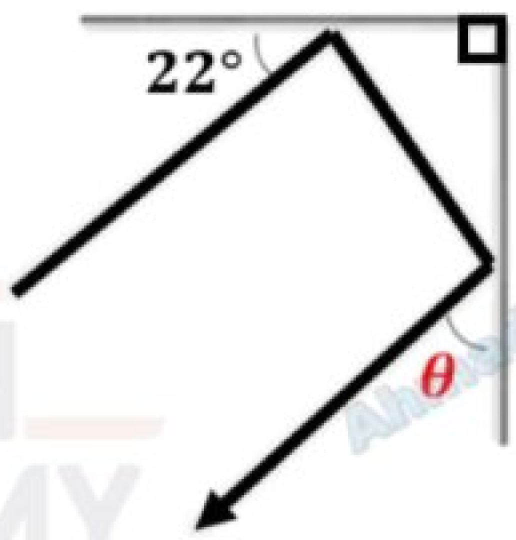
Question 40

Three plane mirrors $\mathbf{M_1}$, $\mathbf{M_2}$, **and** $\mathbf{M_3}$ are arranged **perpendicular to each other**. A light ray strikes **mirror** $\mathbf{M_1}$ with an **angle of incidence of 35°**. After reflecting successively from $\mathbf{M_1}$, $\mathbf{M_2}$, and $\mathbf{M_3}$, what will be the **angle of reflection from the third mirror** ($\mathbf{M_3}$)?



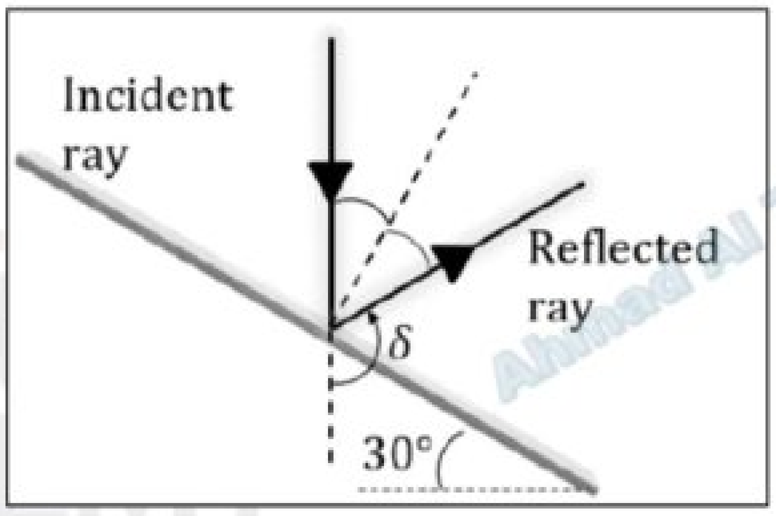
A	35°	B	45°
C	55°	D	56°

Question 41				
Two plane mirrors are inclined at an angle of 60° as shown in Figure. A ray of light **parallel** to M_1 strikes M_2. **What is the angle of reflection from mirror M_2**				
A	10°	B	20°	
C	30°	D	50°	

Question 42		
If an incident ray directed towards a corner reflected as shown, at what angle **θ** does the reflected ray emerge?		
A	22°	
B	68°	
C	44°	
D	46°	

Question 43

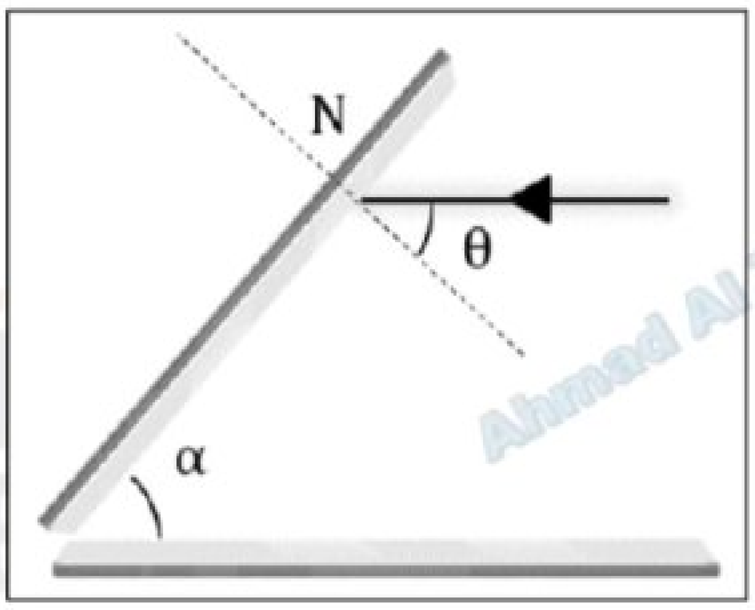
A plane mirror makes an angle of 30° with the horizontal. If a ray strikes the mirror vertically as shown in the figure, find the angle between the incident and reflected rays.



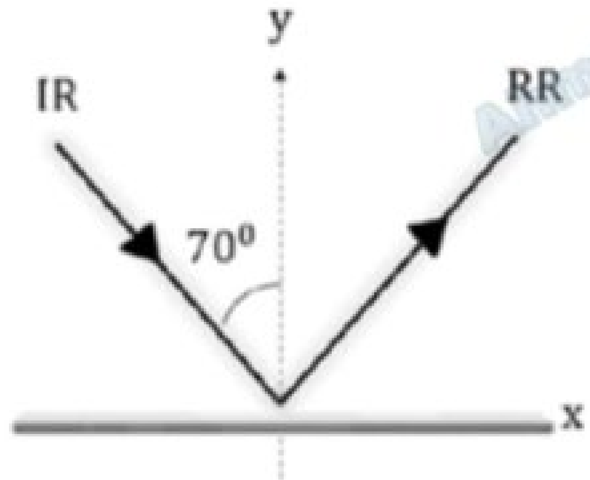
A	30°
B	60°
C	90°
D	120°

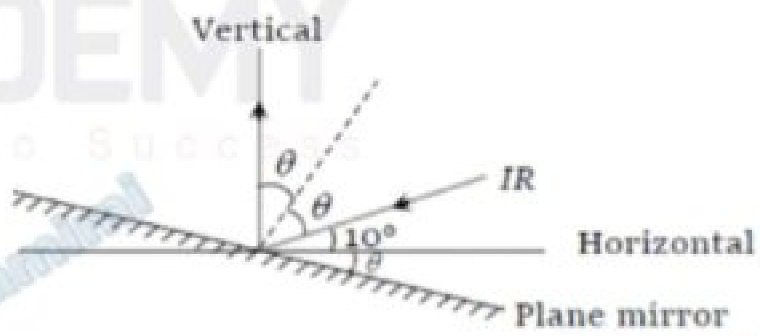
Question 44

In the figure shown below, a ray is incident on a plane mirror. Find the value of **θ** for which the ray retraces its path after the third reflection.



A	$\theta = \alpha/2$
B	$\theta = 2\alpha$
C	$\theta = \alpha$
D	$\theta = \alpha/4$

Question 45		
In the given figure, by what angle should the mirror be rotated such that the reflected ray becomes horizontal along positive x-axis?		
A	10° clockwise (CW)	
B	10° counter-clockwise (CCW)	
C	20° clockwise (CW)	
D	20° counter–clockwise (CCW)	

Question 46		
A ray of light makes an angle of 10° with the horizontal above it and strikes a plane mirror which is inclined at an angle θ to the horizontal. The angle θ for which the reflected ray becomes vertical is ______.		
A	40°	
B	50°	
C	80°	
D	100°	

EXAMPLE Problem 1

CHANGING THE ANGLE OF INCIDENCE A light ray strikes a plane mirror at an angle of 52.0° to the normal. The mirror then rotates 35.0° around the point where the ray strikes the mirror so that the angle of incidence of the light ray decreases. The axis of rotation is perpendicular to the plane of the incident and the reflected rays. What is the angle between the initial and final reflected ray?

Question 47

A light ray strikes a plane mirror at an angle of 15° to the normal. The mirror then rotates 20° around the point where the beam strikes it so that the ray's angle of incidence increases. The axis of rotation is perpendicular to the plane of the incident and to the reflected rays. What is the final angle of reflection of the light ray

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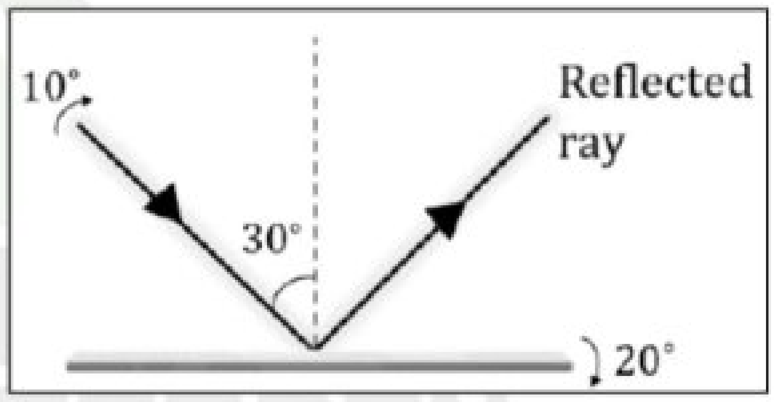
Question 48

A light ray strikes a plane mirror at an angle of 38.0° to the normal. The mirror is then rotated by 22.0° (about the point of incidence) so that the angle of incidence increases. The axis of rotation is perpendicular to the plane of the incident and reflected rays. What is the angle between the incident ray and the final reflected rays?

Question 49		
Figure shows a plane mirror onto which a light ray is incident. **If the incident light ray is turned by 10° and the mirror by 20° as shown in the figure**, then the angle turned by the reflected ray will be______.		
A	30° clockwise	
B	30° counter–clockwise	
C	50° clockwise	
D	50° counter–clockwise	

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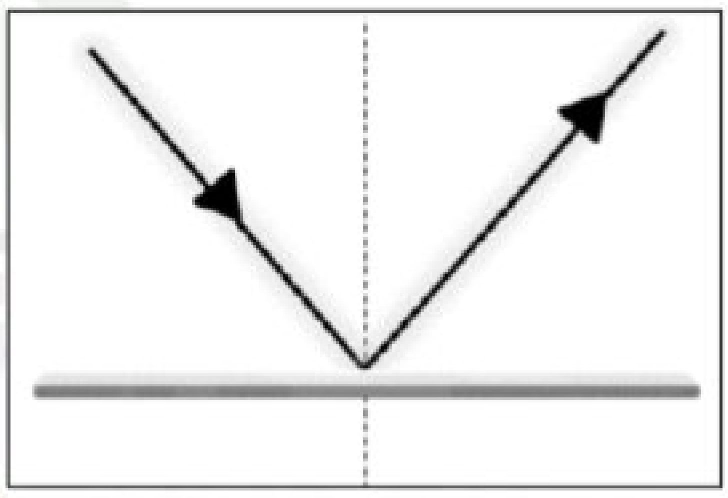
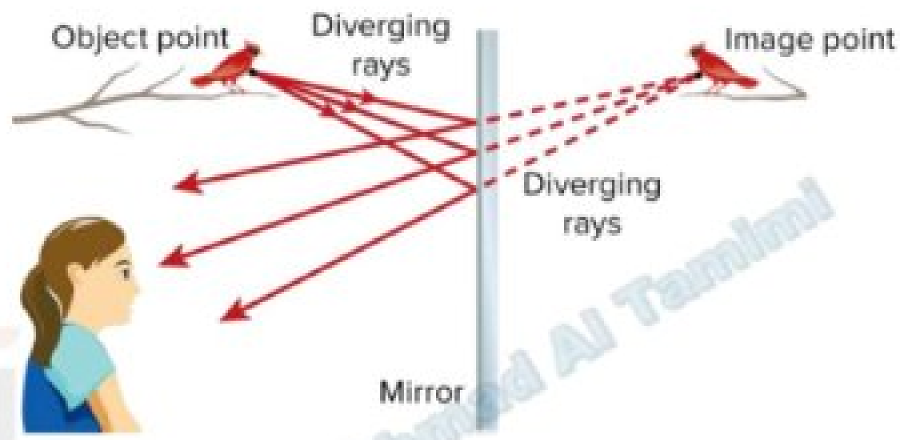
Question 50		
In the figure shown, the incident ray is rotated by **2°** in **clockwise** sense, the mirror is rotated by **8°** in **counterclockwise** sense, then the angle by which reflected ray will be rotated is_________.		
A	18° clockwise	
B	18° counter–clockwise	
C	16° clockwise	
D	16° counter–clockwise	

7	-Draw a ray diagram to locate the position of an image formed by a plane mirror, showing its properties. -Represent mathematically the relation between image position and object position, as well as the image height and object height for a plane mirror.	Student Textbook Check your progress	32,33 33

- The **image forms where the reflected rays appear to diverge**.
- The image of the object is:
  - **Virtual (وهمية أو افتراضية)** (not formed by actual meeting of rays).
  - **Upright (معتدلة)** and **located behind the mirror**.
- Important: **Plane mirrors always form virtual images where extensions of reflected rays converge behind the mirror only.**

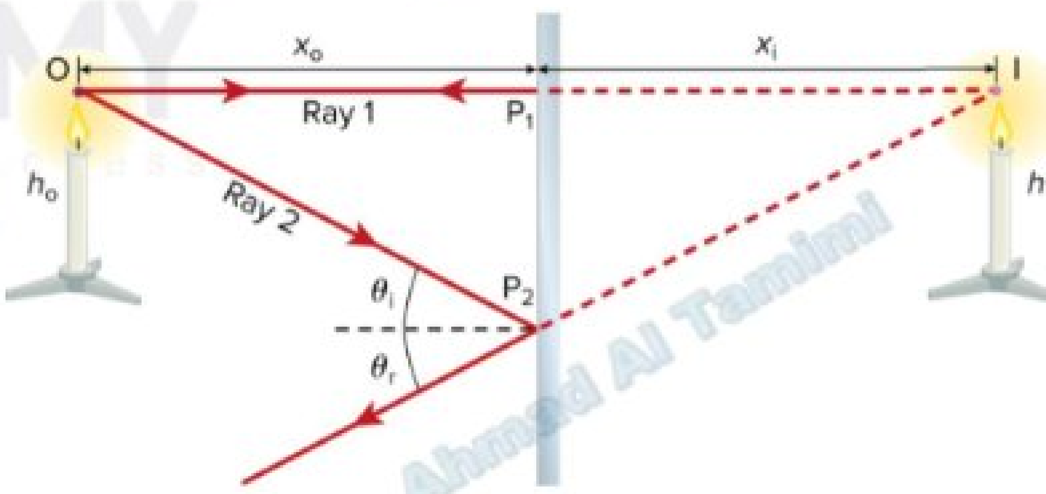


- **Size of the Image:** The image height equals the object

$$\boxed{h_i = h_o}$$

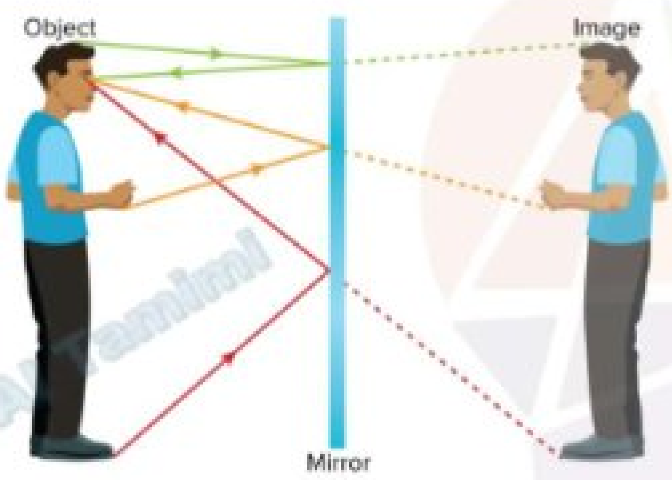
- **Position of the Image:** Image appears the same distance behind the mirror as the object is in front:

$$\boxed{x_i = -x_o}$$



Orientation of Plane-Mirror Images

Vertical mirrors (in front of the object)



Front-back reversal

(illusion of left-right swap)

Plane mirror

12345678 | 87654321

Object | Image

Horizontal mirrors (beneath or above the object)

Top-bottom inversion

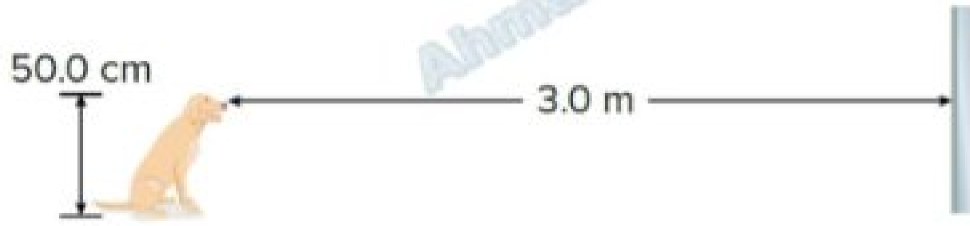
(illusion of up-down swap)

L I G H T

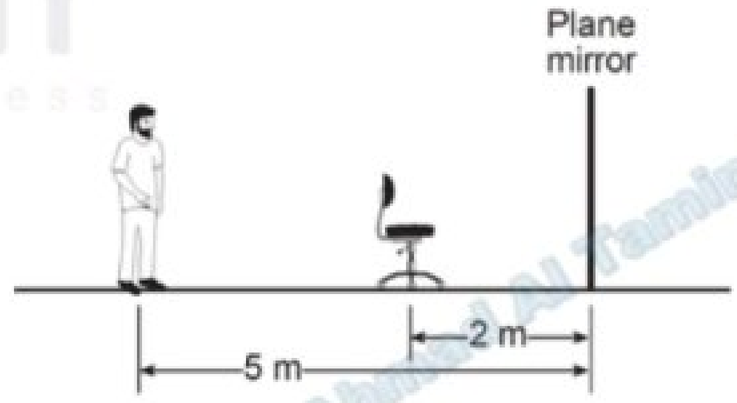
Γ I G H ⅂

Check Your Progress — Page 33

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



Question 51
In the diagram below, a person is standing 5 meters from a plane mirror. The chair in front of the person is located **2** meters from the mirror. What is the distance between the person and the image he observes of the chair?



Question 52			
An object is placed 30 cm in front of a plane mirror. Which statement describes the image of the object?			
A	The image is the same size and 30 cm from the object.	B	The image is the same size and 60 cm from the object.
C	The image is smaller and 60 cm from the object.	D	The image is smaller and 30 cm from the object.

Question 53			
Virtual images are formed by _________ rays.			
A	parallel	B	refracted
C	converging	D	diverging

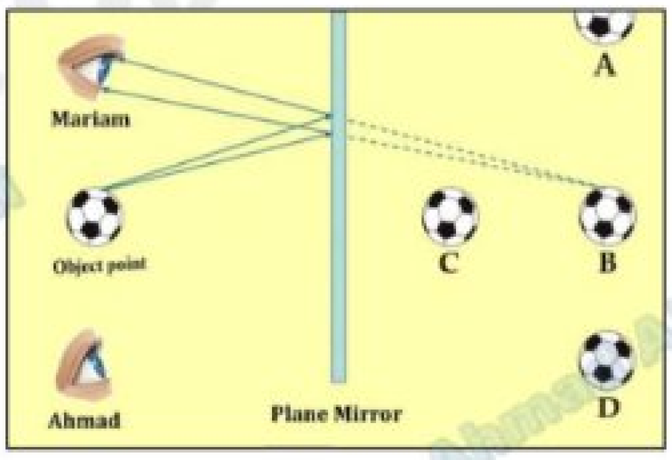
Question 54

Salam of (1.5 m) height stands at (0.5 m) away from a plane mirror, depicted his image as shown in Figure. What is the image's type and how far away is it from Salam?

A	Virtual, 1.5 m
B	Virtual, 1.0 m
C	Virtual, 0.5 m
D	Real, 0.5 m

Question 55

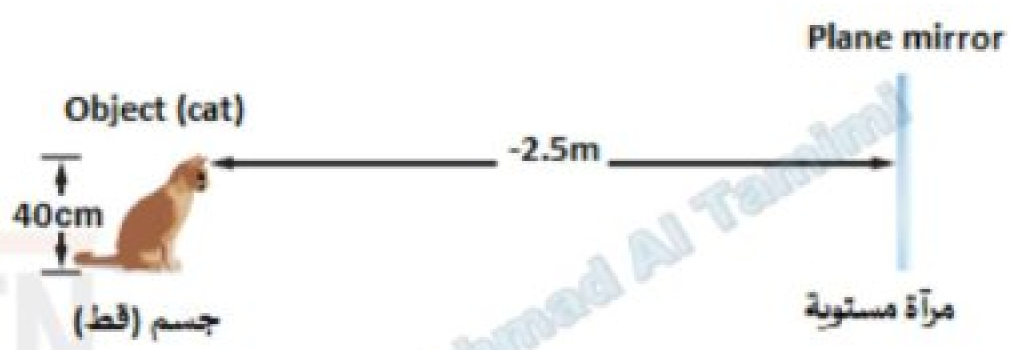
In the figure, Mariam observes the image of the ball at position B when looking into the plane mirror. From Ahmad's position, where will he observe the image of the ball?



A	A
B	B
C	C
D	D

Question 56

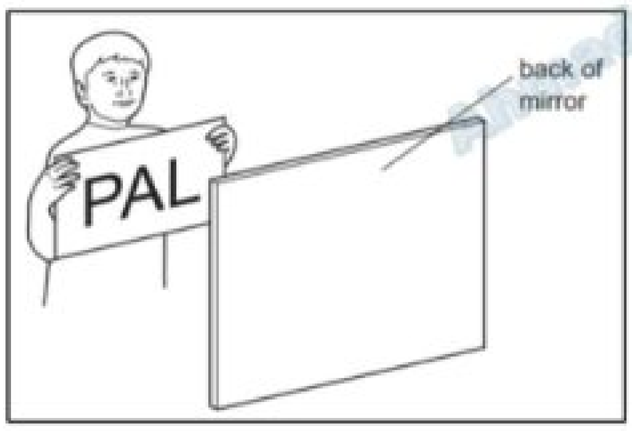
According to the figure, what are the cat's image position and image height formed by the mirror?

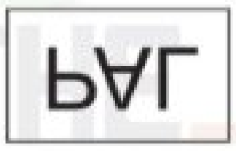


	Position of the image	Height of the image
A	-2.5 m	-40 cm
B	5.0 m	2.5 m
C	40 cm	2.5 m
D	2.5 m	40 cm

Question 57

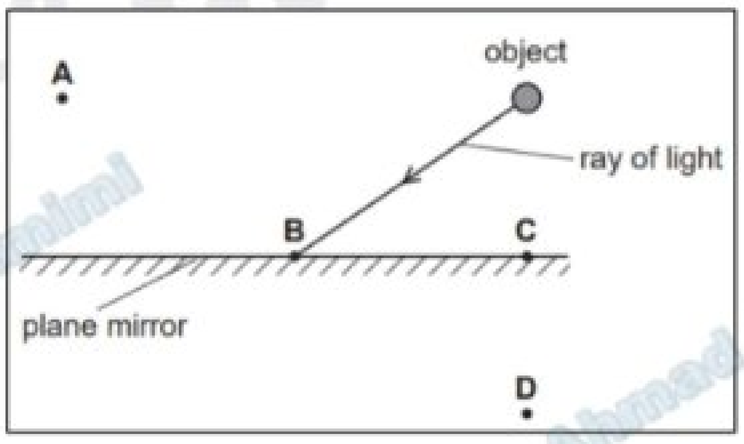
A boy is holding a card with the word PAL in front of a plane mirror as shown. Which option correctly shows the appearance of the word in the mirror?



A		B	
C		D	

Question 58

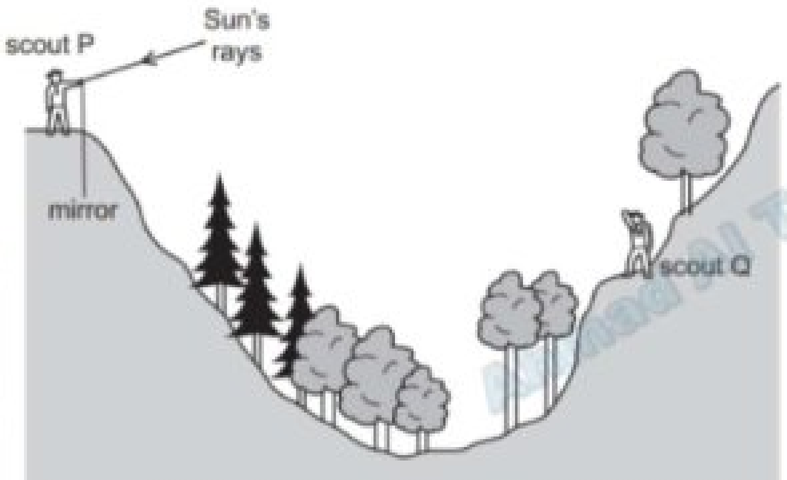
A plane mirror is used to form an image of an object. At which labelled point is the image formed?

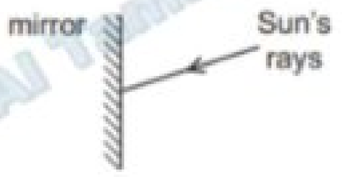
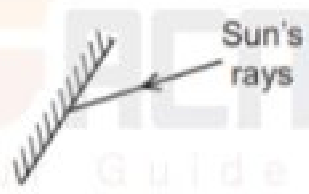


A	A
B	B
C	C
D	D

Question 59

Scout P signals to scout Q on the other side of a valley by using a mirror to reflect the Sun's rays. Which mirror position would allow the Sun's rays to be reflected to scout Q?



A		B	
C		D	

Question 60

Diagram shows a student standing 5 m in front of a mirror. If the mirror is moved towards the student by a distance of 1 m, what is the distance between the student and his image?	
A	4
B	5
C	8
D	10

Question 61

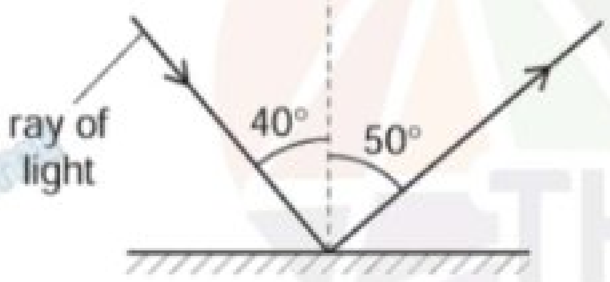
The diagram shows the image of a clock in a plane mirror. Which is the actual time?

A	4:15
B	4:45
C	7:15
D	7:45

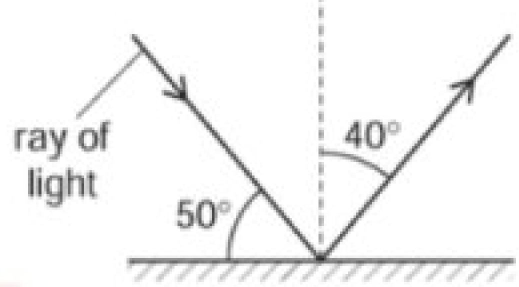
Question 62

Which diagram correctly shows a ray of light reflected by a plane mirror?

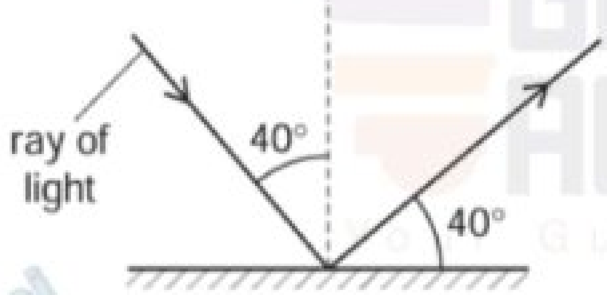
A



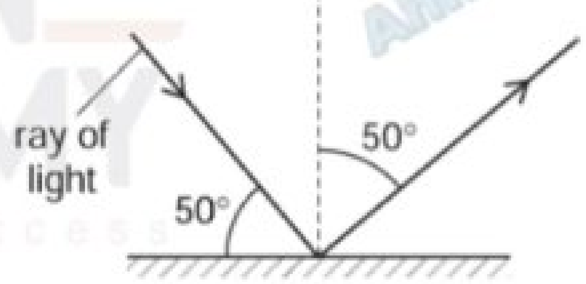
B



C



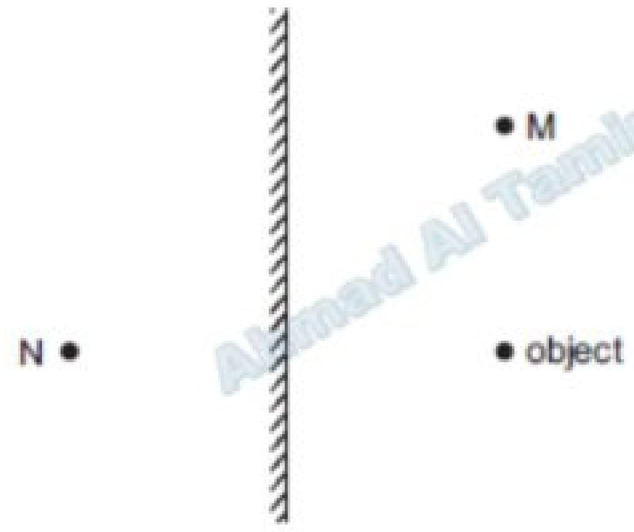
D



Question 63

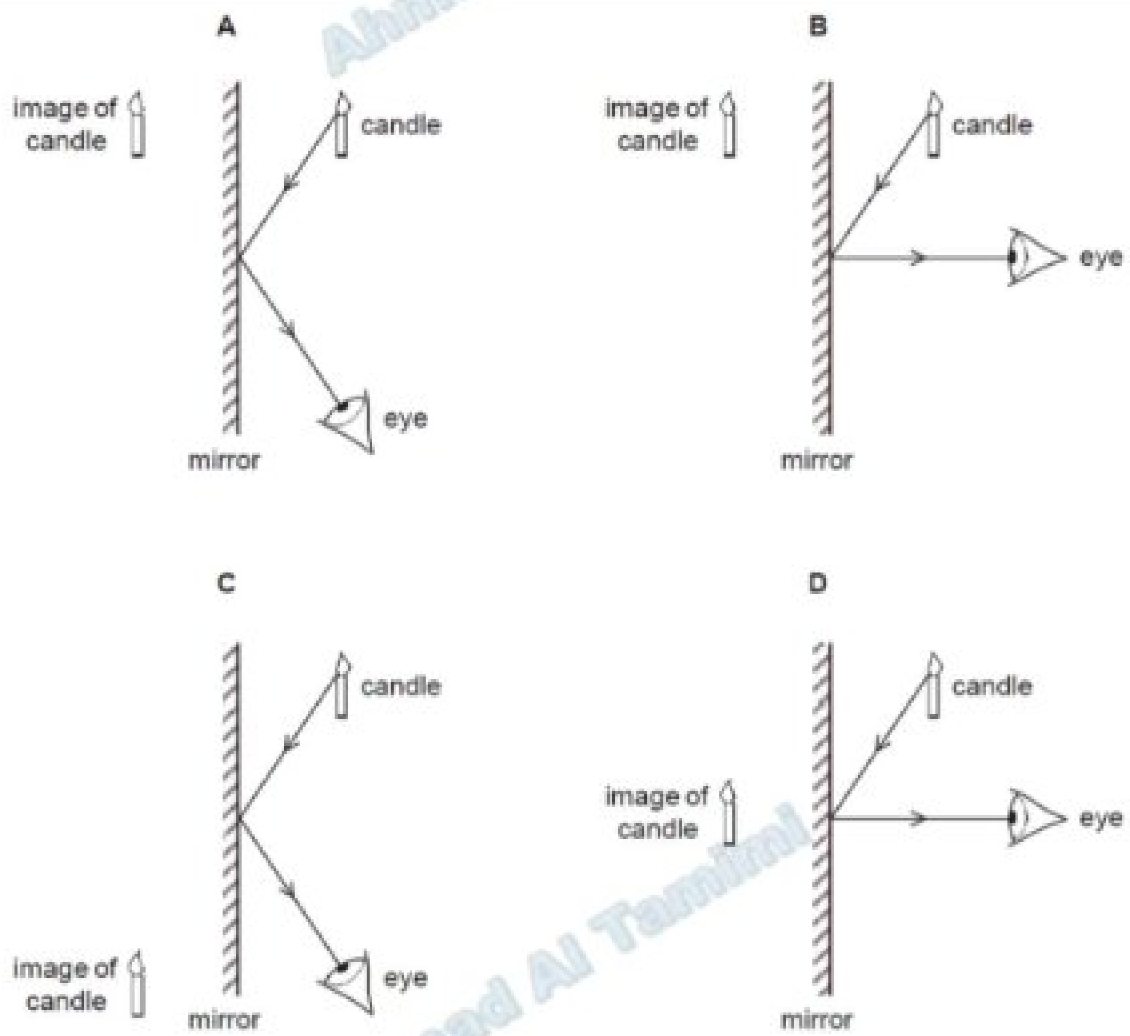
The diagram shows an object in front of a plane mirror. The mirror forms an image of the object. At which labelled point is the image formed, and which type of image is formed?

	where the image is formed	type of image
A	at M	real
B	at M	virtual
C	at N	real
D	at N	virtual



Question 64

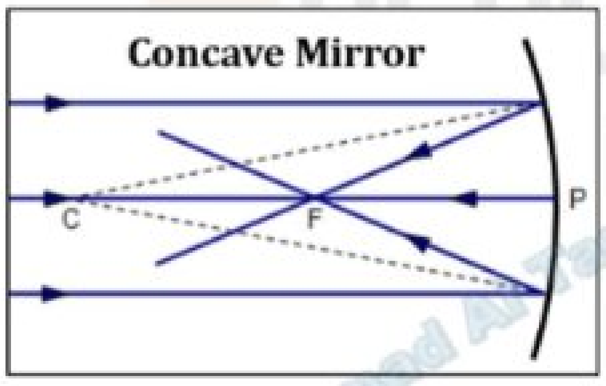
Which diagram shows how the light from a candle is reflected by a mirror, and shows the position of the imageformed?



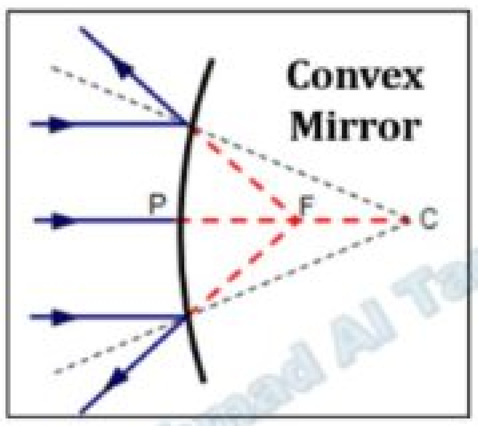
8	-Describe defects in concave mirrors, such as curved aberration, and how they can be corrected. -List some of the uses of concave and mirrors	Student Textbook	35 39

Feature	Concave Mirror	Convex Mirror
Shape	Inward-curving reflective surface (curves toward the observer)	Outward-curving reflective surface (curves away from the observer)
Ray Behavior	Parallel rays converge at the focal point (converging mirror)	Parallel rays appear to diverge from the focal point behind the mirror (diverging mirror)
Focal Length (f)	Positive	Negative
Image Formation	Can form **real or virtual** images (depending on object position)	Always forms a **virtual, upright, and smaller** image
Applications	**Car headlights, shaving/makeup mirrors, telescopes, solar concentrators**	**Store security mirrors, car side-view mirrors, traffic mirrors**

Concave Vs. Convex Mirrors



Geometric Center is In front of the mirror



Geometric Center is behind the mirror

Defects in Concave Mirrors

Spherical aberration: inability of spherical mirrors to focus all parallel rays to a single point.

Cause of spherical aberration:

- In a **spherical mirror**, light rays parallel to the principal axis do not all meet at a single focal point.
- Rays near the **principal axis** reflect and pass through the actual focal point (F).
- Rays far from the axis (at the mirror's edges) converge **closer to the mirror**, not at F.

Resulting defect:

- Since rays do not converge at the same point, the image appears **blurred or fuzzy** instead of sharp.

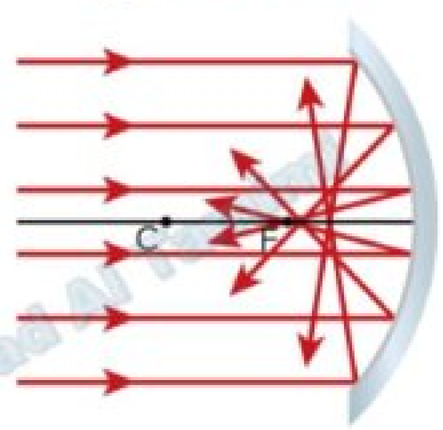
Parabolic mirrors vs. spherical mirrors:

- **Parabolic mirrors eliminate spherical aberration** because all parallel rays converge exactly at the focal point.
- **Spherical mirrors** are easier and cheaper to make but suffer from spherical aberration.

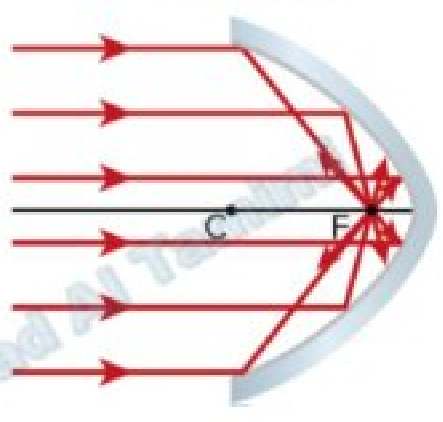
Applications and corrections:

- **Large telescopes** and precision optical instruments often use **parabolic mirrors** to avoid this defect.
- To reduce cost, many telescopes use **spherical mirrors** combined with **secondary mirrors or corrective lenses** to fix spherical aberration.

Spherical Mirror



Parabolic Mirror



Question 65

Which of the following mirrors is used in car side mirrors?

A	Convex mirrors	B	Concave mirrors
C	Plane mirrors	D	Parabolic mirrors

Question 66

Which mirror is used in a solar cooker to focus sunlight at one point?

A	Convex mirrors	B	Concave mirrors
C	Plane mirrors	D	Parabolic mirrors

Question 67

Which mirror is used in car headlights to make the light rays parallel?

A	Convex mirrors	B	Concave mirrors
C	Plane mirrors	D	Parabolic mirrors

Question 68

Which mirror helps a store security guard see a large area of the shop at once?

A	Convex mirrors	B	Concave mirrors
C	Plane mirrors	D	Parabolic mirrors

الفــيزياء
الأستاذ أحمد التميمي

Question 69

Which of the following statements is true about the spherical aberration of concave mirrors?

A	Occurs because the reflected light rays converge at a focal point.	B	We can reduce it by increasing the ratio of the mirror's diameter to its radius of curvature.
C	It occurs for parabolic mirrors.	D	It occurs for spherical mirrors.

Question 70

Which of the following statements is not true about spherical aberration?

A	Occurs because the reflected parallel rays don't converge at a focal point.	B	We can reduce it by decreasing the ratio of the mirror's height to its radius of curvature.
C	It occurs for parabolic mirrors.	D	It occurs for spherical mirrors.

Question 71

Which mirror shape eliminates spherical aberration?

A	Convex spherical mirror	B	Parabolic mirror
C	Plane mirror	D	Cylindrical mirror

Question 72

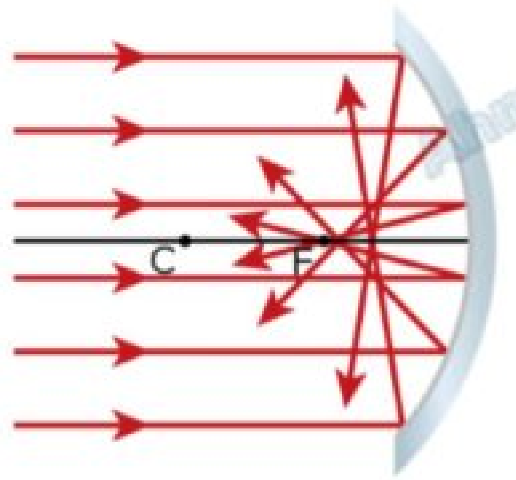
Spherical aberration occurs because:

A	Light rays bend too much near the focus	B	Rays parallel to the principal axis do not meet at one focal point
C	The mirror is placed at an angle to the axis	D	The mirror is too small

Question 73

The mirror shown suffers from________.

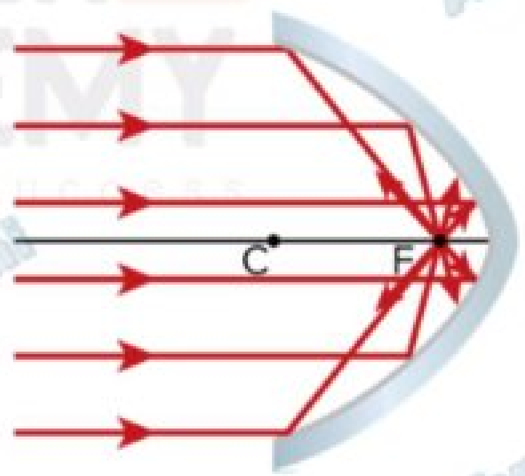
A	spherical aberration
B	chromatic aberration
C	field Curvature
D	diffraction



Question 74

The shown mirror is used to eliminate ________.

A	spherical aberration
B	chromatic aberration
C	field Curvature
D	diffraction

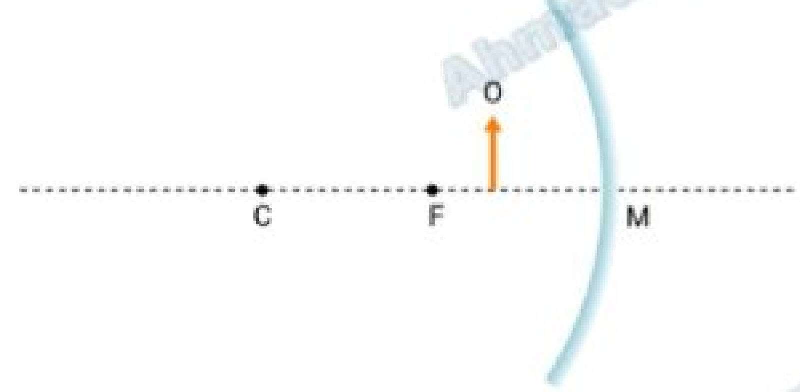


9	-Draw a ray diagram to find the image of an object formed by a curved mirror and determine the properties of the formed image.	Student Textbook	36-38

طريقة رسم ال Ray Diagram تم شرحها بالتفصيل في الجزء الورقي من الامتحان

Question 75

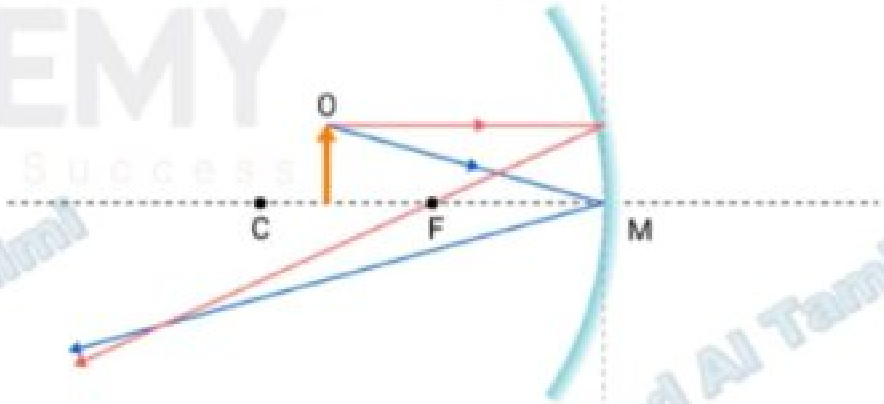
What image forms if the object is between the focal point and concave mirror?



A	The image is virtual, upright, and larger than the object.
B	The image is real, inverted, and smaller than the object.
C	The image is real, upright, and the same size as the object.
D	No image is formed because the rays do not meet.

Question 76

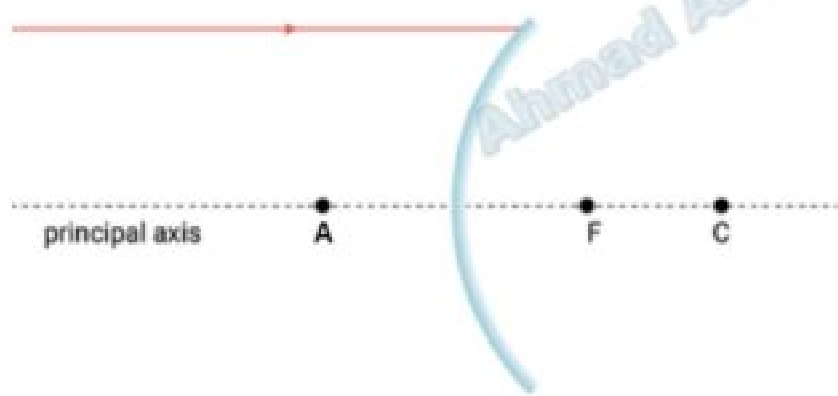
Mahmoud places an object as shown in the diagram. What are the characteristics of the image that will be formed by the mirror?



A	The image is not seen.
B	The image is virtual.
C	The image is upright.
D	The image is real.

Question 77

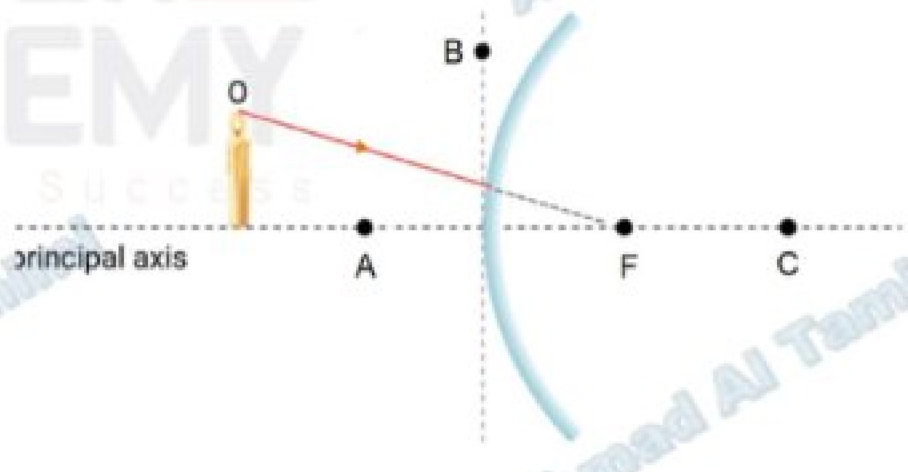
The given diagram shows a ray incident on a convex mirror parallel to its principal axis. How is the corresponding reflected ray drawn?



A	bounces off the mirror and passes by A
B	bounces off the mirror as if it is issued from F
C	bounces off the mirror along the same incidence direction
D	bounces off the mirror as if it is issued from C

Question 78

The given figure shows a ray incident toward the focal point of a convex mirror. How is the reflected ray oriented?

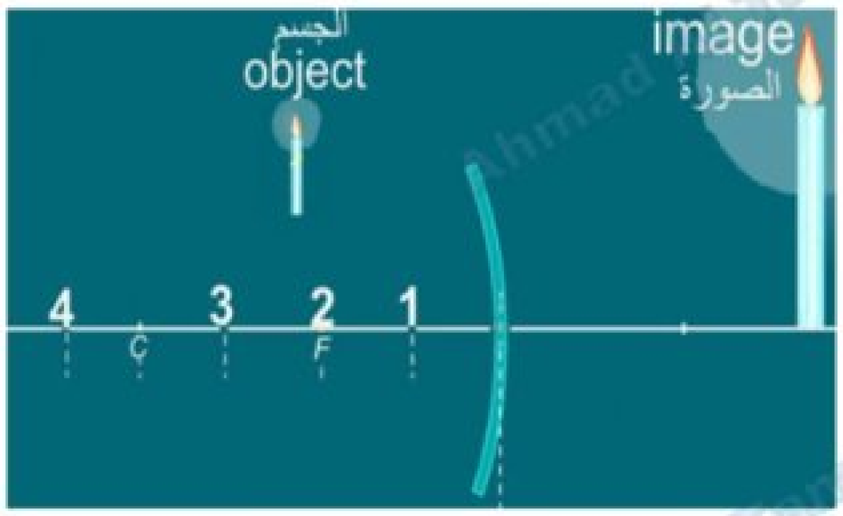


A	The reflected ray bounces off the mirror and appears coming from C.
B	The reflected ray is parallel to the principal axis.
C	The reflected ray passes through A, the symmetry of F with respect to themirror.
D	The reflected ray passes through point B.

Question 79

Where should the object be positioned in front of the concave mirror, as shown in the figure, so that its image appears behind the mirror?

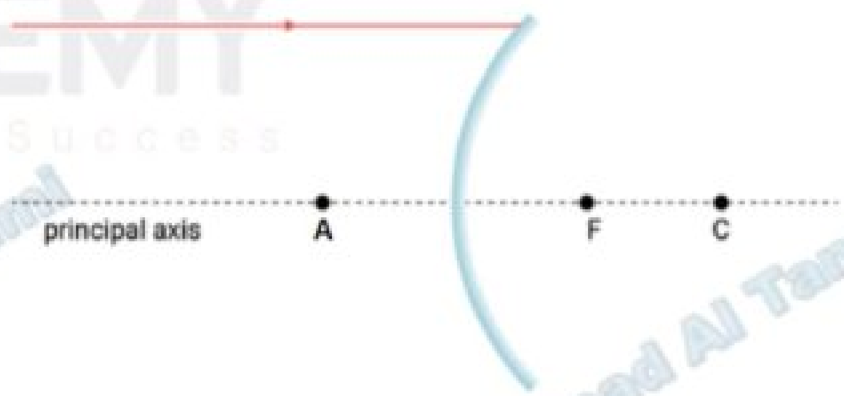
A	Position 1
B	Position 2
C	Position 3
D	Position 4



Question 80

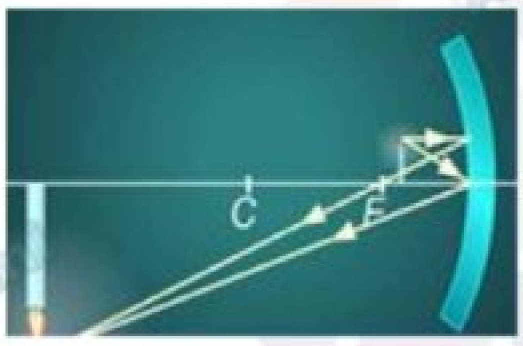
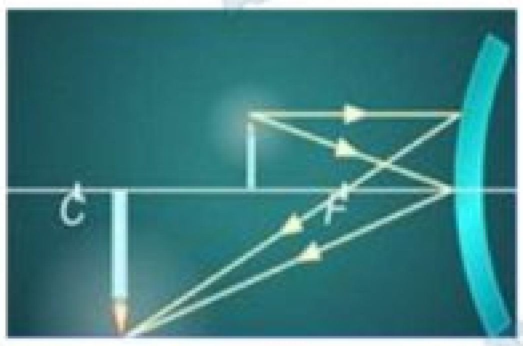
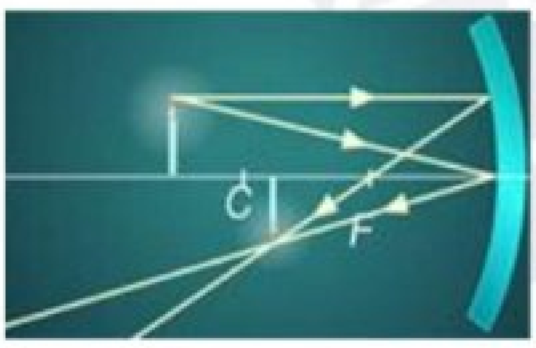
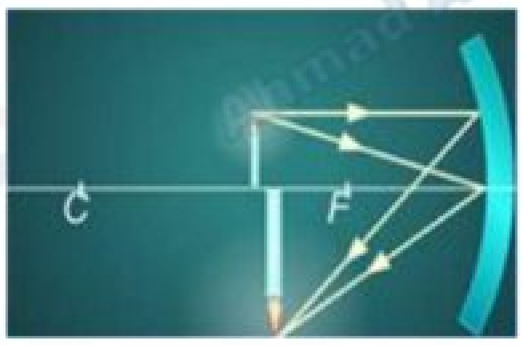
The given diagram shows a ray incident on a convex mirror parallel to its principal axis. How is the corresponding reflected ray drawn?

A	bounces off the mirror and passes by A
B	bounces off the mirror as if it is issued from F
C	bounces off the mirror along the same incidence direction
D	bounces off the mirror as if it is issued from C



Question 81

Where should the object be positioned in front of the concave mirror, as shown in the figure, so that its image appears behind the mirror?

A		B	
C		D	

Question 82

Which location of an object creates a virtual image in a concave mirror?

A	At the focal point	B	At the center of curvature
C	Between the focal point and the center of curvature	D	Between the mirror and the focal point

Question 83

In what way is a convex mirror and a concave mirror similar?

A	They have the same kind of curvature.	B	Virtual images can be produced by both.
C	Only real images are produced by both.	D	They produce images with the same height of the object.

Question 84

Which statement about x_o in a diagram of reflection is true?

A	It is the object position relative to the mirror and its value is always positive.	B	It is the object position relative to the image and its value is always positive.
C	It is the object position relative to the center of curvature and its value is always negative.	D	It is the object position relative to the focal point and its value is always negative.

Question 85

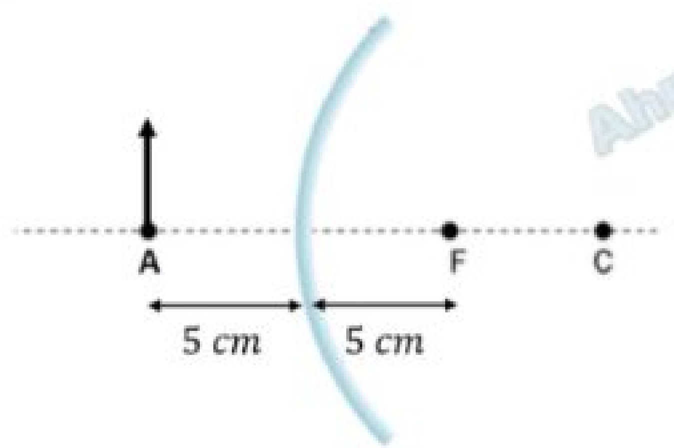
The image obtained for an object placed in front of a concave mirror is virtual, right side up, and larger than the object. Where is the object placed?

A	between the focal point and the center of curvature	B	at the center of curvature
C	at the focal point	D	between the focal point and the surface of the mirror

Question 86

What is the focal length of the mirror?

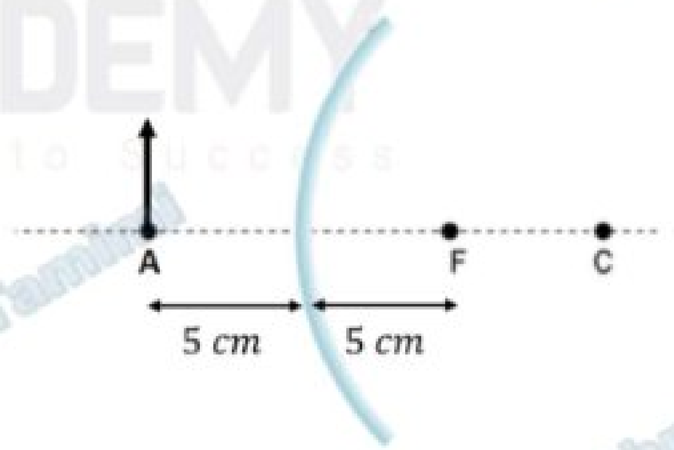
A	f = +10 cm
B	f = -10 cm
C	f = +5.0 cm
D	f = −5.0 cm



Question 87

What is the radius of curvature of the mirror?

A	r = 5 cm
B	r = 10 cm
C	r = 15 cm
D	r = 20 cm



10	-Apply the mirror equation to calculate the image distance, the object distance, or the focal length of a spherical mirror using appropriate algebraic signs for focal length and corresponding distances	Example problem2,3 Practice problems	41,42

هذا السؤال مشروح بالتفصيل ومكرر في الجزء الورقي من الامتحان.

Symbol	Meaning	Sign Convention
m	Magnification	+ → virtual image – → real image |m| < 1 → image smaller |m| > 1 → image larger
h_i	Image Height	+ → image is upright – → image is upside down (inverted)
h_o	Object Height	always positive
x_i	Image Position	+ → image in front of mirror (real) – → behind mirror (virtual)
x_o	Object Position	always positive

$$\text{magnification } (m) = \frac{h_i}{h_o} = -\frac{x_i}{x_o}$$

Sign conventions (we'll use these throughout)	
x_o	(+) always
x_i	(+) for **real** images, (-) for **virtual** images.
f	(+) for **concave** mirrors, (-) for **convex** mirrors.

$$\text{Mirror equation: } \frac{1}{f} = \frac{1}{x_i} + \frac{1}{x_o}$$

11	Infer the type, orientation, and size of an image from the magnitude and algebraic sign of magnification.	Student Textbook	35

Symbol	Meaning	Sign Convention
m	Magnification	+ → virtual image – → real image |m| < 1 → image smaller |m| > 1 → image larger
h_i	Image Height	+ → image is upright – → image is upside down (inverted)
h_o	Object Height	always positive
x_i	Image Position	+ → image in front of mirror (real) – → behind mirror (virtual)
x_o	Object Position	always positive

$$\text{magnification } (m) = \frac{h_i}{h_o} = -\frac{x_i}{x_o}$$

Question 88

An image formed by a concave mirror has a magnification of m = −2.0. Which statement best describes the image?

A	Virtual, upright, and twice the size of the object	B	Real, inverted, and twice the size of the object
C	Real, upright, and half the size of the object	D	Virtual, inverted, and smaller than the object

Question 89

A convex mirror produces a magnification of m = +0.5. What can you infer about the image?

A	Real, inverted, and half the size of the object	B	Real, upright, and larger than the object
C	Virtual, upright, and smaller than the object	D	Virtual, inverted, and larger than the object

Question 90

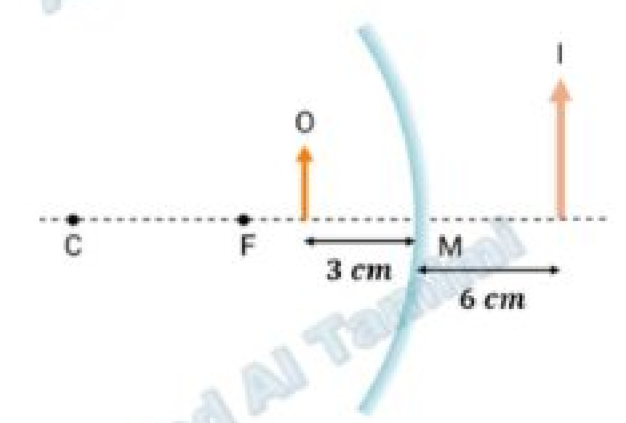
Which of the following quantities represents the ratio of the object height to the image height?

A	Focal length (f)	B	Inverse of focal length (1/f)
C	Magnification (m)	D	Inverse of magnification (1/m)

Question 91

Based on the given figure, find the magnification of the image.

A	m = +0.5
B	m = -0.5
C	m = +2.0
D	m = −2.0



Question 92

A mirror forms an image 5 cm high with a magnification of m = −2. What type of mirror is it, and what is the height of the object?

A	Concave mirror, object height = 10 cm	B	Concave mirror, object height = 2.5 cm
C	Convex mirror, object height = 2.5 cm	D	Convex mirror, object height = 10 cm

Question 93

A mirror produces an upright image 4 cm high of an object placed in front of it. If the object height is 8 cm, find the magnification and state where the object is placed relative to the mirror.

A	m = -0.5 between F and the mirror	B	m = +0.5 Anywhere In front of the mirror
C	m = +2.0 Beyond C	D	m = -2.0 Between C and F

12	Compare and contrast plane, concave, and convex mirrors regarding the properties of images formed and the algebraic	Student Textbook	43

Mirror Type	Object Location (x_o)	Image Location (x_i)	Image Size (Height)	Image Type	Orientation (Attitude)	Magnification (m)	Focal length (f)
Concave (Converging)	Beyond C	Between F & C	Reduced (diminished)	Real	Inverted	-	+
	At C	At C	Same size	Real	Inverted	-	
	Between C & F	Beyond C	Enlarged (magnified)	Real	Inverted	-	
	At F	At infinity	Highly enlarged (blurred)	Real	Inverted	—	
	Between F & Mirror	Behind mirror	Enlarged (magnified)	Virtual	Upright	+	
Convex (Diverging)	Anywhere in front	Behind mirror (between F & mirror)	Reduced (diminished)	Virtual	Upright	+	-
Plane Mirror	Anywhere in front	Behind mirror at same distance as object	Same size	Virtual	Upright	+	∞

Question 94

Which of the following can produce images that are enlarged and virtual?

A	Convex mirror	B	Plane mirror
C	Concave lens	D	Concave mirror

Four students are facing four different mirrors, and their reflections appear as shown in the table below:

يقف أربعة طلاب أمام أربع مرايا مختلفة فتظهر صورة كل منهم كما في الجدول التالي:

Saif سيف	Hamad حمد	Saeed سعيد	Rashid راشد	Student الطالب
معتدلة - مصغرة Reduced- upright	مقلوبة – مصغرة Reduced-inverted	معتدلة – مساوية Same size - upright	معتدلة – مكبرة Enlarged-upright	نوع الصورة Image's type

Which student(s) is (are) facing a concave mirror?

أي من الطلبة يقف أمام مرآة مقعرة؟

A	Only Saeed
B	Only Rashed
C	Hamad and Rashid
D	Saif and Rashid

Question 95

Which of the following mirrors always produce virtual images?

A	Convex mirror	B	Plane mirror
C	Concave lens	D	A and B

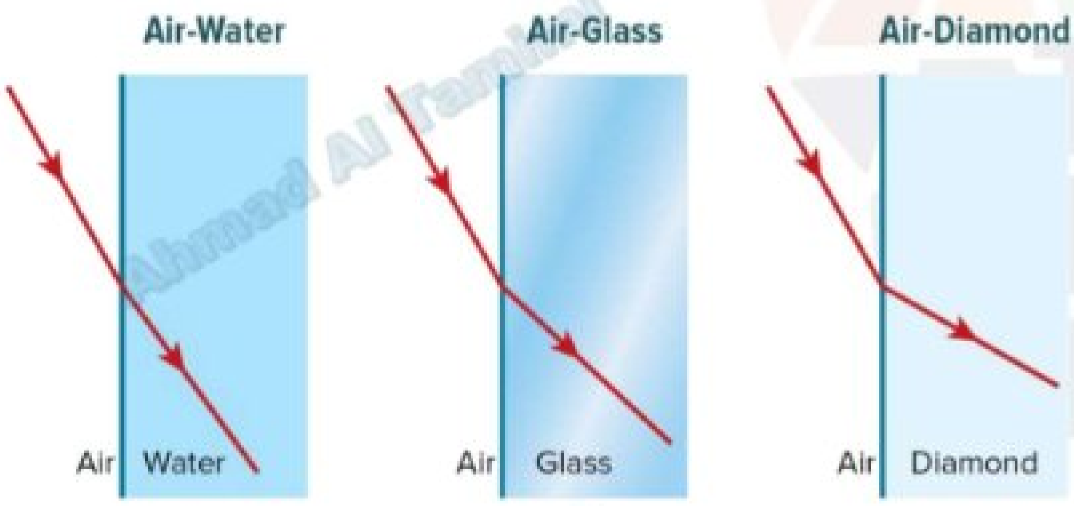
Question 96

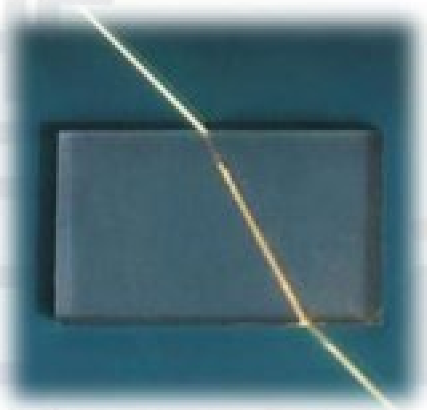
Which of the following can produce inverted images?

A	Convex mirror	B	Plane mirror
C	Concave lens	D	A and B

13	**Describe refraction of light (or a wave) as it crosses the boundary between two different mediums and represent that in a ray diagram.**	**Student Textbook**	**44,45**
14	**-Define the index of refraction of a medium and relate it to the properties of the medium.**	**Student Textbook**	**45**

- **Refraction** is the change in speed and direction of light when it crosses a boundary between two transparent mediums.



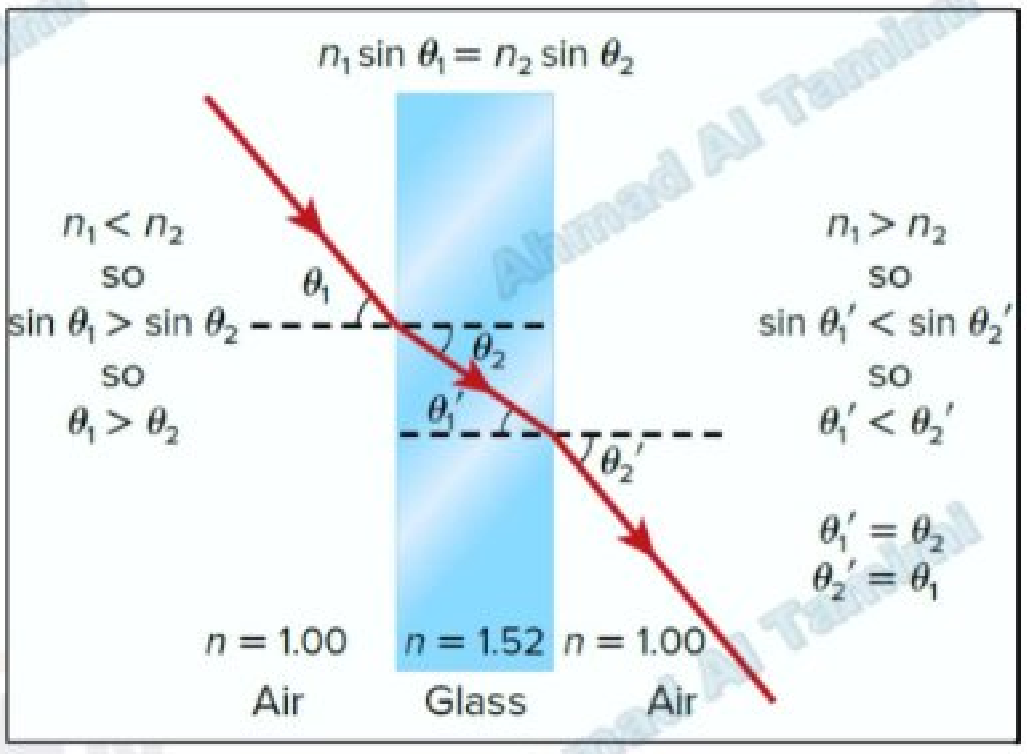


Medium	n
Vacuum	1.00
Air	1.0003*
Water	1.33
Ethanol	1.36
Float glass	1.52
Quartz	1.54
Flint glass	1.62
Diamond	2.42

- The **index of refraction (n)** tells us **how much slower** light travels in a material compared to in air (or vacuum). It determines the **speed** and **direction** of light entering it from another medium.

Bending of Light & Index of Refraction

- When light enters a medium with a **higher index of refraction (n↑)** → it **slows down** and bends **towards the normal**.
- When light enters a medium with **a lower index of refraction (n↓)** → it **speeds up** and bends **away from the normal**.
- If light enters **perpendicular (along the normal)** → it passes **straight through** with **no bending**.



- At the boundary, **frequency does not change**.
- When light slows down in a medium, its **wavelength decreases**.
- The **speed of light** is always slower in a <u>medium</u> than in a <u>vacuum</u>.
- Therefore, the **<u>wavelength in any medium is shorter than in a vacuum.</u>**

To find index of Refraction:

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

Where

c = speed of light in vacuum.
v = speed of light in the medium

Question 97

When light passes from air into water, it bends:

A	Toward the normal	B	Away from the normal
C	Does not bend at all	D	Parallel to the surface

Question 98

The reason for the bending of light during refraction is:

A	Change in wavelength only	B	Unequal reflection from the surface
C	Change in direction of the normal	D	Change in speed of light

Question 99

If the angle of incidence is 0°, the light ray:

A	Bends away from the normal	B	Bends toward the normal
C	Passes straight without deviation	D	Gets totally internally reflected

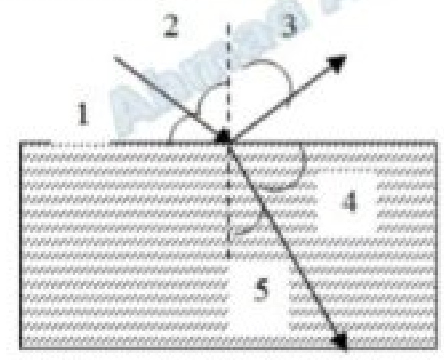
Question 100

When light passes from glass to air, which of the following increases?

A	Angle of refraction	B	Density of medium
C	Index of refraction	D	Angle of incidence

Question 101

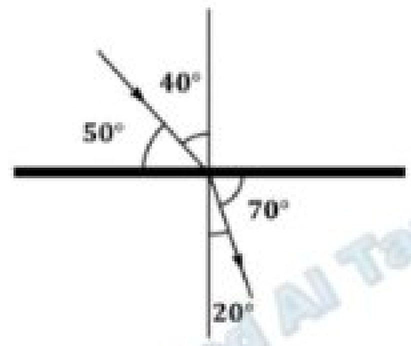
A beam of light passes from the air through a thick piece of glass as shown. Which of the following angles is the angle of refraction?



A	1	B	2
C	4	D	5

Question 102

The diagram shows the passage of a ray of light from air into a substance X. What is the angle of incidence?

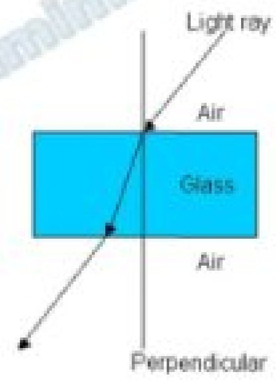


A	40°	B	50°
C	20°	D	70°

Question 130

What happens to the refracted beam when light passes through air to glass and then back to air?

$n_{glass} > n_{air}$



A	it refracts away and then toward the normal	B	it refracts toward and then toward the normal
C	it refracts toward and then away from the normal	D	it refracts away and then away from the normal

Question 104

What quantity do we get when dividing the speed of light in a vacuum by the speed of light in a medium?

A	the index of refraction of the medium	B	the critical angle
C	the wavelength of the light in the medium	D	the frequency of the light in the medium

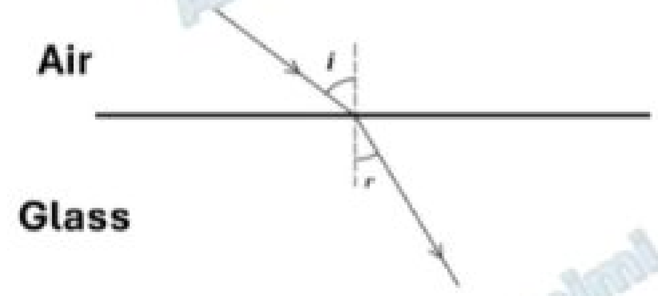
Question 105

A light beam falls perpendicular to a surface separating two transparent media with different refractive indices. Assume $n_r > n_i$. In this case, which of the following correctly describes the relationship between the angle of incidence θ_i and the angle of refraction θ_r?

A	$\theta_i > \theta_r$	B	$\theta_i < \theta_r$
C	$\theta_i = \theta_r = 90°$	D	$\theta_i = \theta_r = 0°$

Question 106

A ray of light enters a glass block and is refracted as shown in the figure. Why is the ray of light refracted towards the normal?



A	Because the refractive index of air is greater than that of glass	B	Because the refractive index of glass is greater than that of air
C	Because both air and glass have the same refractive index	D	Because the refractive index does not affect the bending of light

Question 107

Which of the following determines the angle of refraction of light as it crosses the boundary between two media?

A	The color of light only	B	The smoothness of the surface between the media
C	The index of refraction	D	The distance traveled by the light in each medium

Question 108

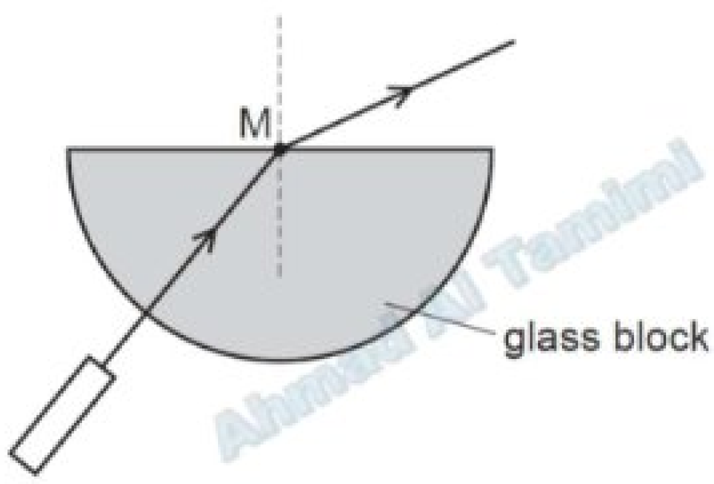
The ______ of light can change when light is refracted because the velocity changes.

A	Frequency	B	Medium
C	Transparency	D	Wavelength

Question 109

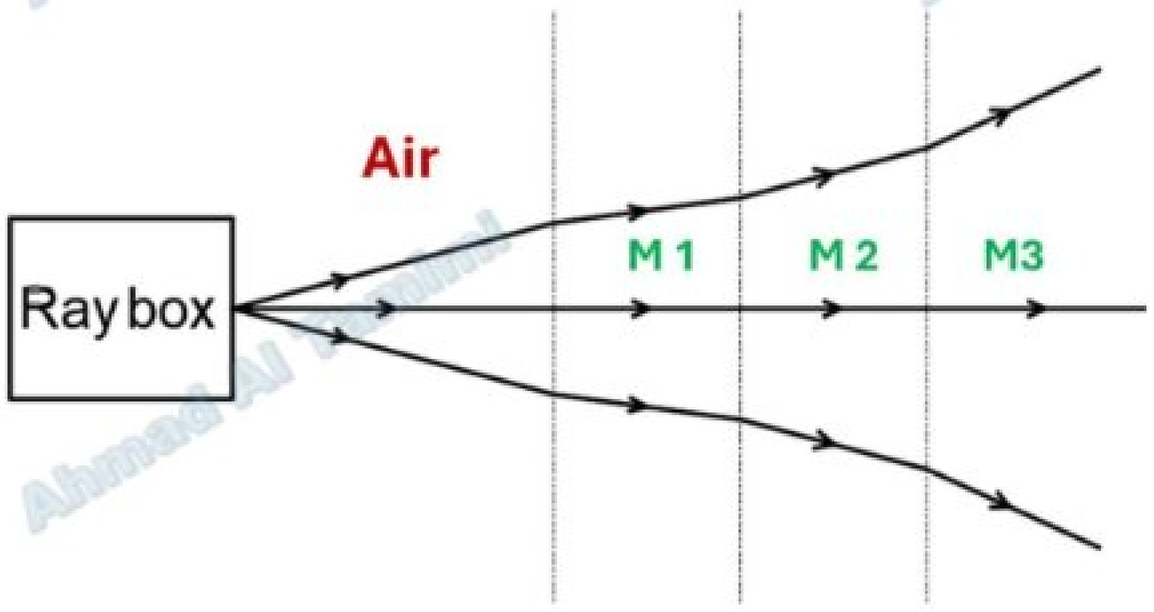
A ray of red light from a laser passes into a semi-circular glass block. What is shown at M?

A	Reflection
B	Rarefaction
C	Refraction
D	Dispersion



Question 110

The rays of light from a ray box pass through three transparent media separated by boundaries at positions 1, 2, and 3, as shown in the figure. Each boundary represents the interface between two different media. Use the given refractive indices to identify the possible material of each medium (M_1, M_2, M_3).

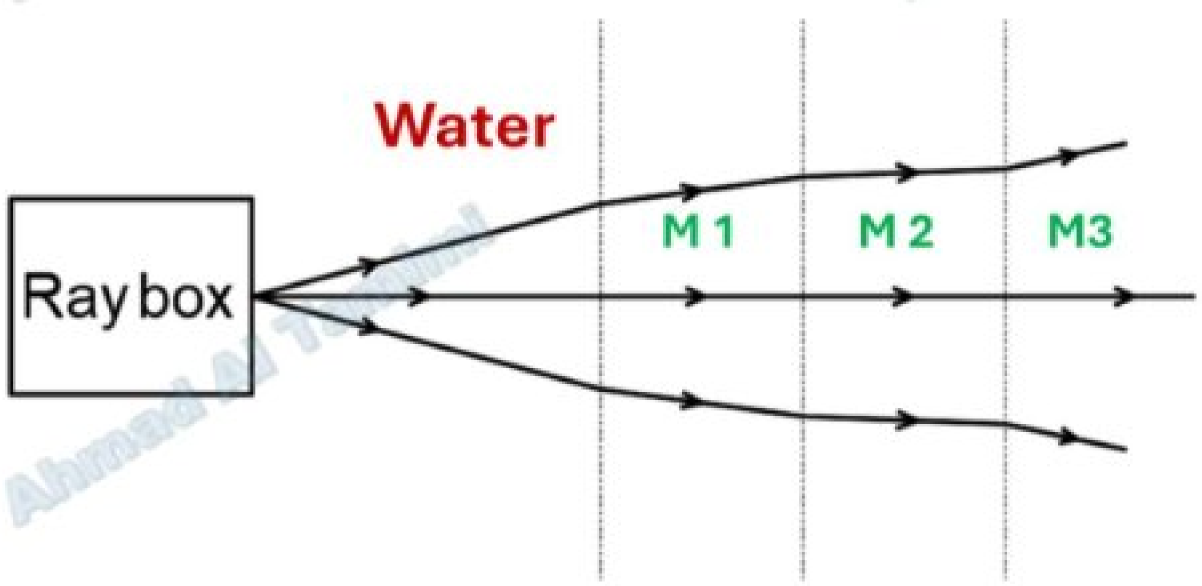


Medium	*n*
Vacuum	1.00
Air	1.0003*
Water	1.33
Ethanol	1.36
Float glass	1.52
Quartz	1.54
Flint glass	1.62
Diamond	2.42

	Medium 1	Medium 2	Medium 3
A	Vacuum	Ethanol	Float Glass
B	Float Glass	Ethanol	Air
C	Quartz	Ethanol	Flint Glass
D	Diamond	Float Glass	Quartz

Question 111

The rays of light from a ray box pass through three transparent media separated by boundaries at positions 1, 2, and 3, as shown in the figure. Each boundary represents the interface between two different media. Use the given refractive indices to identify the possible material of each medium (M_1, M_2, M_3).



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

	Medium 1	Medium 2	Medium 3
A	Air	Flint Glass	Quartz
B	Float Glass	Ethanol	Quartz
C	Float Glass	Flint Glass	Water
D	Diamond	Float Glass	Quartz

بطاقة الفيزياء
صف 12 متقدم
شرح أ. احمد التميمي

THE GARDEN ACADEMY

جاهز للنجاح وإطلاق إبداعاتك

- فيديوهات
- ملازم شرح
- أوراق عمل
- اختبارات

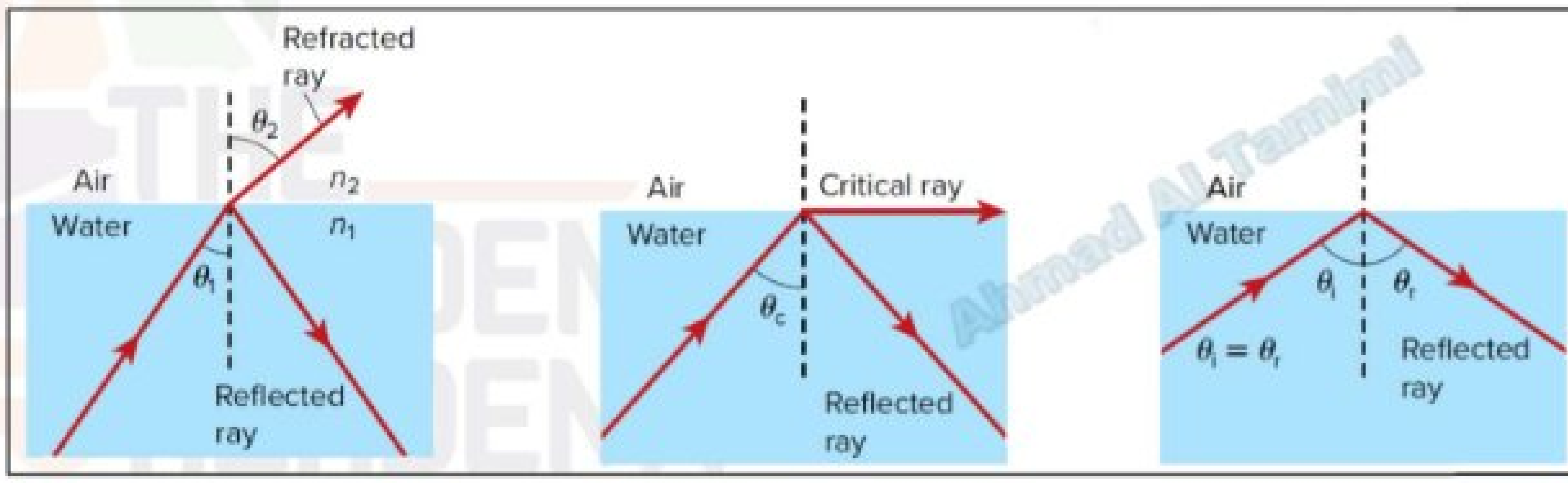
مراجعة تفصيلية شاملة للهيكل

للاشتراك في البطاقة واتساب الدعم
الفني للأكاديمية 0569174493

15	-Describe some applications of total internal reflection -Explain some natural phenomena, such as the formation of mirage or rainbows or others, which involve optical phenomena like reflection, refraction, total internal reflection, or dispersion of light.	Student Textbook	48,49
16	Define dispersion and explain the dispersion of light through a prism.	Student Textbook	49,50

- The **critical angle (θ_c)** is an angle of incidence that causes a ray to exit along the boundary between two mediums. ($\theta_r = 90°$)

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



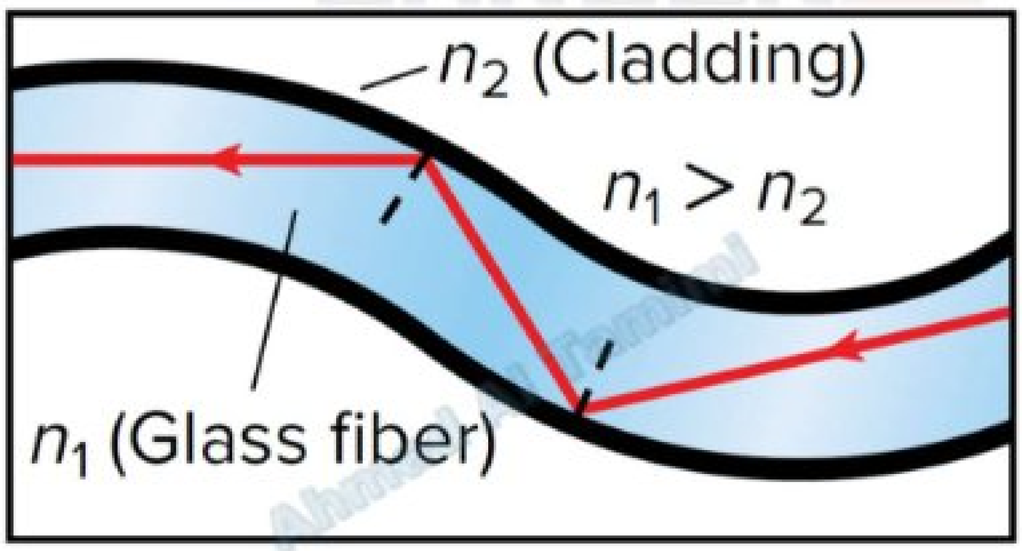
Total internal reflection happens when:

- Light goes from a medium with **higher index of refraction** → to a medium with **lower index of refraction.**
- The **angle of incidence θ_1 is greater than the critical angle θ_c.**

The light then reflects back inside the medium with the higher index of refraction.

- **Total internal reflection** is used in communication via **optical fibers**.
- Light travels through the transparent glass fiber core ($\mathbf{n_1}$) and always hits the internal boundary with the cladding ($\mathbf{n_2}$) at an angle greater than the **critical angle**.
- Since $\mathbf{n_1 > n_2}$, all the light is reflected back inside the fiber instead of escaping. **(Total internal reflection)**
- No light is transmitted through the cladding boundary. **(Cladding is the outer layer)**

  - Light pulses inside fiber optic cables can carry **large amounts of information**.
  - Fiber optics allow communication over **longer distances** compared to other methods.



Phenomenon	Cause / Conditions	Optical Principle(s)	Description of Light Behavior	Result / Observation
Mirage	Hot air near the road is **less dense** and has a **lower refractive index** than the cooler air above.	**Refraction** through air layers of **different refractive indices**	Light from the sky bends **gradually upward** toward the cooler air (higher n). The brain traces the bent rays as if coming from below.	A **virtual image** appears on the road, resembling **water or reflection** — an **optical illusion** due to **gradual refraction**.
Dispersion of Light	Occurs when **white light passes through a prism** or medium with **different refractive indices for different wavelengths.**	**Refraction and Dispersion**	Shorter wavelengths (violet) bend more than longer ones (red) because they **slow down more** in the medium.	White light separates into a **spectrum of colors** — **ROYGBIV**
Rainbow Formation	**Sunlight enters raindrops**, refracting, reflecting, and dispersing within them. Each droplet acts as a tiny **prism and mirror.**	**Refraction, Reflection, and Dispersion**	Light refracts entering the drop, reflects internally, then refracts again exiting. **Different colors** emerge at slightly **different angles.**	A **spectrum-shaped arc** (rainbow) appears in the sky. A **secondary rainbow** may form with **reversed colors** and **lower brightness** due to **two internal reflections.**

Question 112

If a ray of light is incident upon an air surface from another medium at an angle greater then the critical angle, the ray will______.

A	Partly refract and partly diffract	B	Partly refract and partly reflect
C	Reflect, only	D	Refract, only

Question 113

The critical angle for a beam of light passing from water into air is 49° . Which of the following statements is true for a beam of light with an incident angle less than the critical angle ?

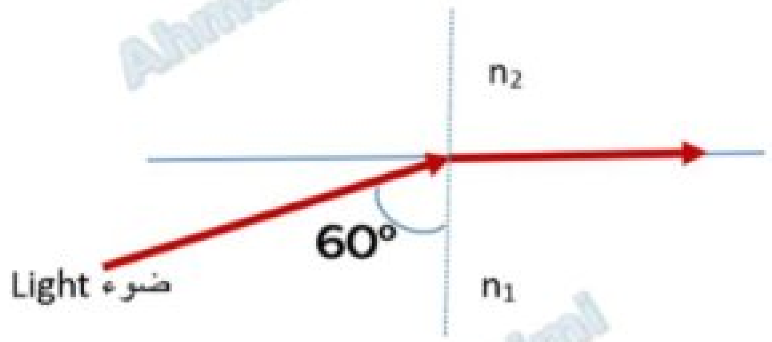
A	The beam will all be absorbed	B	The beam will be totally reflected
C	The beam will be partially reflected and partially refracted	D	The beam will be totally transmitted

Question 114

What is the critical angle for light passing from mineral oil ($n = 1.47$) to air ($n = 1$)?

A	42.9°	B	90°
C	64.8°	D	25.2°

According to the figure. Which of the following is correct?



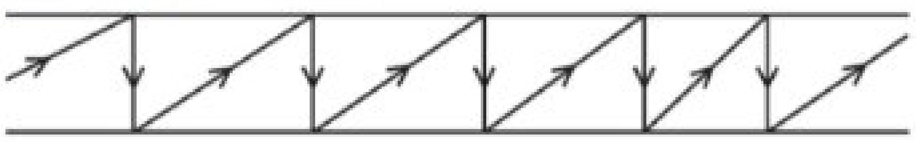
A	$\theta_c = 60°$
B	$\theta_c = 90°$
C	$n_1 = n_2$
D	$n_1 < n_2$

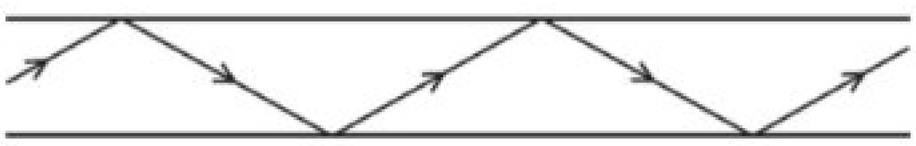
What occurs to a light ray, when it falls at an incidence angle of (50.0^0) from water to air?
$(n_{water} = 1.33 , n_{air} = 1.0)$

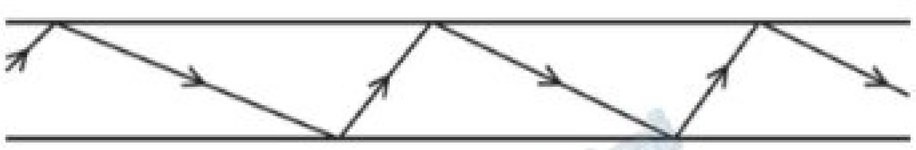
A	Refracts along the boundary
B	Reflects internally in total
C	Refracts in air by an angle less than (50°)
D	Refracts in air by an angle greater than (50°)

Question 115

A plastic tube is immersed in a liquid of refractive index 1.4. Light travelling in the plastic tube strikes the inside surface at an angle of incidence of 70°. The light undergoes total internal reflection. What describes the values of the critical angle in the plastic and the refractive index of the plastic?

A


B


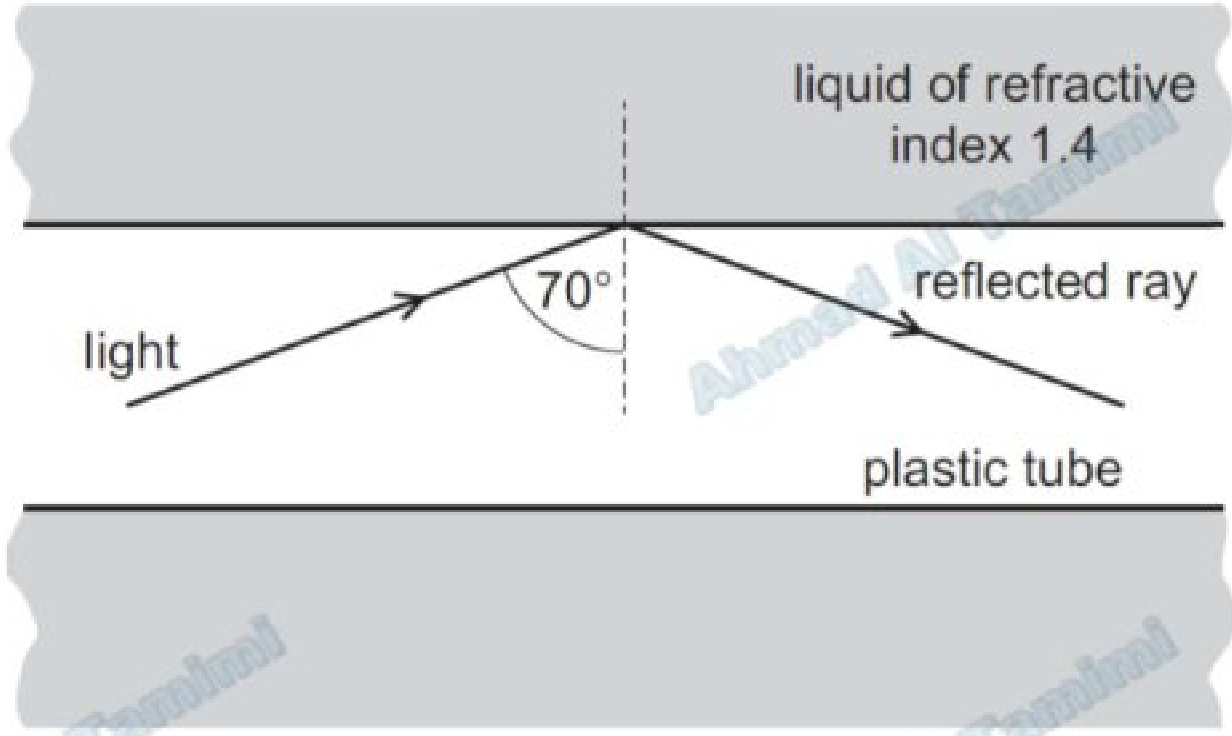
C


D


Question 116

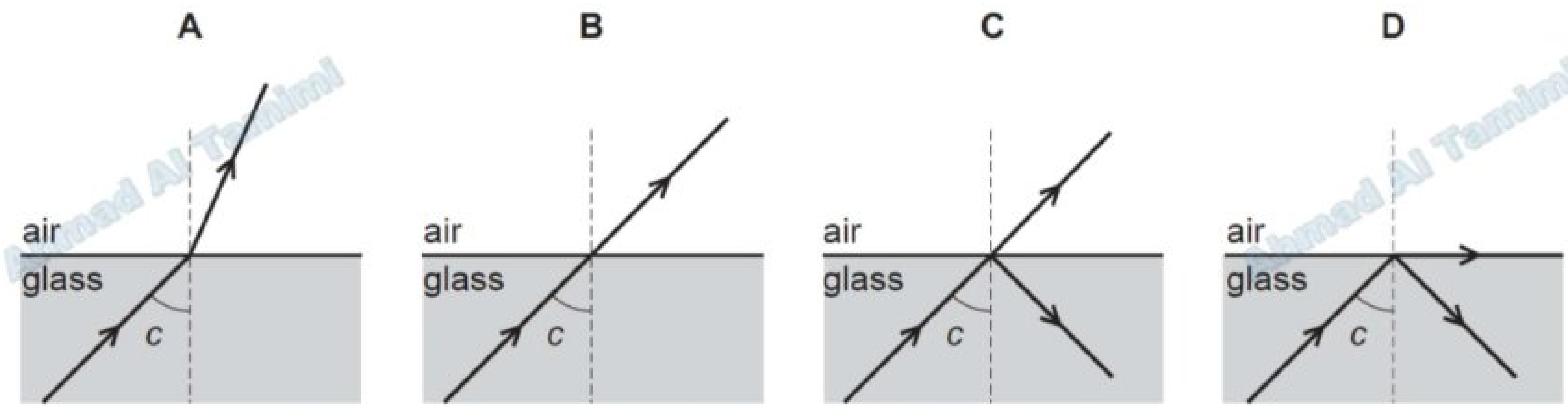
A plastic tube is immersed in a liquid of refractive index 1.4. Light travelling in the plastic tube strikes the inside surface at an angle of incidence of 70°. The light undergoes total internal reflection. What describes the values of the critical angle in the plastic and the refractive index of the plastic?

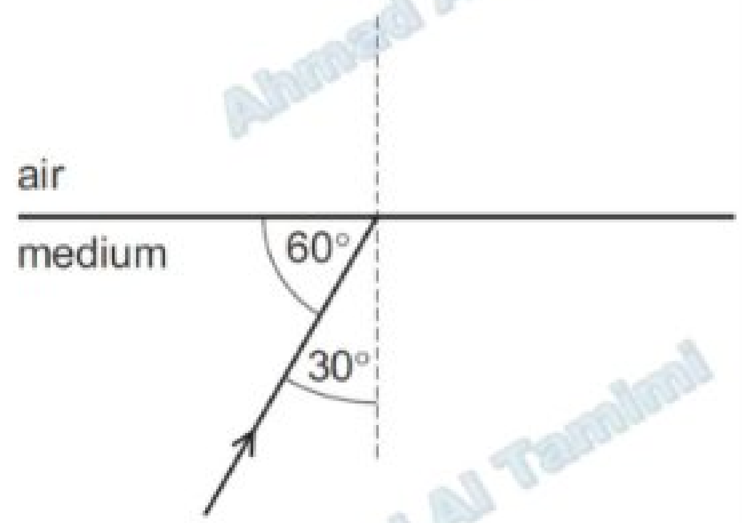
	critical angle in plastic	refractive index of plastic
A	greater than 70°	greater than 1.4
B	greater than 70°	less than 1.4
C	less than 70°	greater than 1.4
D	less than 70°	less than 1.4



Question 117

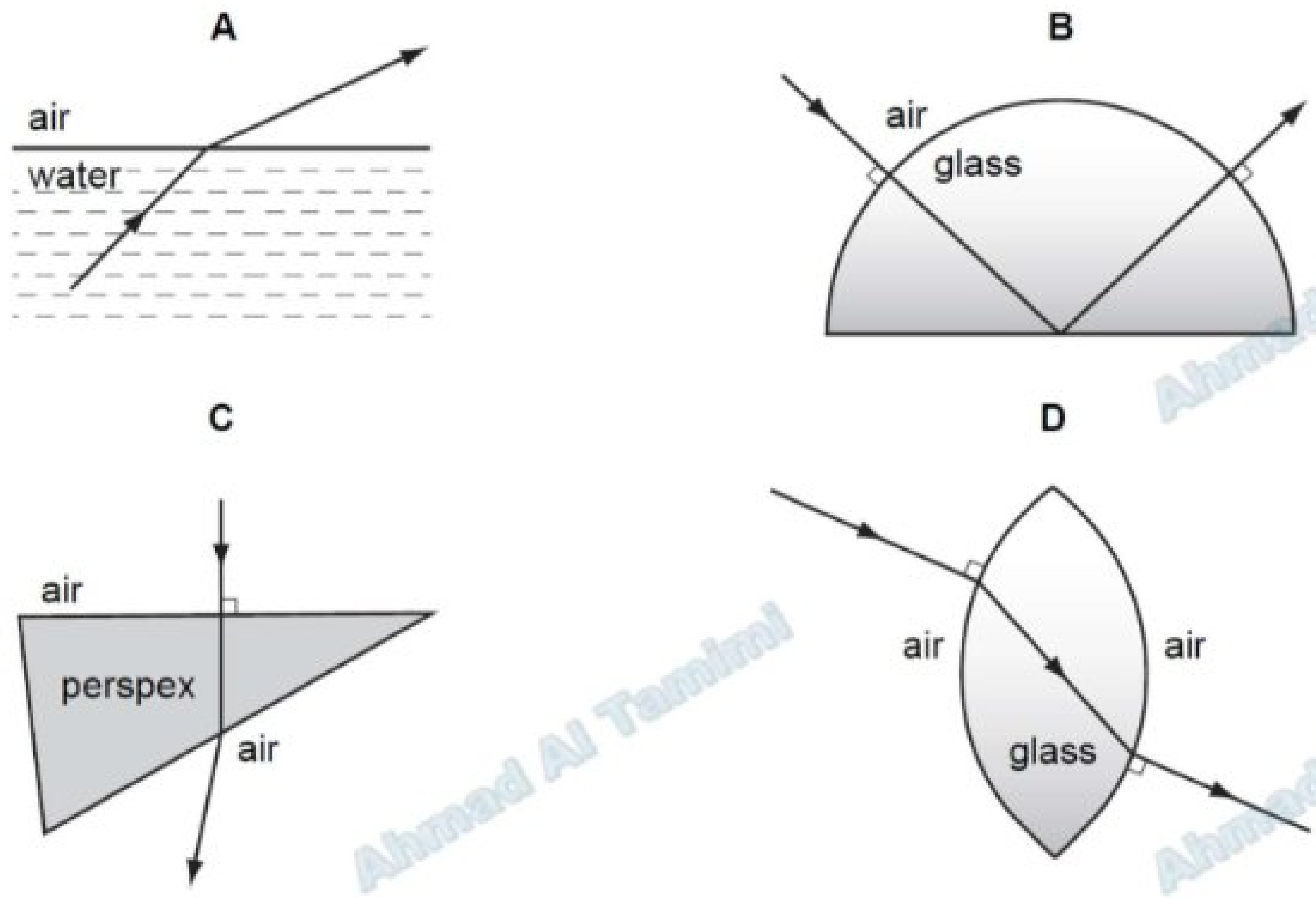
A ray of light in glass is incident on the surface at an angle *c*. The angle *c* is the critical angle. Which diagram shows what happens to the light?



Question 118				
A ray of light in a transparent medium of refractive index 1.8 is incident on the surface as shown. The light enters air. What is the angle between the refracted ray and the normal in air?				
A	29°	B	33°	
C	54°	D	64°	

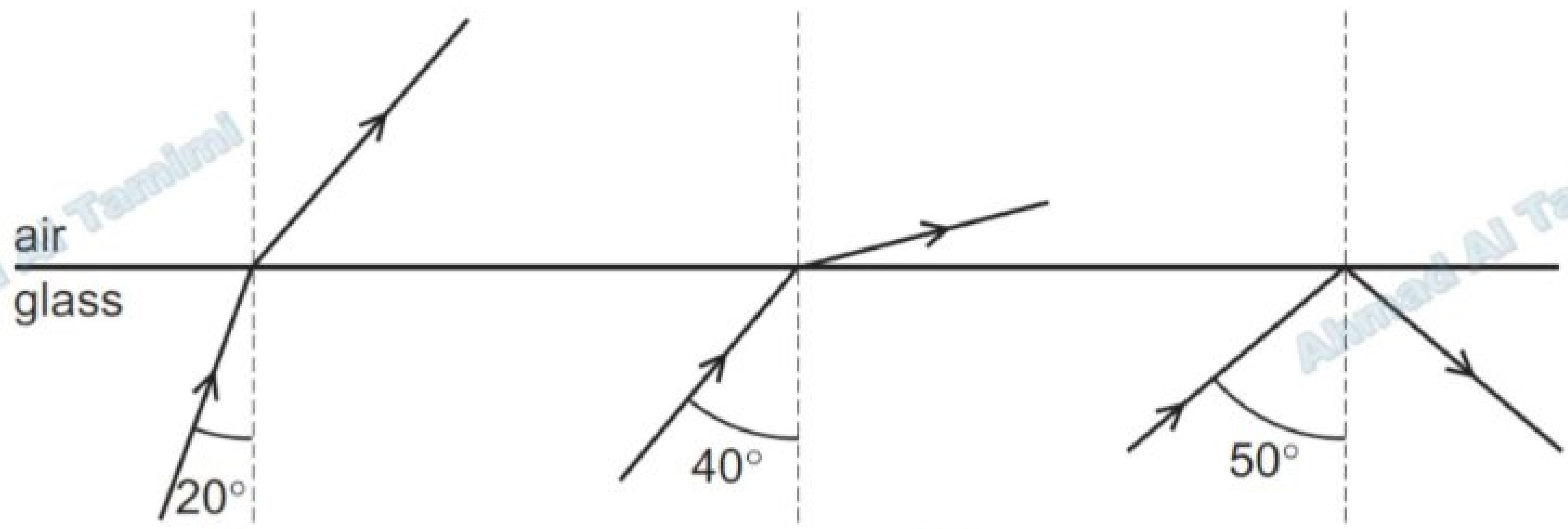
Question 119

In which diagram is the path of the light ray not correct?



Question 120

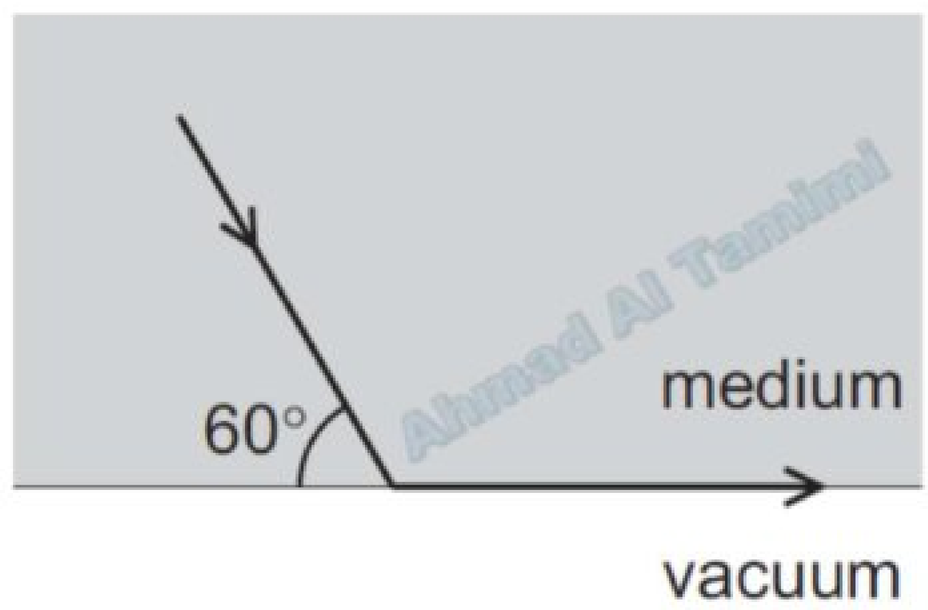
Three rays of light are incident on the boundary between a glass block and air. The angles of incidence are different.



A	15°	B	30°	C	45°	D	60°

Question 121

Three rays of light are incident on the boundary between a glass block and air. The angles of incidence are different.

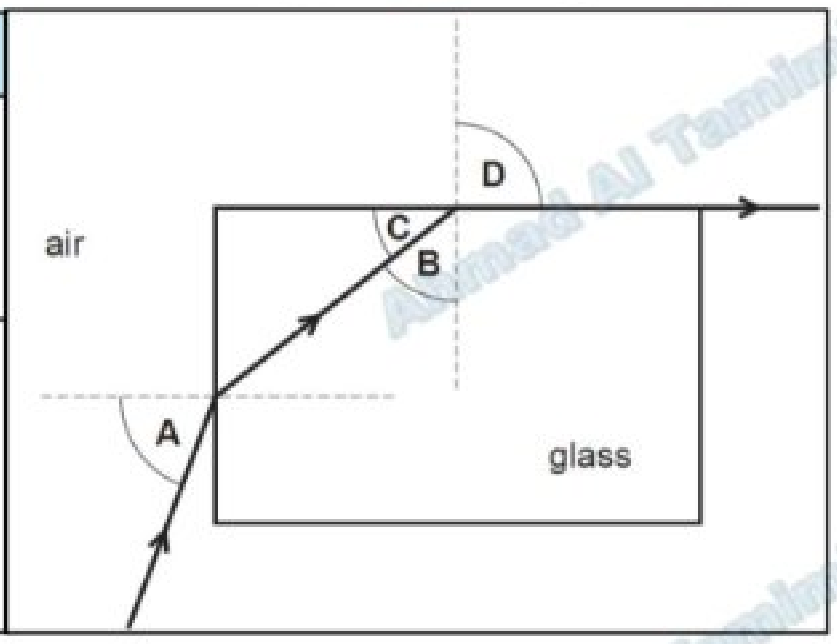


A	$\frac{\sin 60°}{\sin 30°}$	**B**	$\frac{\sin 60°}{\sin 90°}$	**C**	$\frac{\sin 90°}{\sin 30°}$	**D**	$\frac{\sin 90°}{\sin 60°}$

Question 122

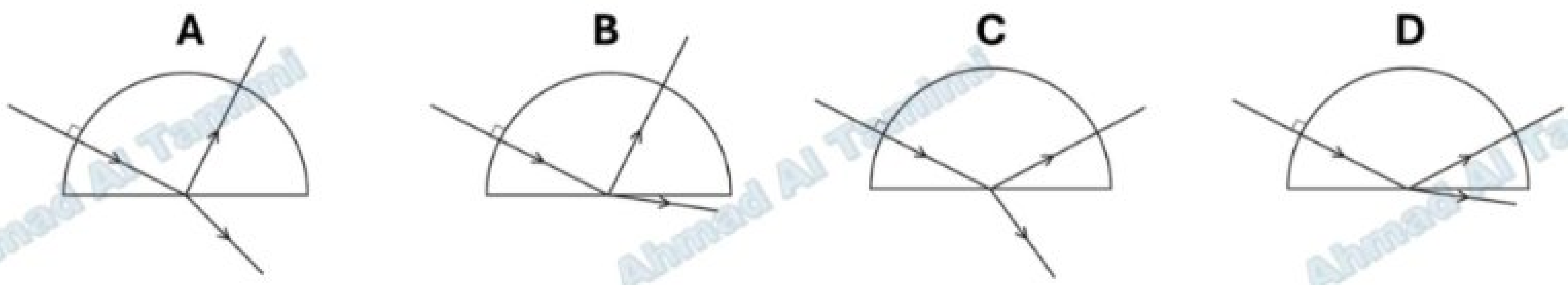
Light travels through a glass block as shown. Which angle is the critical angle for light in the glass?

A	B	C	D



Question 123

Light travels through a glass block as shown. Which angle is the critical angle for light in the glass?



Question 124

When driving on a hot day, the road ahead looks like it is covered with water. What causes this illusion?

A	Reflection of light from the road surface	B	Diffraction of sunlight through air
C	Refraction of light through air layers with different temperatures	D	Scattering of light by dust particles

Question 125

In a mirage, light bends upward because:

A	Cooler air is near the road	B	Hot air near the road has a lower refractive index
C	The road reflects light strongly	D	The cooler air below has higher density

Question 126

When white light passes through a glass prism, the violet light deviates more than red light because:

A	Violet light travels faster in glass	B	Violet light has a higher refractive index in glass
C	Red light interacts more strongly with the glass	D	The prism shape amplifies shorter wavelengths only

Question 127

A rainbow is produced because light in raindrops undergoes:

A	Only refraction	B	Refraction and diffraction
C	Refraction, internal reflection, and dispersion	D	Scattering and polarization

Question 128

A secondary rainbow appears outside the primary one and has reversed colors because:

A	The light passes through larger droplets	B	The sunlight contains higher intensity red light
C	The light undergoes two internal reflections inside raindrops	D	The air refractive index increases with height

Question 129

A scientist observes three different light behaviors:

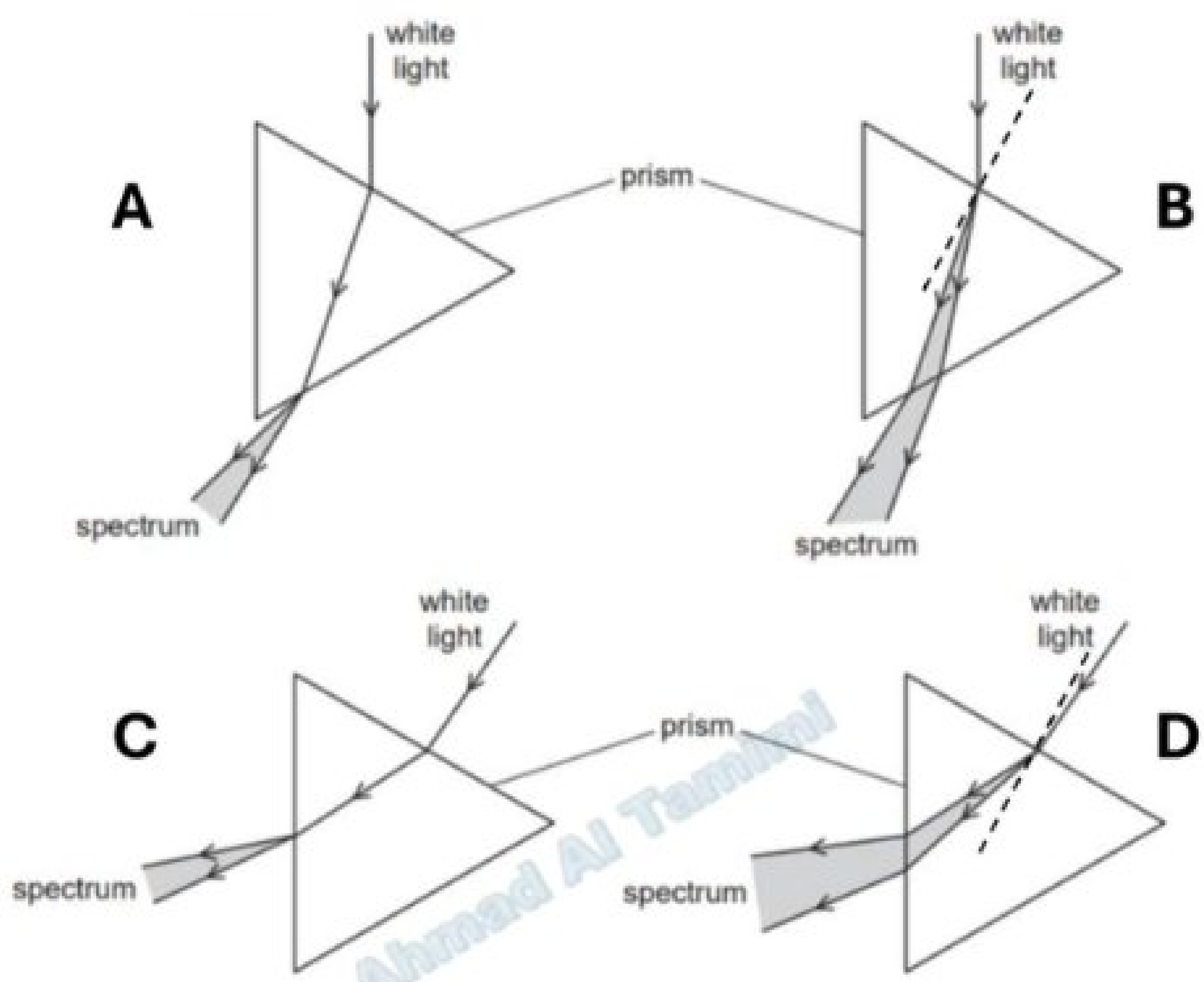
1. **Mirage on hot summer days.**
2. **The interaction of white light with glass prism.**
3. **Rainbows after rain.**

He decides to test which phenomenon depends on **both refraction and reflection** of light.
Which of the following correctly identifies the phenomenon he should study?

A	Mirage only	B	Dispersion through a prism
C	Rainbow formation	D	All three depend equally on reflection and refraction

Question 130

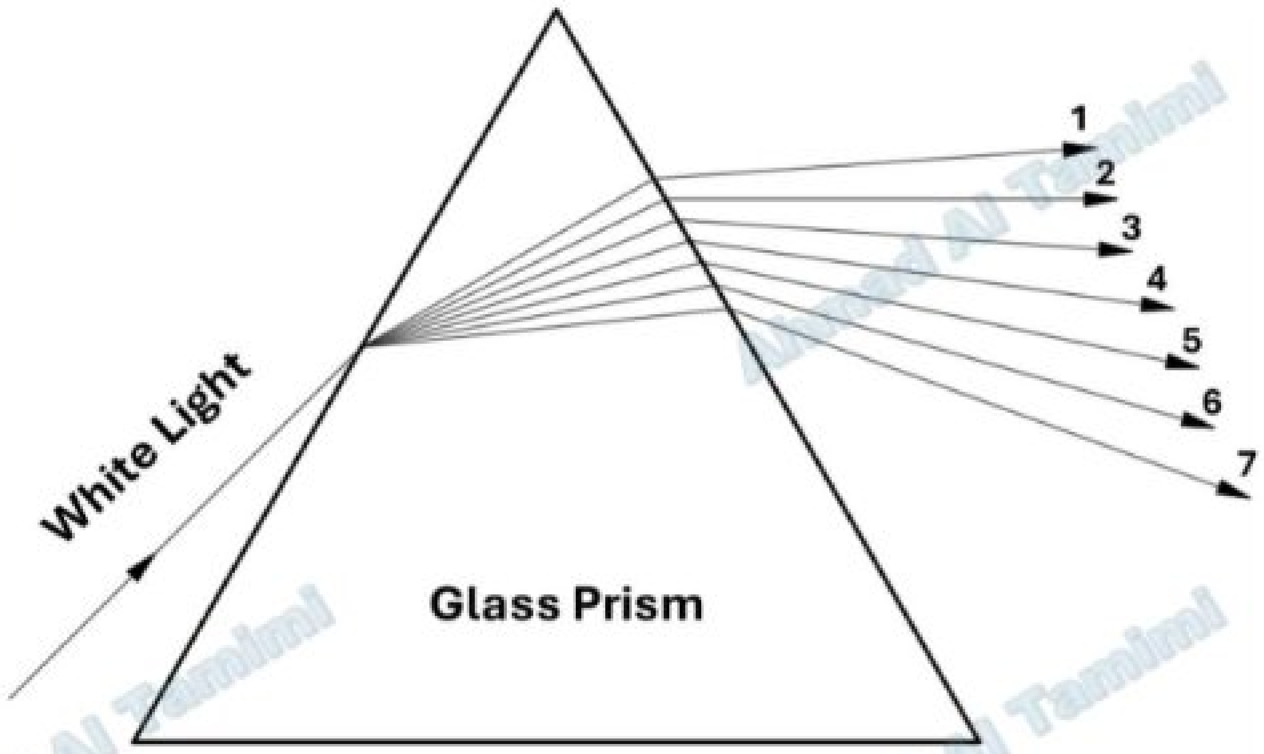
A teacher demonstrates the dispersion of white light using a triangular glass prism. Which diagram correctly shows how white light splits into its component colors as it passes through the prism?



Question 131

According to the figure, white light passes through a triangular glass prism and disperses into seven colors (rays 1–7). Choose the correct answer based only on the figure.

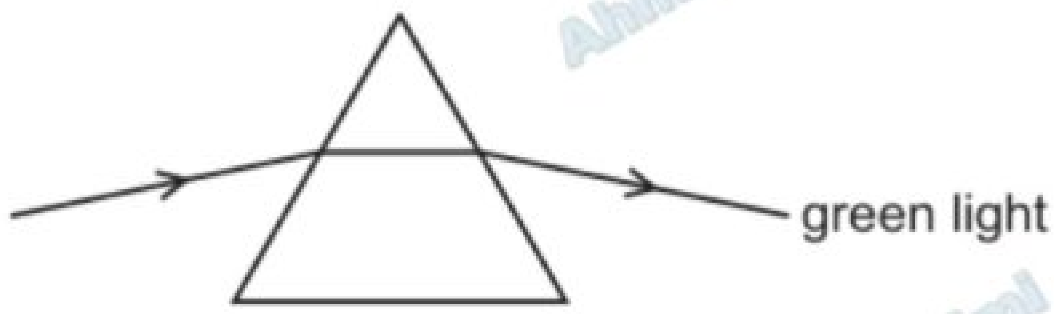
	Ray 1	Ray 7	n_1	n_7
A	Red	Violet	1.51	1.53
B	Red	Violet	1.53	1.51
C	Violet	Green	1.53	1.51
D	Green	Violet	1.51	1.53



Question 132

A ray of green light passes through a glass prism, as shown. Which colors of light refract as shown in the table?

	refracts more than green	refracts less than green
A	red	blue
B	red	yellow
C	violet	blue
D	violet	yellow



Question 133

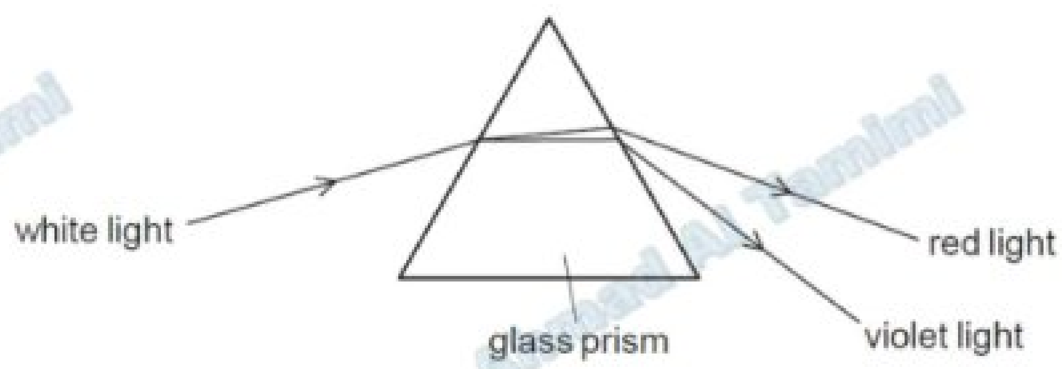
The diagram shows the dispersion of white light by a glass prism. Why does dispersion occur when white light enters the glass?

A The frequency of red light decreases more than that of violet light.

B The frequency of violet light decreases more than that of red light.

C The speed of red light decreases more than that of violet light.

D The speed of violet light decreases more than that of red light.

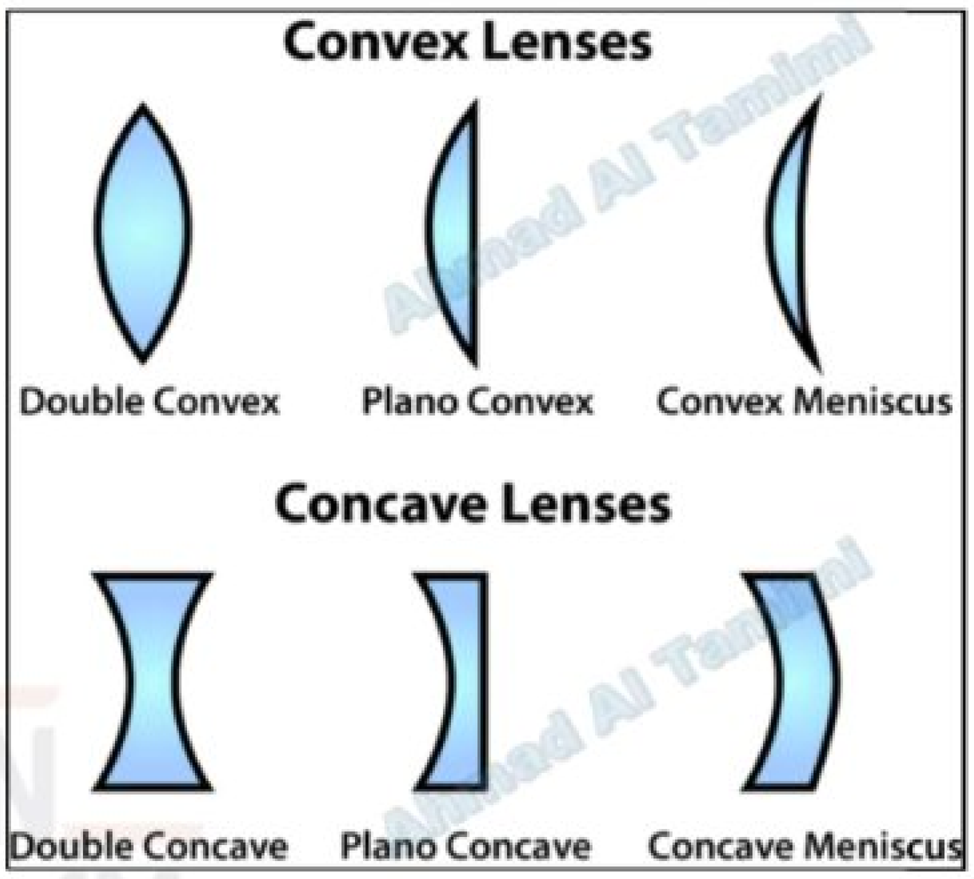


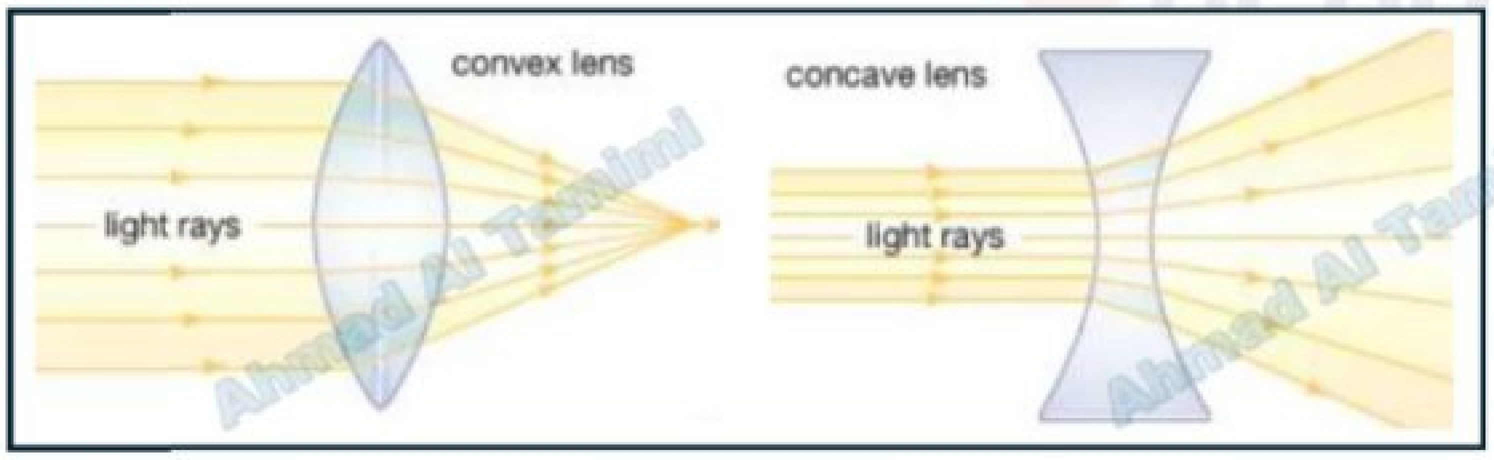
17	-Distinguish between a convex (converging) lens and a concave (diverging) lens. --Compare and contrast convex and concave lenses regarding the properties of images formed and the algebraic signs for different quantities involved.	Student Textbook Check your progress 50	51, 54 60

Lens Type	Focal Length (f)	Object Location (x_o)	Image Location (x_i)	Image Size (Height)	Image Type	Orientation (Attitude)	Magnification (m)
Convex (Converging)	+	$x_o > 2f$	$2f > x_i > f$	Reduced (diminished)	Real	Inverted	−
		$x_o = 2f$	$x_i = 2f$	Same size	Real	Inverted	−
		$2f > x_o > f$	$x_i > 2f$	Enlarged (magnified)	Real	Inverted	−
		$x_o = f$	At infinity	Highly enlarged (blurred)	Real	Inverted	−
		$f > x_o > 0$	$\|x_i\| > x_o$ (negative)	Enlarged (magnified)	Virtual	Upright	+
Concave (Diverging)	−	$x_o > 0$	$\|f\| > \|x_i\| > 0$ (negative)	Reduced (diminished)	Virtual	Upright	+

Feature	Convex Lens	Concave Lens
Shape	Thicker at the center, thinner at the edges	Thinner at the center, thicker at the edges
Alternate Name	Converging lens	Diverging lens
Refraction Behavior	Refracts parallel rays to meet (converge) at a focal point	Refracts parallel rays to spread out (diverge) as if from a focal point behind the lens
Image Formed	Can be real or virtual depending on object position	Always forms a virtual, upright, and smaller image

A convex lens acts as a converging lens and a concave lens acts as a diverging lens only when the surrounding medium has a lower refractive index than the lens material (e.g., glass in air).



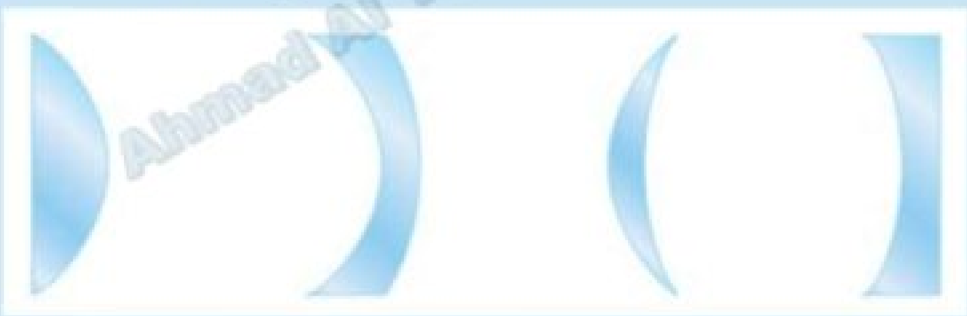



Concave Lens


Convex Lens

Check Your Progress Page 60

50. **Types of Lenses** The cross sections of four different thin lenses are shown in **Figure 38.**
   a. Which of these lenses, if any, are convex, or converging, lenses?
   b. Which of these lenses, if any, are concave, or diverging, lenses?

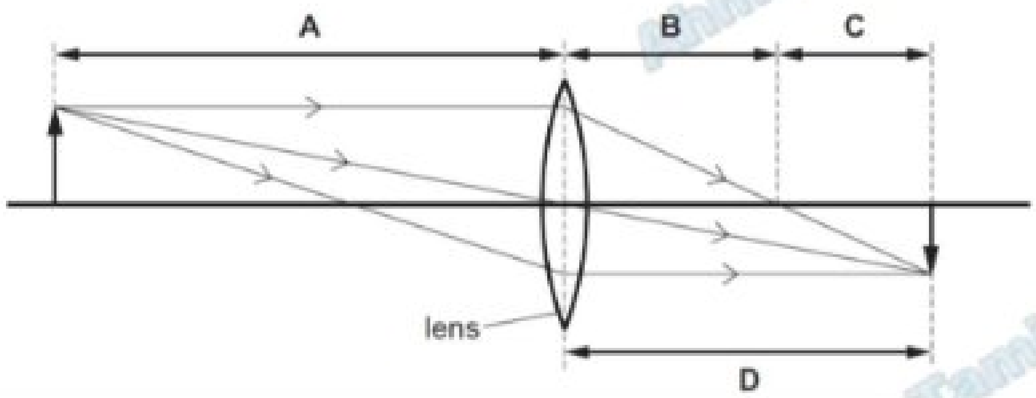


Question 134

Which length is the focal length of the lens shown in the diagram?

طريقة رسم ال Ray Diagram تم شرحها
بالتفصيل فى الجزء الورقى من الامتحان

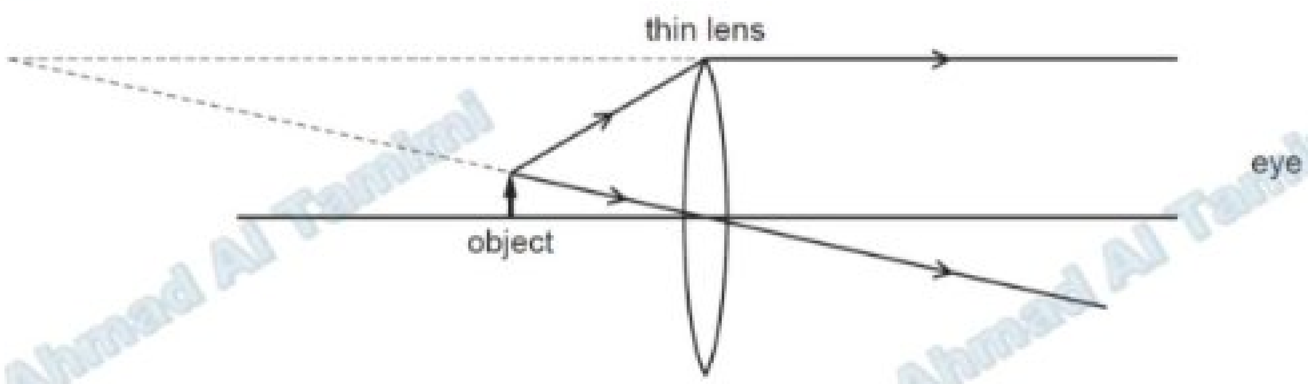
A	B	C	D



Question 135

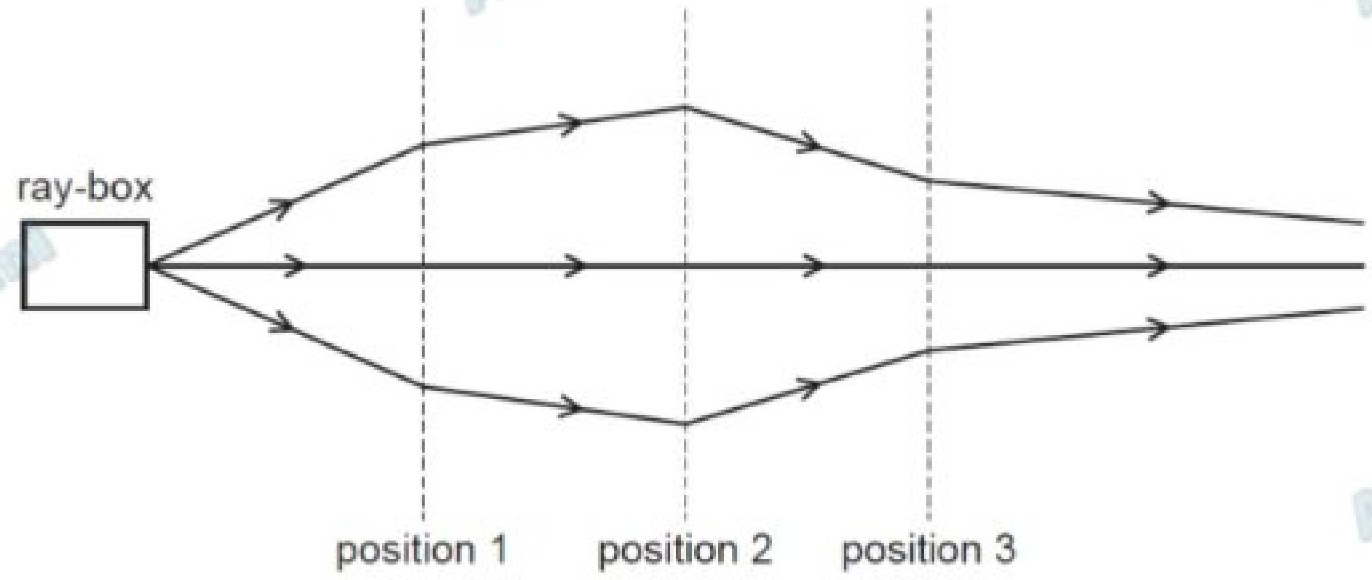
Light travels through a glass block as shown. Which angle is the critical angle for light in the glass?

A It is larger and inverted.
B It is larger and upright.
C It is smaller and inverted.
D It is smaller and upright.



Question 136

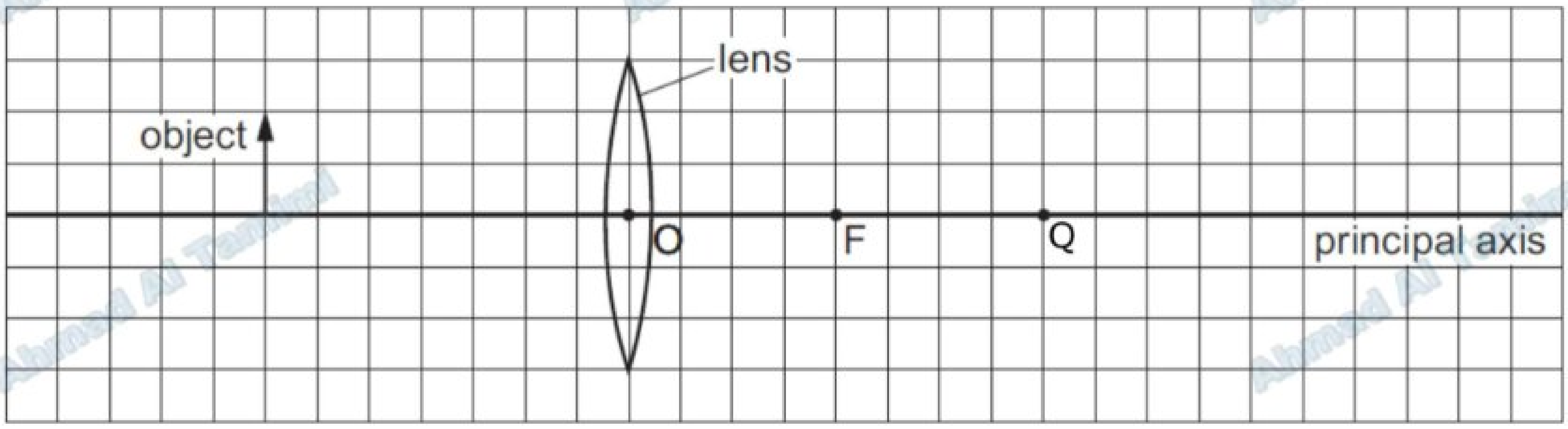
The rays of light from a ray-box pass through three lenses placed at positions 1, 2 and 3. What type of lens is used at each position?



	Position 1	Position 2	Position 3
A	Converging	Converging	Converging
B	Converging	Converging	Diverging
C	Diverging	Diverging	Converging
D	Diverging	Diverging	Diverging

Question 137

The diagram shows an object on the principal axis of a converging (convex) lens. A principal focus of the lens is at F. Where is the image formed by the lens?

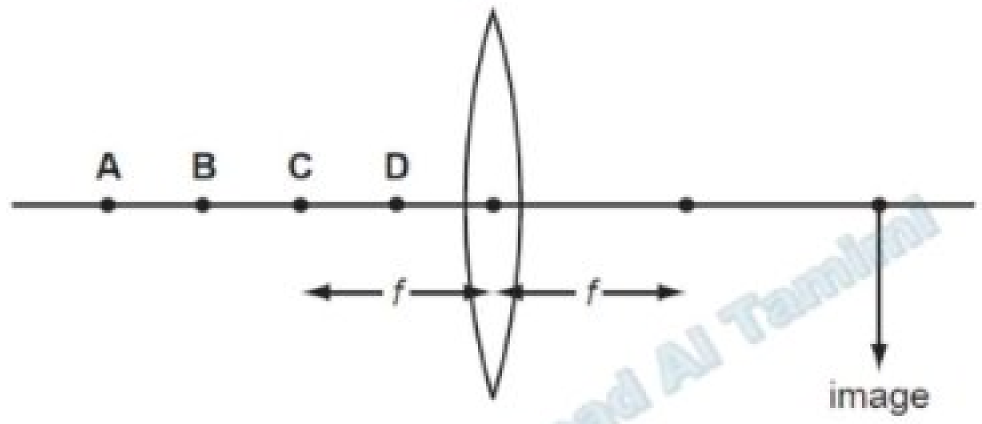


A	Between O and F
B	Between F and Q
C	At Q
D	To the right of Q

Question 138

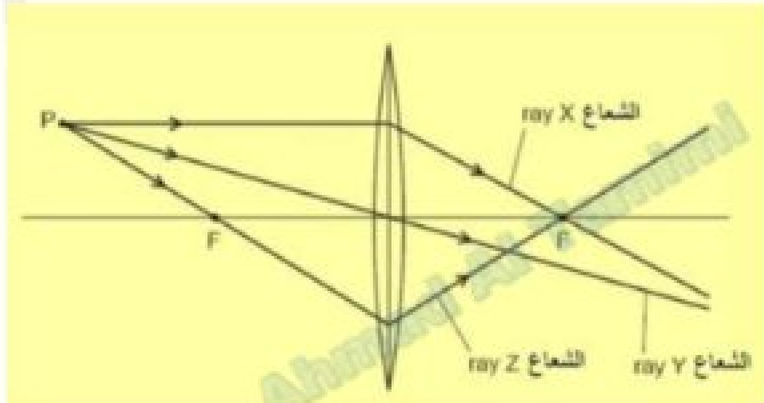
The diagram shows a thin converging lens of focal length f. Where must an object be placed to produce a real image in the position shown?

A	B	C	D



Question 139

A student draws three rays of light from point (p) through a converging lens. Which of the rays are drawn incorrectly?



A	Ray (X) and ray (Y)	B	Ray (X) only
C	Ray (Z) and ray (Y)	D	Ray (Z) only

Question 140

Which of the following can produce images that are enlarged and virtual?

A	Convex mirror	B	Plane mirror
C	Concave lens	D	Convex lens

Question 141

Which of the following can produce images that are inverted?

A	Convex mirror	B	Convex lens
C	Concave lens	D	None of the above

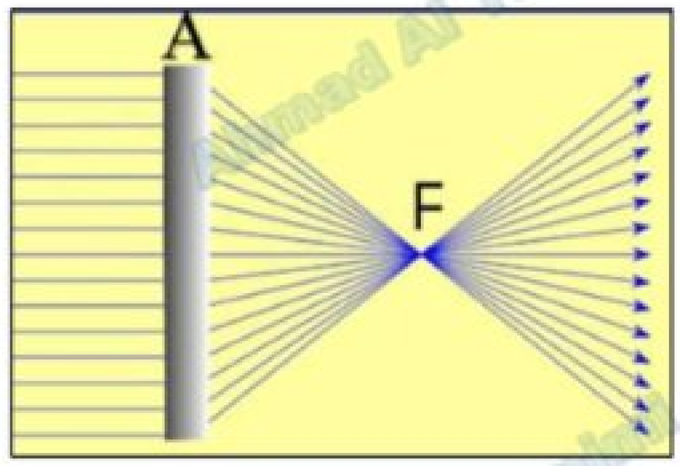
Question 142

Which of the following statements about a concave lens is true?

A	Its focal length is positive	B	Its focal length is negative
C	Displays real images	D	It has infinity focal length

Question 143

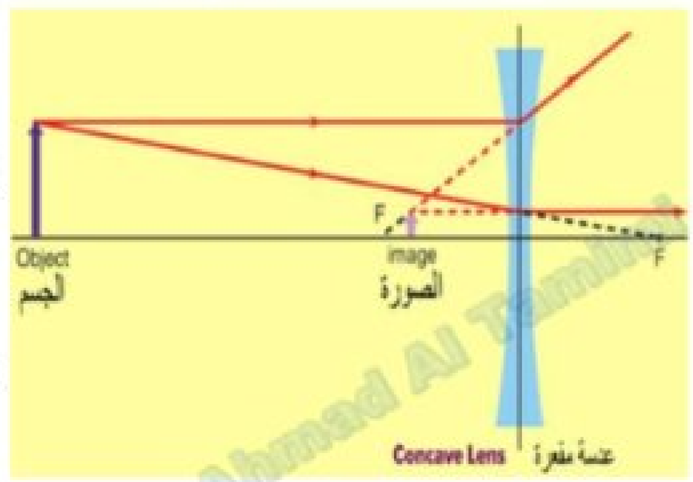
Which of the following optical devices can be found hidden under piece A?



A	Convex mirror	B	Concave mirror
C	Convex lens	D	Concave lens

Question 144

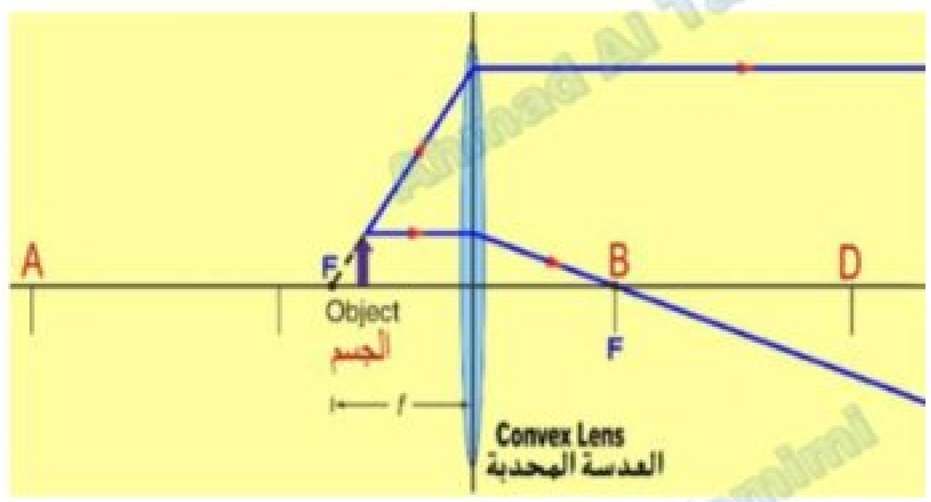
As shown in the figure, an object is placed in front of the concave lens. What happens to the image's properties as the object gets closer to the image?



A	Stay the same	B	Appear behind the lens
C	Become enlarged	D	Become inverted

Question 145

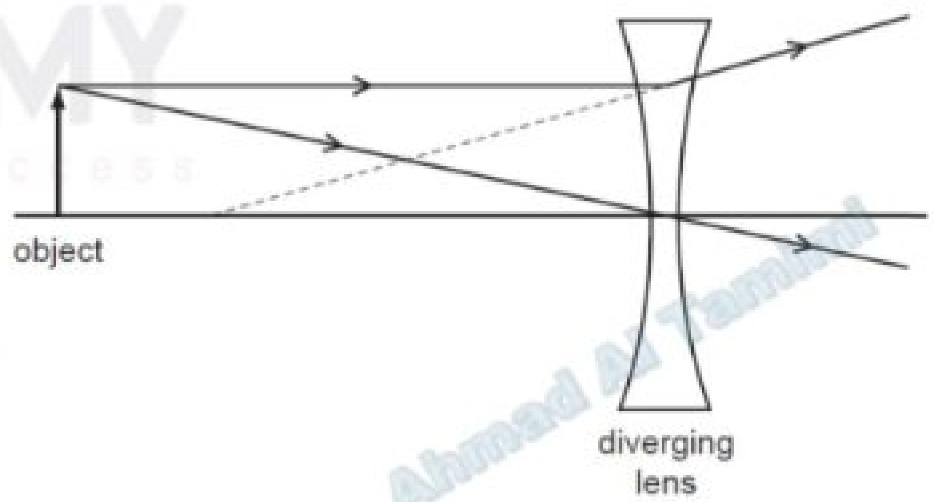
An object placed in front of the convex lens as shown in the figure. Determine the location of the image (if any)?



A	Position B
B	No image is found
C	Position D
D	Position A

Question 146

The ray diagram shows two rays from a point on an object placed in front of a diverging (concave) lens. What are the properties of the image produced?



A	real and larger than the object
B	real and smaller than the object
C	virtual and larger than the object
D	virtual and smaller than the object

Question 147

What is the characteristic of image formed by a convex lens that is placed at the focal length of the lens?

A	Virtual	B	Upright
C	Reduced	D	No image can be found

Question 148

Which of the following is a characteristic of the image formed by a concave lens?

A	Upright	B	Inverted
C	Real	D	Enlarged

Question 149

Which of the following can burn a piece of paper by sunlight?

A	A convex lens	B	A concave lens
C	A convex mirror	D	A plane mirror

Question 150

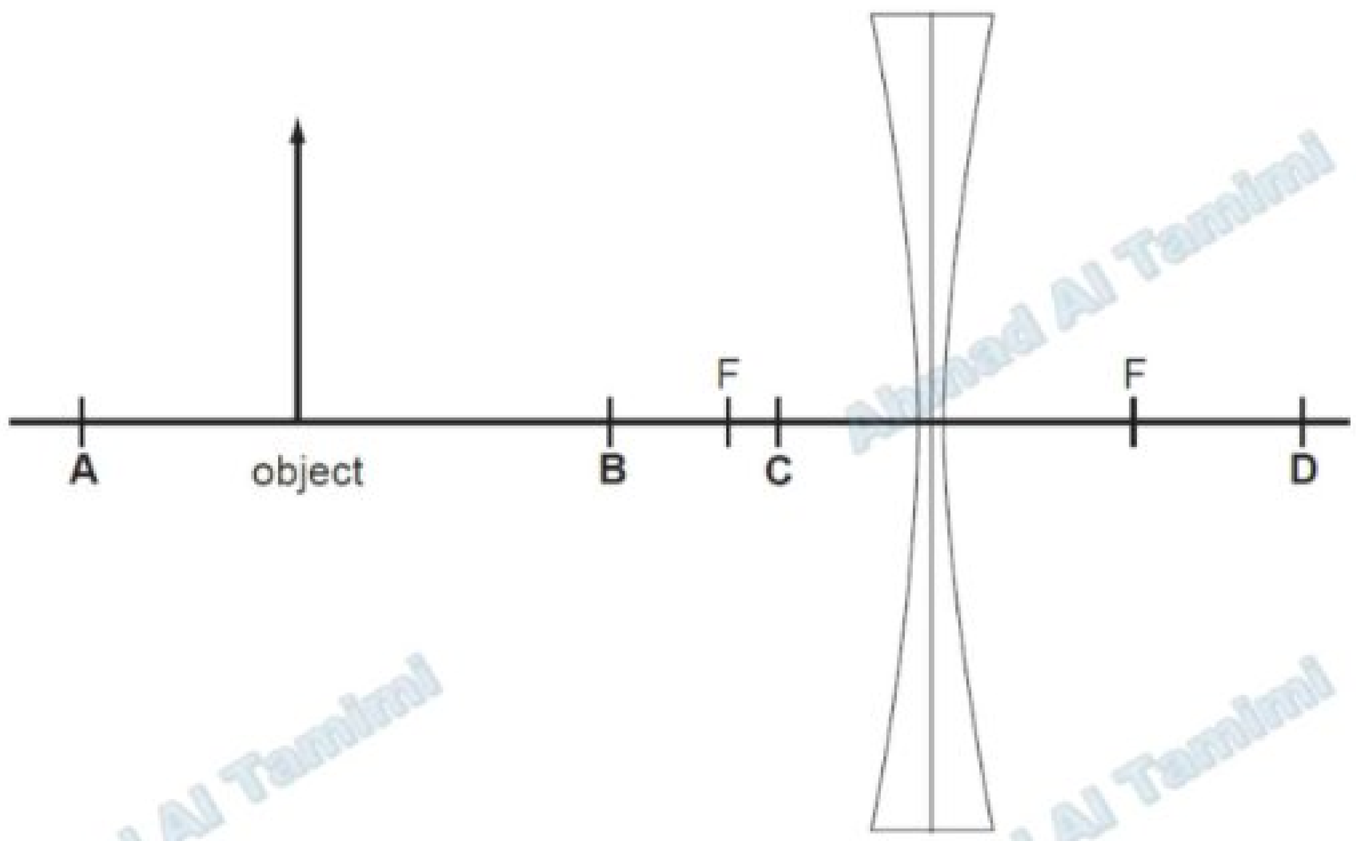
The radius of curvature of a lens is _______ times the focal length of the lens.

A	2.0	B	1.5
C	0.5	D	4.0

Question 151

An object is placed in front of a diverging lens as shown on the scale diagram. The principal focus F is marked on each side of the lens. At which position will the image be formed?

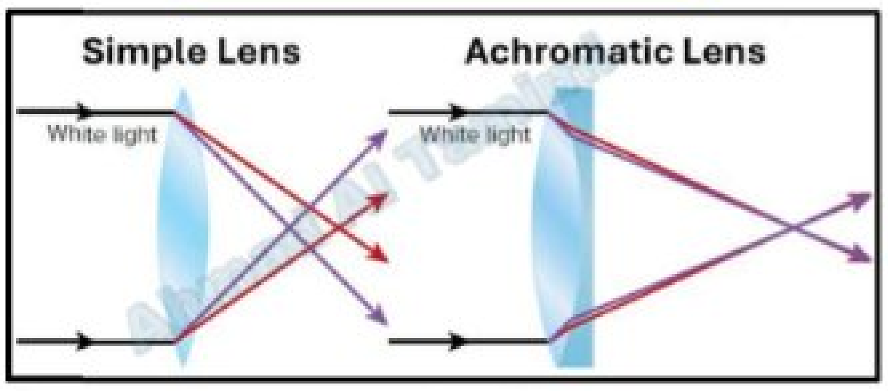
A
B
C
D



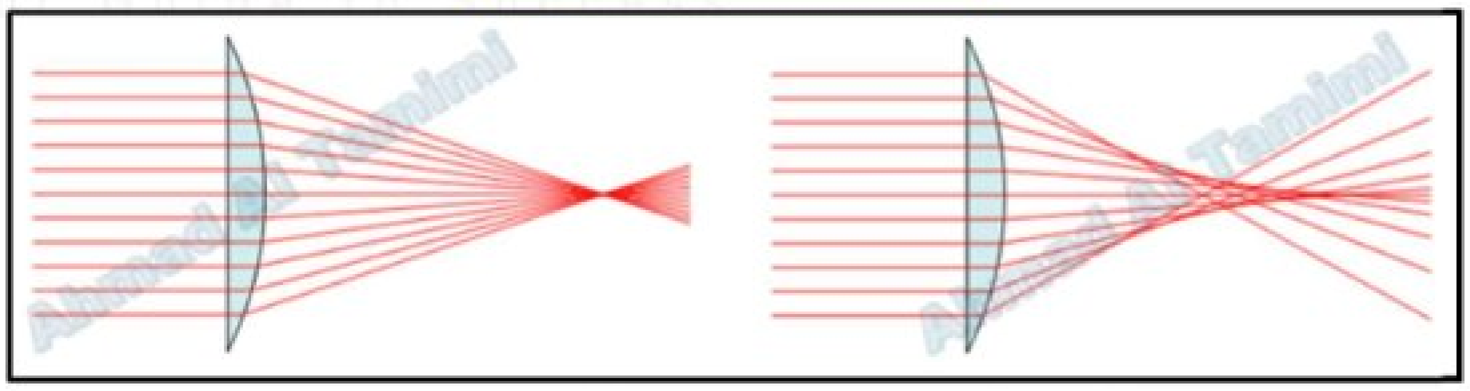
18	Explain defects in spherical lenses such as spherical aberration and chromatic aberration and how they can be corrected.	Student Textbook	56

Type of Defect	Cause / Reason	Effect on Image	Correction Method	Notes / Examples
Spherical Aberration	Rays passing through the **edges** of a spherical lens focus at **different points** than rays near the center.	Image appears **blurred** or **out of focus**, especially at the edges.	Use **multiple lenses** or **non-spherical (parabolic)** surfaces to focus all rays at one point.	• **Meniscus lens** → most spherical aberration. • **Double convex lens** → least spherical aberration.
Chromatic Aberration	Different **colors (wavelengths)** of light refract by **different amounts**, causing dispersion.	Produces **colored fringes** or **blurry edges**, especially at image borders.	Use **achromatic lenses** made by combining one **convex** and one **concave** lens of different refractive indices.	• Occurs **only in lenses**, not in mirrors. • Caused by **dispersion of light**.

Chromatic Aberration



Spherical Aberration



Question 152

Which of the following statements is true about the spherical aberration of lenses?

A	Inability of a spherical lens to focus all parallel rays to a single point	B	All parallel rays focus on the same position
C	It can only be seen with concave lenses	D	This is seen as an apparent ring of color around an object viewed through a lens

Question 153

Which of the following statements is true about the chromatic aberration of lenses?

A	Inability of a spherical lens to focus all parallel rays to a single point	B	All parallel rays focus on the same position
C	It can only be seen with concave lenses	D	This is seen as an apparent ring of color around an object viewed through a lens

Question 154

What is common between spherical mirrors and spherical lenses?

A	Both can produce chromatic aberration	B	Both can suffer from spherical aberration
C	Both disperse light into colors	D	Both always form real images

Question 158

Which type of lens produces the most spherical aberration?

A	Plano-convex	B	Meniscus lens
C	Double convex	D	Biconcave

Question 156

In high-precision optical instruments, spherical aberration is reduced by:

A	Using mirrors instead of lenses	B	Using multiple lenses combined
C	Using only concave lenses	D	Using colored filters

Question 157

Chromatic aberration occurs because:

A	Light rays bend evenly across the lens surface	B	Light reflects differently from mirror edges
C	Lens curvature changes with temperature	D	Different colors of light refract by different amounts

Question 158

Which of the following does not show chromatic aberration?

A	Convex lens	B	Concave lens
C	Plane mirror	D	Meniscus lens

Question 159

An achromatic lens is made by combining:

A	Two lenses of the same refractive index	B	One convex and one concave lens of different refractive indices
C	Two convex lenses of equal curvature	D	One convex and one mirror

Question 160

The main purpose of an achromatic lens is to:

A	Focus all rays at infinity	B	Block ultraviolet light
C	Cancel out color dispersion	D	Increase magnification

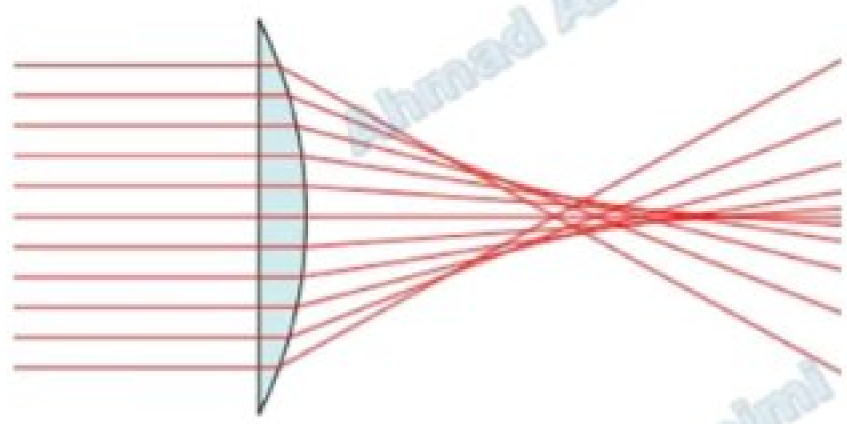
Question 161

In an achromatic lenses, the refractive indices of the materials are chosen so that:

A	All colors converge at one focal point	B	Red and blue light diverge
C	Only green light passes through	D	Dispersion increases

Question 162

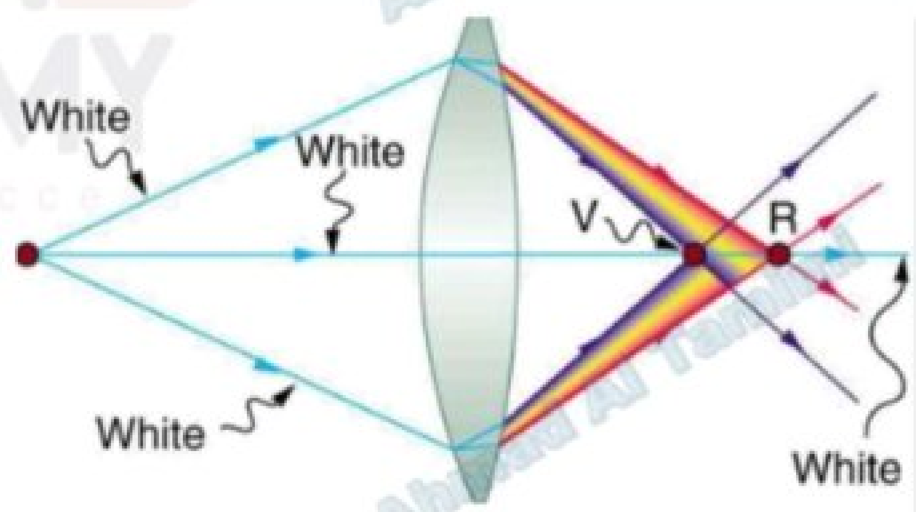
The figure shows parallel rays passing through a convex lens but failing to meet at a single point. What can be done to correct this defect and obtain a sharper image?



A	Use a system of multiple lenses.
B	Reduce the distance between the object and the lens.
C	Replace the lens with a concave lens.
D	Increase the thickness of the lens at the center.

Question 163

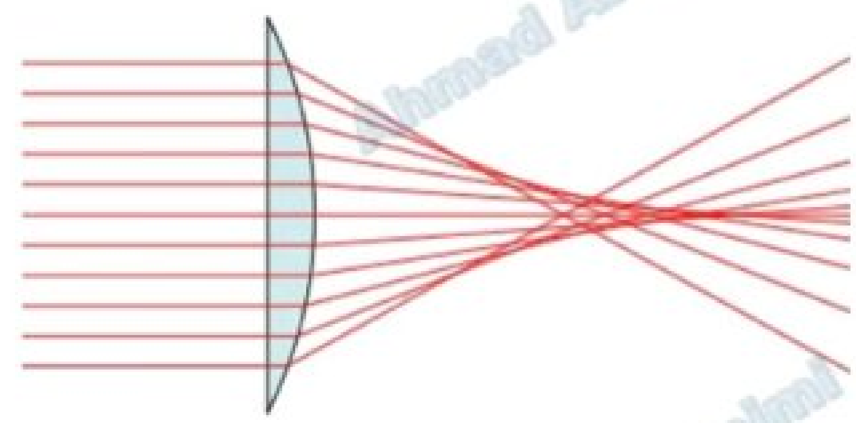
The image shows a convex lens causing the separation of white light into different colors after refraction. What can be done to correct this defect and make all colors focus at the same point?



A	Use a parabolic lens instead of a spherical one.
B	Replace the lens with an achromatic lens.
C	Increase the curvature of the convex lens to reduce refraction.
D	Use mirrors instead of lenses to focus light.

Question 164

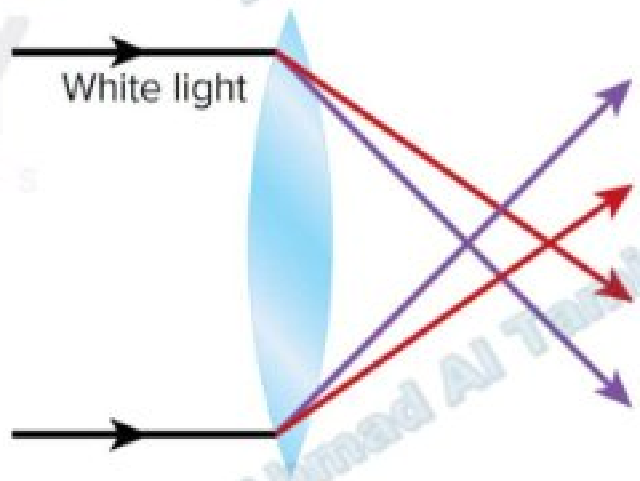
The figure shows parallel rays passing through a convex lens but failing to meet at a single point. What is the defect in the lens shown in the figure?



A	Chromatic aberration
B	Spherical aberration
C	Astigmatism
D	Distortion

Question 165

The figure shows white light separating into different colors after passing through a convex lens. This defect can be corrected by combining two lenses. Which two lenses are used to fix this problem?

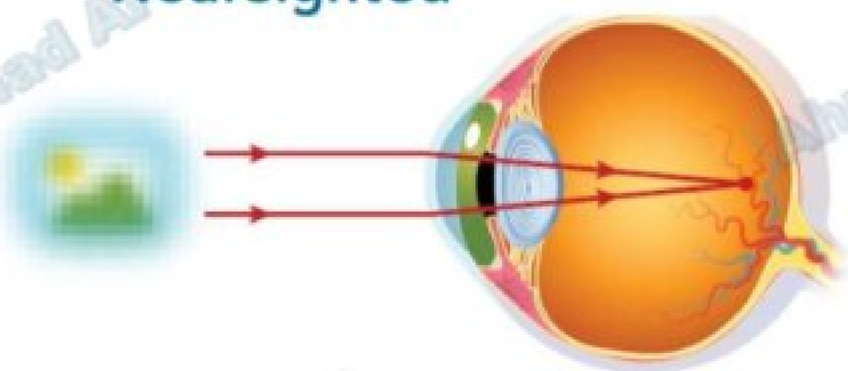


A	Two convex lenses made of the same material
B	One convex lens and one concave lens of different materials
C	Two concave lenses
D	One convex and one plane lens

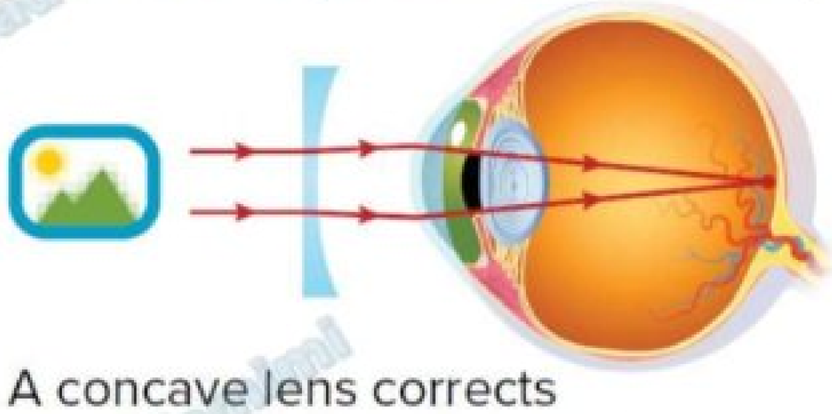
19	-Define nearsightedness (Myopia) and farsightedness (Hyperopia). -Describe the formation of image in case of nearsightedness and farsightedness and how defects in vision are corrected using concave and convex lenses.	Student Textbook Check your progress 57	58 60

Feature / Aspect	Farsightedness (Hyperopia)	Nearsightedness (Myopia)
Definition	The focal length of the eye is **too long**, so light focuses **behind the retina**.	The focal length of the eye is **too short**, so light focuses **in front of the retina**.
Effect on Vision	**Nearby objects appear blurry**; distant objects are seen clearly.	**Distant objects appear blurry**; nearby objects are seen clearly.
Image Formation	Image forms **behind the retina**.	Image forms **in front of the retina**.
Correction Lens	**Convex lens (converging lens)** – reduces focal length and focuses image on retina.	**Concave lens (diverging lens)** – increases focal length and focuses image on retina.
Effect of Age	Common in **older people (over 45 years)** due to lens rigidity (presbyopia).	Often occurs in **younger people or teenagers** due to longer eye shape.
Type of Vision Problem	Difficulty focusing on **near objects**.	Difficulty focusing on **distant objects**.
Light Rays after Correction	Convex lens **converges** light before it enters the eye.	Concave lens **diverges** light before it enters the eye.

Nearsighted

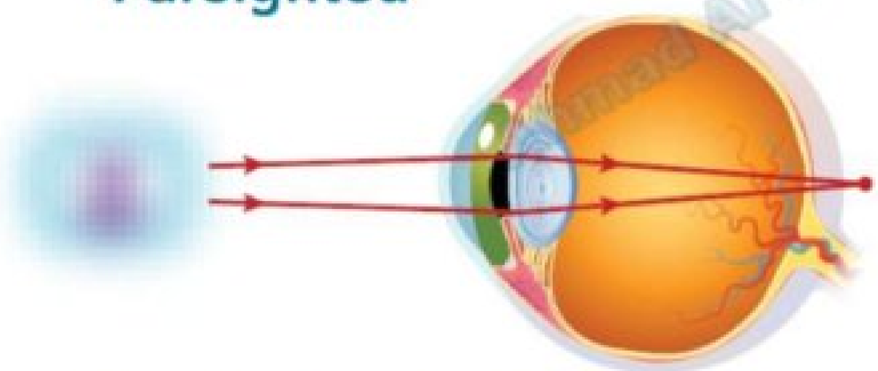


A nearsighted eye focuses images at a point in front of the retina, making distant images blurry.

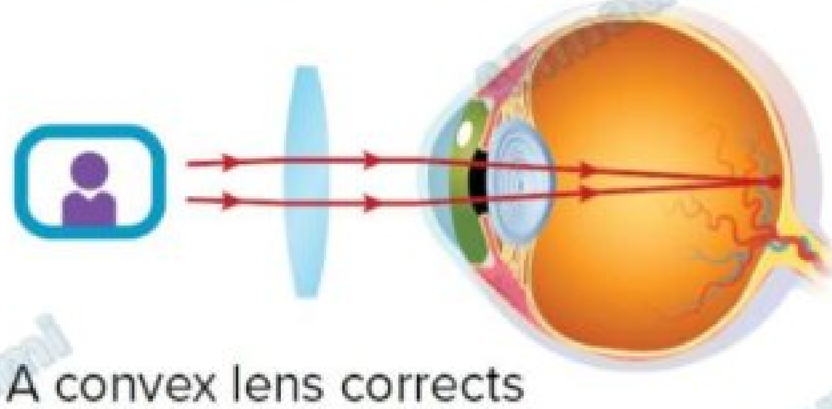


A concave lens corrects nearsightedness by increasing the focal length.

Farsighted



A farsighted eye focuses images at a point behind the retina, making nearby images blurry.



A convex lens corrects farsightedness by reducing the focal length.

Check Your Progress Page 60

57. **Eyeglass Lenses** Which type of lens, convex or concave, should a nearsighted person use? Which type should a farsighted person use? See **Figure 40.** Explain.

Figure 40

Question 166			
What type of lens is used to correct farsightedness?			
A	Convex lens	B	Concave lens
C	Achromatic lens	D	Cylindrical lens

Question 167

What is the main function of the cornea in the human eye?

A	To control the amount of light entering the eye	B	To provide most of the refraction of light entering the eye
C	To change the focal length of the eye	D	To detect colors and light intensity

Question 168

Why does most of the refraction occur at the air–cornea boundary rather than at the lens?

A	Because the cornea is transparent	B	Because the difference in indices of refraction between air and cornea is greater
C	Because the lens has a smaller curvature	D	Because the retina absorbs more light

Question 169

What is the role of the lens in the human eye?

A	To collect light from distant stars	B	To prevent chromatic aberration
C	To reflect light onto the retina	D	To provide fine focus for near and distant objects

Question 170

What is the process called when the eye changes the shape of its lens to focus on near or distant objects?

A	Refraction	B	Reflection
C	Accommodation	D	Adaptation

Question 171

In a nearsighted eye, where are images of distant objects formed?

A	On the retina	B	Behind the retina
C	On the cornea	D	In front of the retina

Question 172

What type of lens corrects nearsightedness?

A	Convex lens	B	Concave lens
C	Achromatic lens	D	Cylindrical lens

Question 173

How does a concave lens correct nearsightedness?

A	By converging light rays	B	By reducing the focal length
C	By diverging light rays so the image forms on the retina	D	By converging light rays so the image forms on the retina

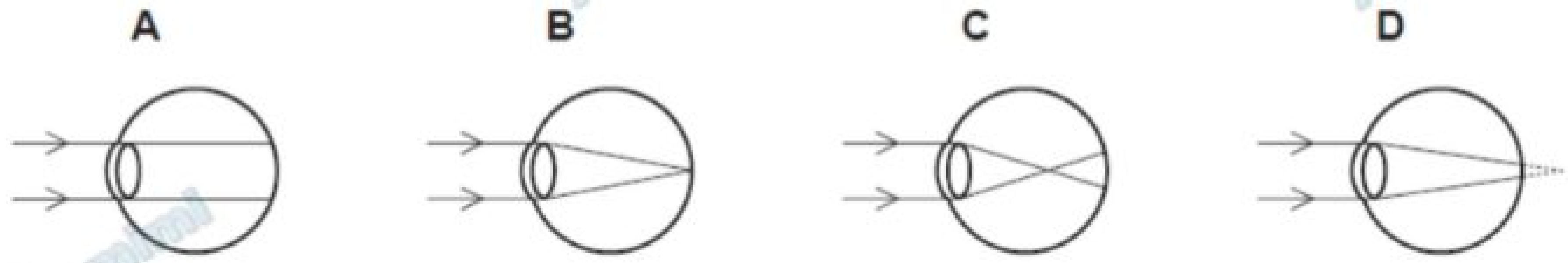
Question 174

In a farsighted eye, where are images of nearby objects focused?

A	On the retina	B	In front of the retina
C	Behind the retina	D	On the cornea

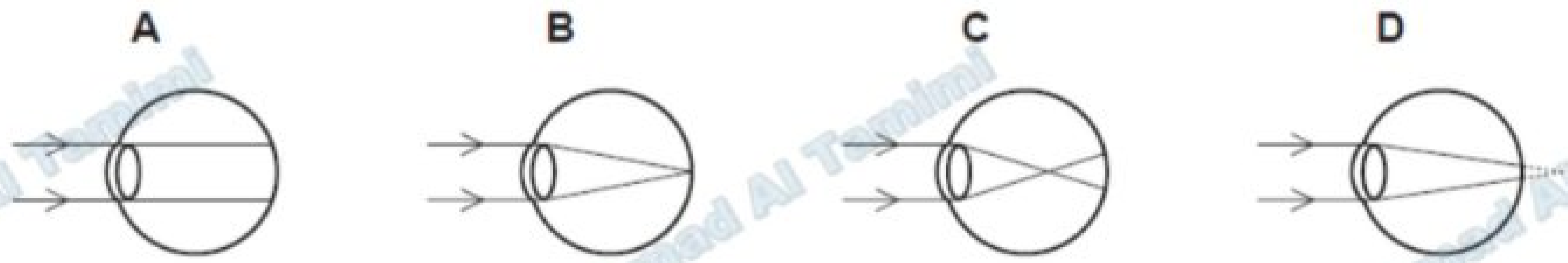
Question 175

A man is nearsighted. Which ray diagram shows what happens in his eye when he looks at a distant object?



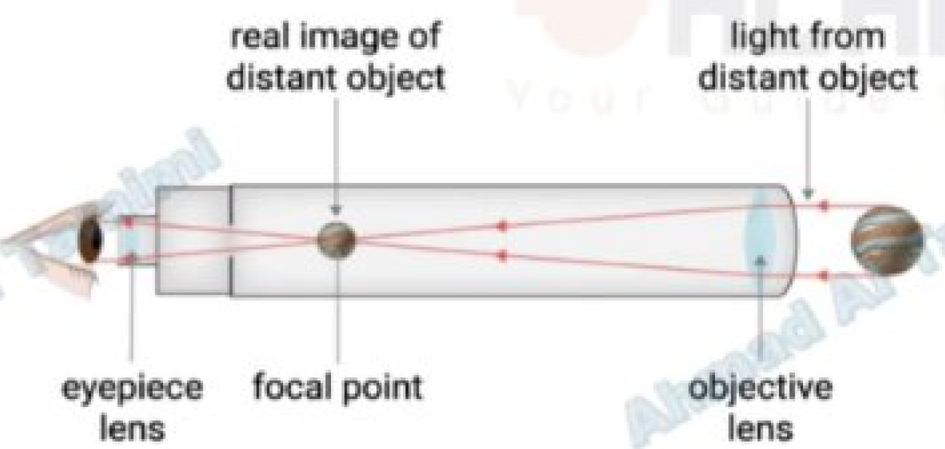
Question 176

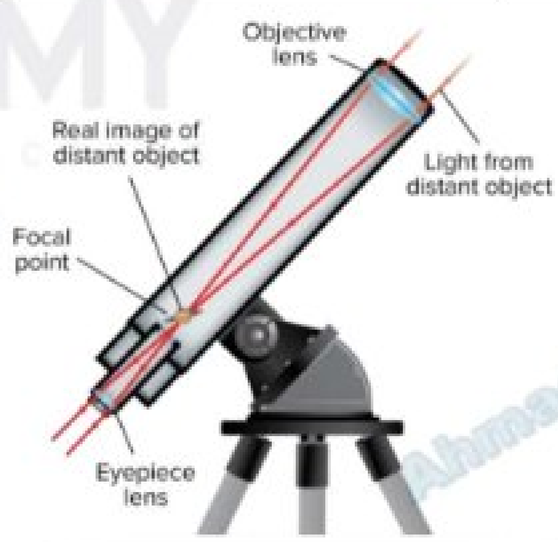
A man is farsighted. Which ray diagram shows what happens in his eye when he looks at a nearby object?



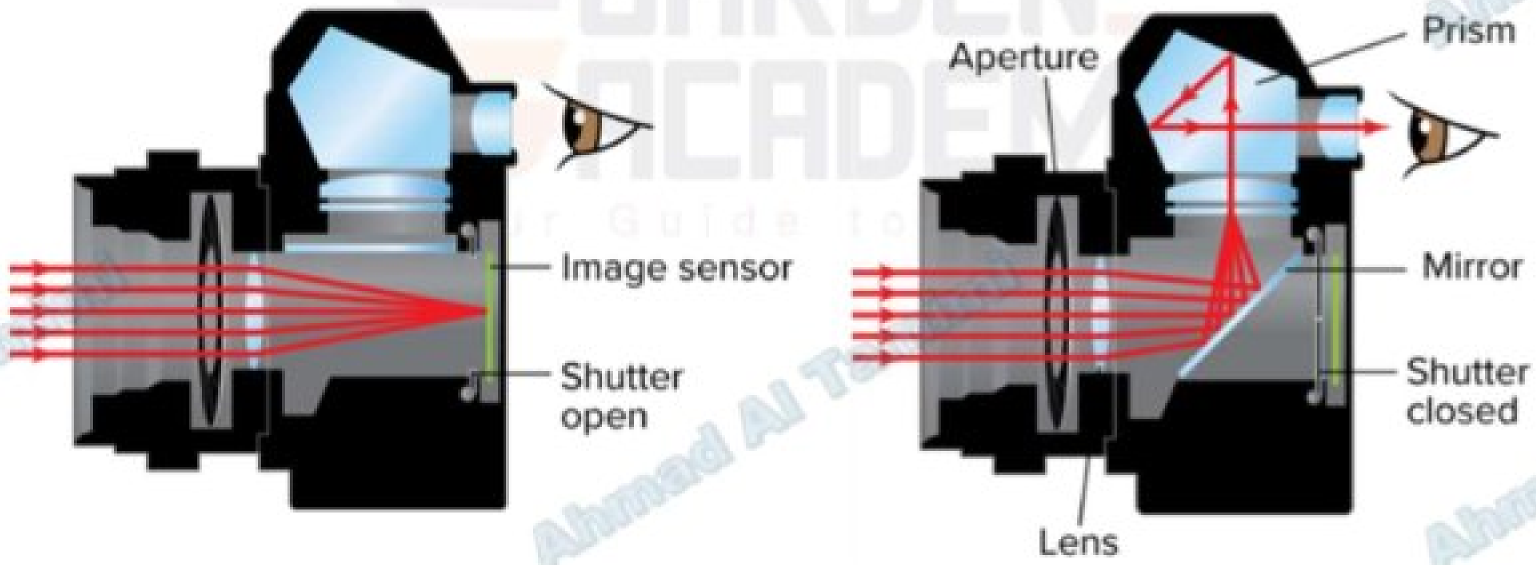
20	Describe the optical systems and formation of images in common optical instruments.	Student Textbook	59

Instrument	Main Optical Components	Image Formation Process	Type of Image Produced	Special Features / Notes
Refracting Telescope (Keplerian Telescope)	• Objective convex lens • Eyepiece convex lens (often achromatic)	• Light from distant object enters as parallel rays. • Objective lens focuses light to form a **real, inverted image** at its focal point. • This image acts as the object for the eyepiece lens. • Eyepiece produces an **enlarged virtual image**.	**Inverted, magnified, virtual**	• Used for viewing distant objects (stars, planets). • Inverted image is acceptable in astronomy. • Eyepiece often **achromatic** to reduce color distortion.

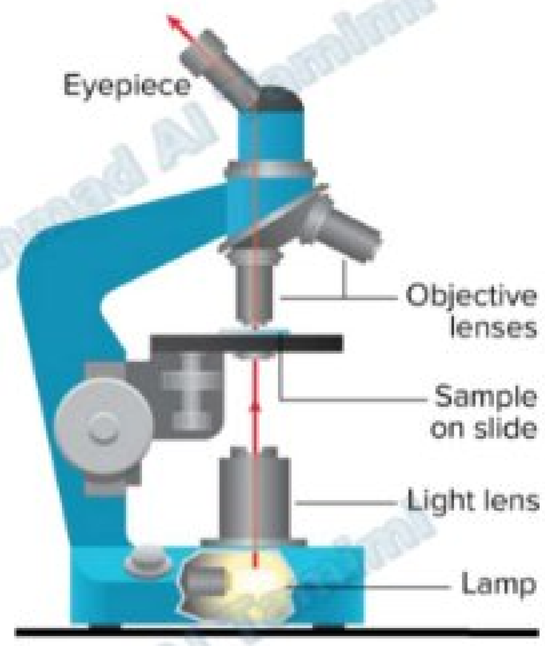




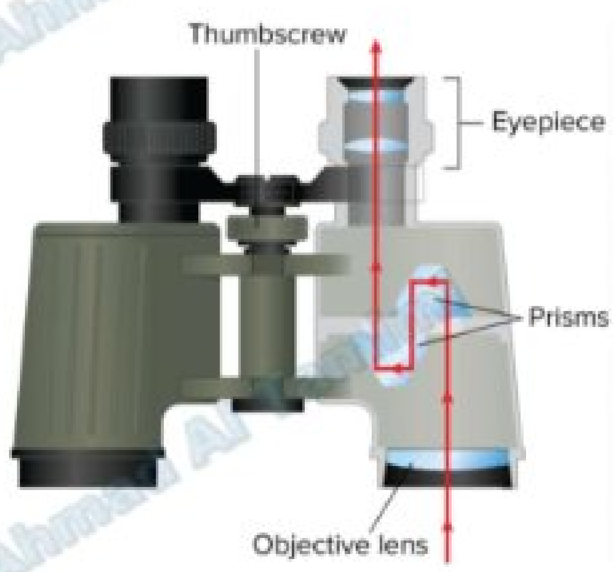
Instrument	Main Optical Components	Image Formation Process	Type of Image Produced	Special Features / Notes
Camera (SLR)	• Convex lens (achromatic) • Mirror • Prism • Image sensor (CCD)	• Light enters through **aperture**, passes through convex lens to form **real inverted image** on reflex mirror. • Mirror reflects image to **prism**, which inverts it for viewing. • During capture, mirror lifts, and image hits **sensor**.	**Real, inverted image** on CCD	• CCD converts light into **electrical signals**. • Produces digital image. • Prism corrects orientation for viewfinder.



Instrument	Main Optical Components	Image Formation Process	Type of Image Produced	Special Features / Notes
Microscope	• Objective convex lens • Eyepiece convex lens	• Object placed between **one and two focal lengths** of objective. • Objective lens forms a **real, inverted, magnified image**. • This image acts as the object for the eyepiece. • Eyepiece produces a **larger, upright virtual image**.	**Virtual, inverted, magnified**	• Used for viewing small objects. • Provides **high magnification**.



Instrument	Main Optical Components	Image Formation Process	Type of Image Produced	Special Features / Notes
Binoculars	• Convex objective lens • Eyepiece lens • Two prisms	• Objective lens forms **real inverted image**. • Prisms cause **total internal reflection** to flip the image upright. • Eyepiece lens magnifies it.	**Upright, magnified, real appearance**	• Two optical tubes provide **3D view**. • Use **prisms** for image inversion correction.



Question 177: Why would you want the shutter to be open longer when taking a photo in dim light?

53. **Chromatic Aberration** All simple lenses have chromatic aberration. Infer why you do not see this effect when you look through a microscope, which has two convex lenses.

Question 178

In a refracting telescope, what does the objective lens do?

A	Produces a virtual image	B	Collects light and forms a real inverted image
C	Reduces chromatic aberration	D	Magnifies the final image

Question 179

What type of image is formed as the final image in a refracting telescope?

A	Real and inverted	B	Virtual and upright
C	Real and upright	D	Virtual and inverted

Question 180

Why is the final image in a refracting telescope inverted?

A	Because of chromatic aberration	B	Because the first image formed by the objective lens was already inverted
C	Because the eyepiece lens inverts the image	D	Because of reflection in the prism

Question 181

What type of lens is usually used as the eyepiece lens in a telescope to reduce color distortion?

A	Normal convex lens	B	Normal concave lens
C	Achromatic lens	D	Meniscus lens

Question 182

What type of lens is used in a single-lens reflex camera?

A	Concave lens	B	Achromatic lens
C	Plano-convex lens	D	Meniscus lens

Question 183

What is the function of the reflex mirror in a camera?

A	To focus light on the sensor	B	To reflect light upward to the prism
C	To capture the image electronically	D	To control shutter speed

Question 184

What happens when the shutter-release button is pressed in a camera?

A	The mirror is raised and light hits the sensor directly	B	The image is reflected to the viewfinder
C	The lens changes shape	D	The prism captures the image

Question 185

What does the CCD sensor in a camera do?

A	Reflects light to the prism	B	Converts light into electrical signals
C	Forms a virtual image	D	Adjusts the focus automatically

Question 186

In binoculars, two prisms are used mainly to:

A	Magnify the image	B	Invert the image again to make it upright
C	Focus light onto the retina	D	Reduce color dispersion

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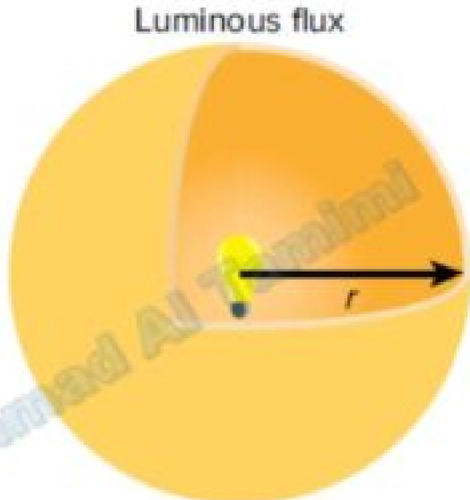
21	-Apply the equation for illuminance of a point source to numerical problems. -Relate luminous intensity to illuminance.	Student Textbook Example problem1 Practice problems Check your progress	6-8 9 11

Quantity	Symbol	Definition	Unit
Luminous Flux	(P)	The rate at which light energy is emitted from a luminous source.	lumen (lm)
Illuminance	(E)	The luminous flux falling on a given surface area at any instant.	lux (lx) = lumen/m^2
Luminous Intensity	(I_v)	the luminous flux that falls on 1 m^2 of the inside of a 1-m radius sphere.	candela (cd)

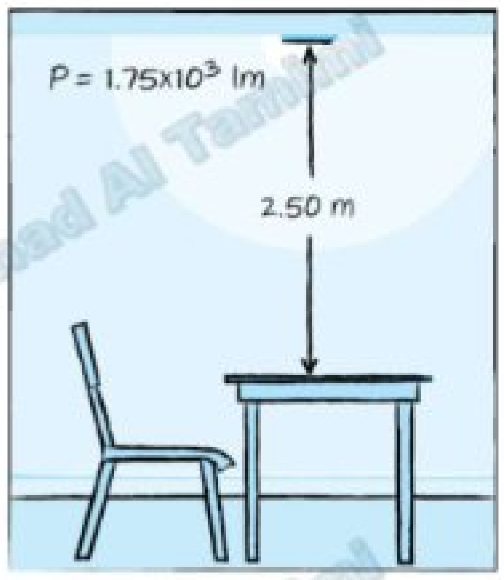


$$E = \frac{P}{4\pi r^2} = \frac{I_v}{r^2}$$

$$I_v = \frac{P}{4\pi}$$

EXAMPLE Problem 1

ILLUMINATION OF A SURFACE What is the illuminance on your desktop if it is lit by a 1750-lm lamp that is 2.50 m above your desk?



PRACTICE Problems Page 9

1. A lamp is moved from 30 cm to 90 cm above the pages of a book. Compare the illumination on the book before and after the lamp is moved.

PRACTICE Problems — Page 9

2. Draw a graph of the illuminance produced by a lamp with a luminous flux of 2275 lm at distances from 0.50 m and 5.0 m.

PRACTICE Problems — Page 9

3. A 64-cd point source of light is 3.0 m away from a painting. What is the illumination on the painting in lux?

4. A screen is placed between two lamps so that they illuminate the screen equally, as shown in **Figure 9.** The first lamp emits a luminous flux of 1445 lm and is 2.5 m from the screen. What is the distance of the second lamp from the screen if the luminous flux is 2375 lm?

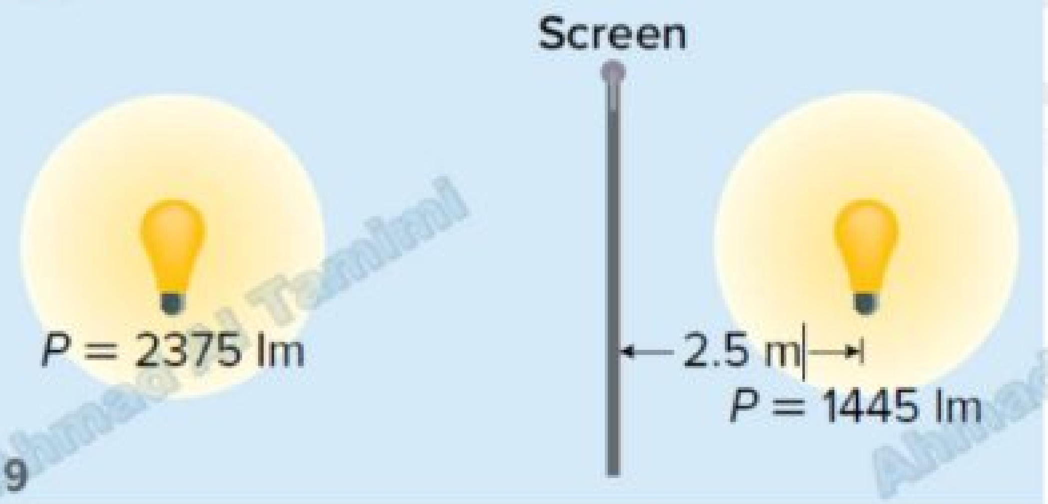


Figure 9

PRACTICE Problems Page 9

5. What is the illumination on a surface that is 3.0 m below a 150-W incandescent lamp that emits a luminous flux of 2275 lm?

6. A public school law requires a minimum illuminance of 160 lx at the surface of each student's desk. An architect's specifications call for classroom lights to be located 2.0 m above the desks. What is the minimum luminous flux that the lights must produce?

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PRACTICE Problems Page 9

7. CHALLENGE Your local public library is planning to remodel the computer lab. The contractors have purchased fluorescent lamps with a rated luminous flux of 1750 lm. The desired illumination on the keyboard surfaces is 175 lx. Assume a single lamp illuminates each keyboard. What distance above the surface should the lights be placed to achieve the desired illumination? If the contractors had also already purchased fixtures to hold the lights that when installed would be 1.5 m above the keyboard surface, would the desired illuminance be achieved? If not, would the illuminance be greater or less than desired? What change in the lamp's luminous flux would be required to achieve the desired illuminance?

Check Your Progress Page 11

10. **Illuminance** Does one lightbulb provide more or less illuminance than two identical lightbulbs at twice the distance? Explain.

11. **Luminous Intensity** Two lamps illuminate a screen equally from distances shown in **Figure 11.** If Lamp A is rated 75 cd, what is Lamp B rated?

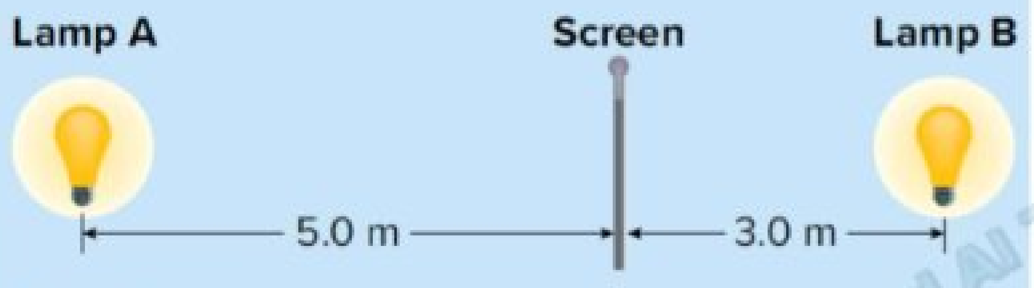
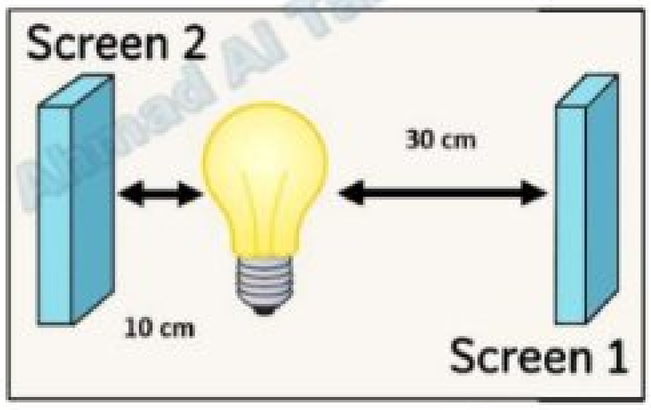


Figure 11

12. **Distance of a Light Source** A lightbulb illuminating your computer keyboard provides only half the illuminance that it should. If it is currently 1.0 m away, how far should it be to provide the correct illuminance?

Question 187

A small lamp acts as a point source of light. Two flat screens are placed along the same straight line with the lamp, as shown below. Screen 1 is placed 30 cm away from the lamp. Screen 2 is placed 10 cm away from the lamp. The illuminance on Screen 2 is measured to be 200 lx.

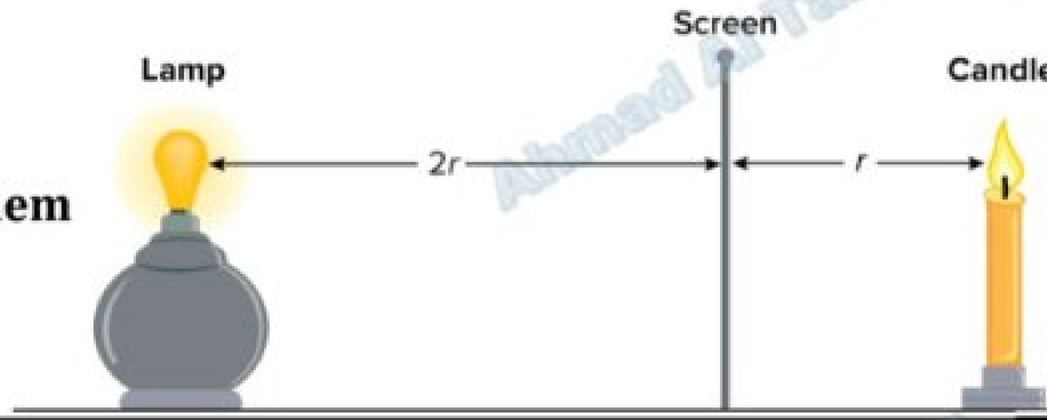


a) calculate the illuminance on Screen 1.

b) Find the luminous intensity of the lamp.

Question 188

A lamp and a candle act as point sources of light. The luminous intensity of the lamp is 10 cd. A small screen is placed between them as shown in the figure.

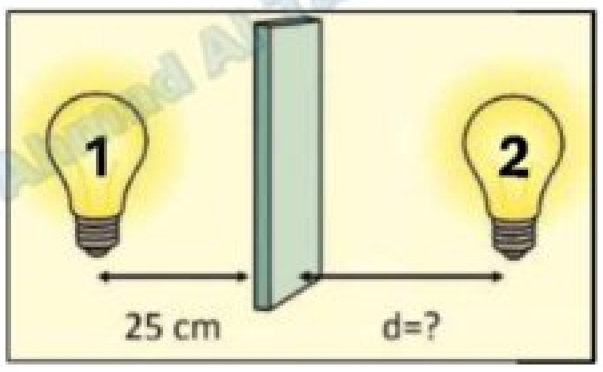


a) Find the luminous flux of the candle so that the illuminance produced by the lamp on the screen is equal to that produced by the candle.

b) How would the illuminance of the lamp on the screen change if:
- The distance between the lamp and the screen is doubled.
- The luminous flux of the lamp is tripled (while the distance remains constant).

Question 189

A screen is placed between two lamps so that they illuminate the screen equally. Lamp 1 emits a luminous flux of 1445 lm and is 25 cm from the screen.



a) What is the distance of lamp 2 from the screen if its luminous flux is 2375 lm?

b) Find the luminous intensity of lamp 2.

Question 190

A streetlight contains two identical light bulbs 3.3 m from the ground. If the community wants to save electrical energy by removing one bulb, how far from the ground should the streetlight be positioned to have the same illumination on the ground under the lamp?

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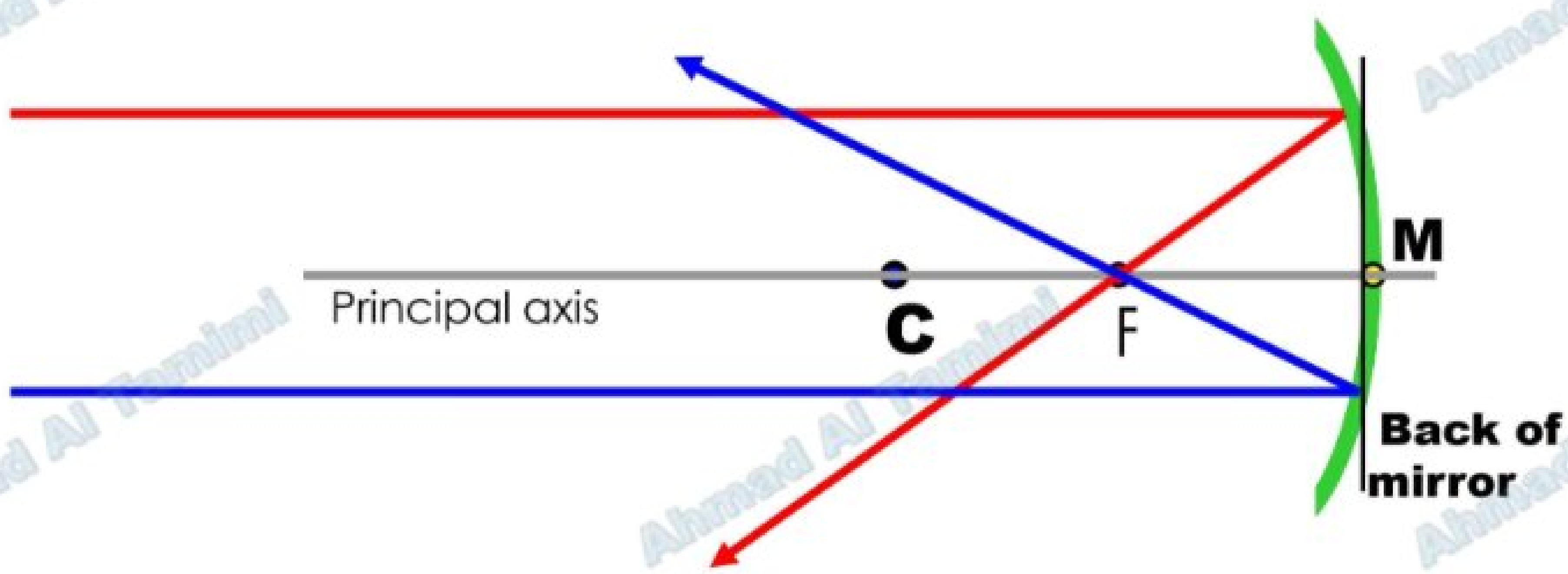
22	-Draw a ray diagram to find the image of an object formed by a curved mirror and determine the properties of the formed image. -Apply the mirror equation to calculate the image distance, the object distance, or the focal length of a spherical mirror using appropriate algebraic signs for focal length and corresponding distances. -Calculate the magnification produced by a spherical mirror.	Student Textbook Example problem2,3 Practice problems	36-38 41,42

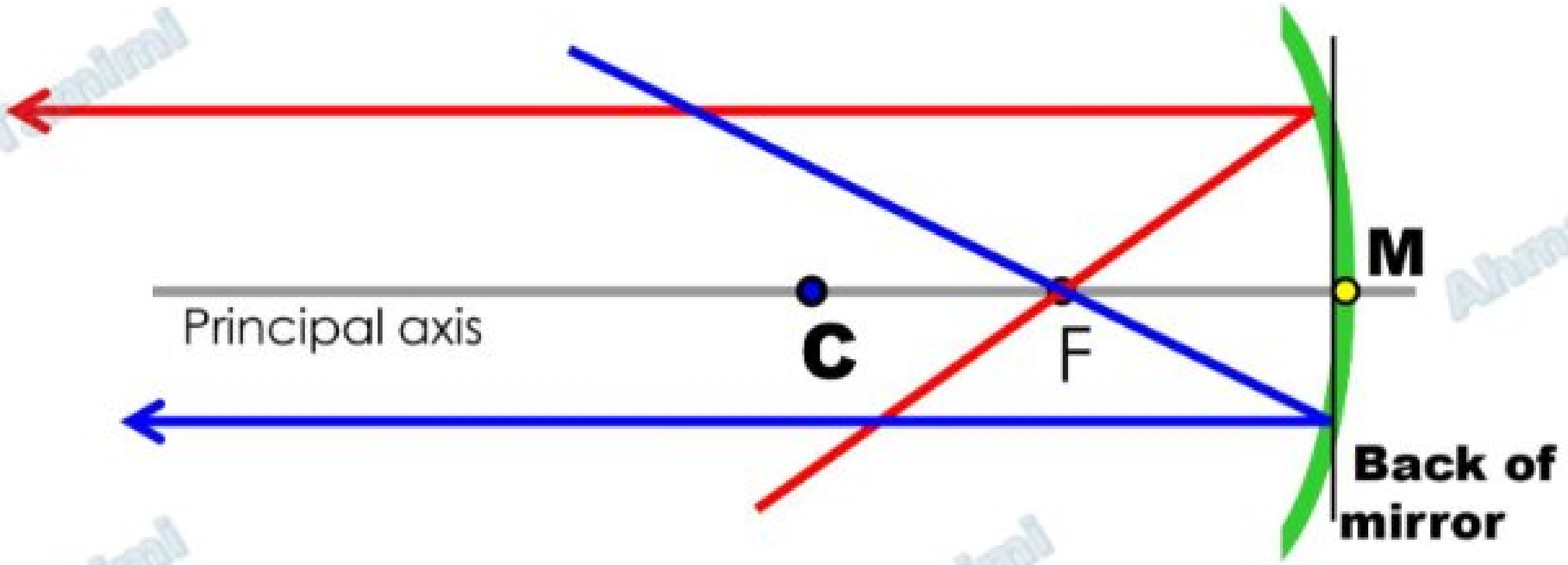
In order to draw images formed by curved mirrors, remember that:

A ray parallel to the principal axis is reflected through the focal point (F). This ray is called the parallel ray



In order to draw images formed by curved mirrors, remember that:

A ray that goes through the focal point (F) is reflected parallel to the principal axis. This ray is called the focus ray.



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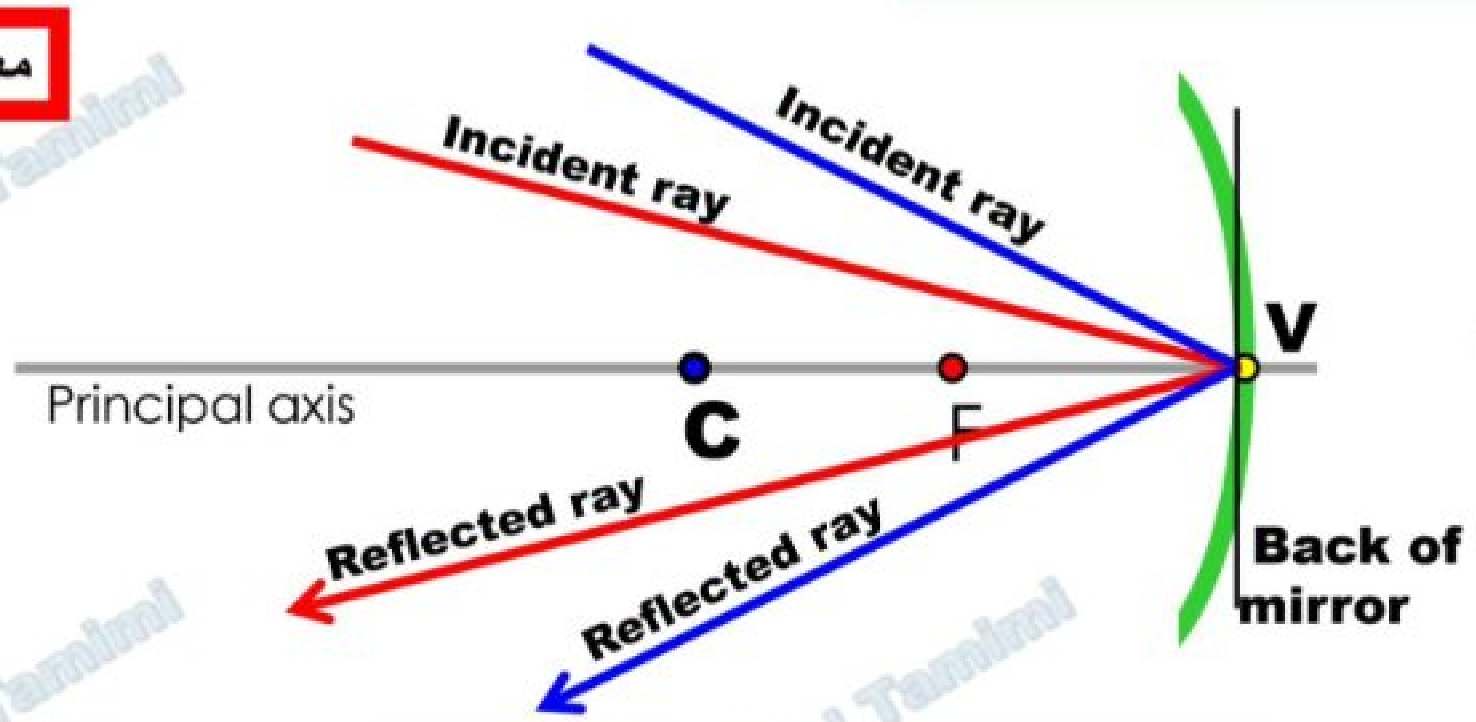
In order to draw images formed by curved mirrors, remember that:

A ray that strikes the vertex (V) is reflected like a plane mirror.
(Angle of incidence = Angle of reflection)

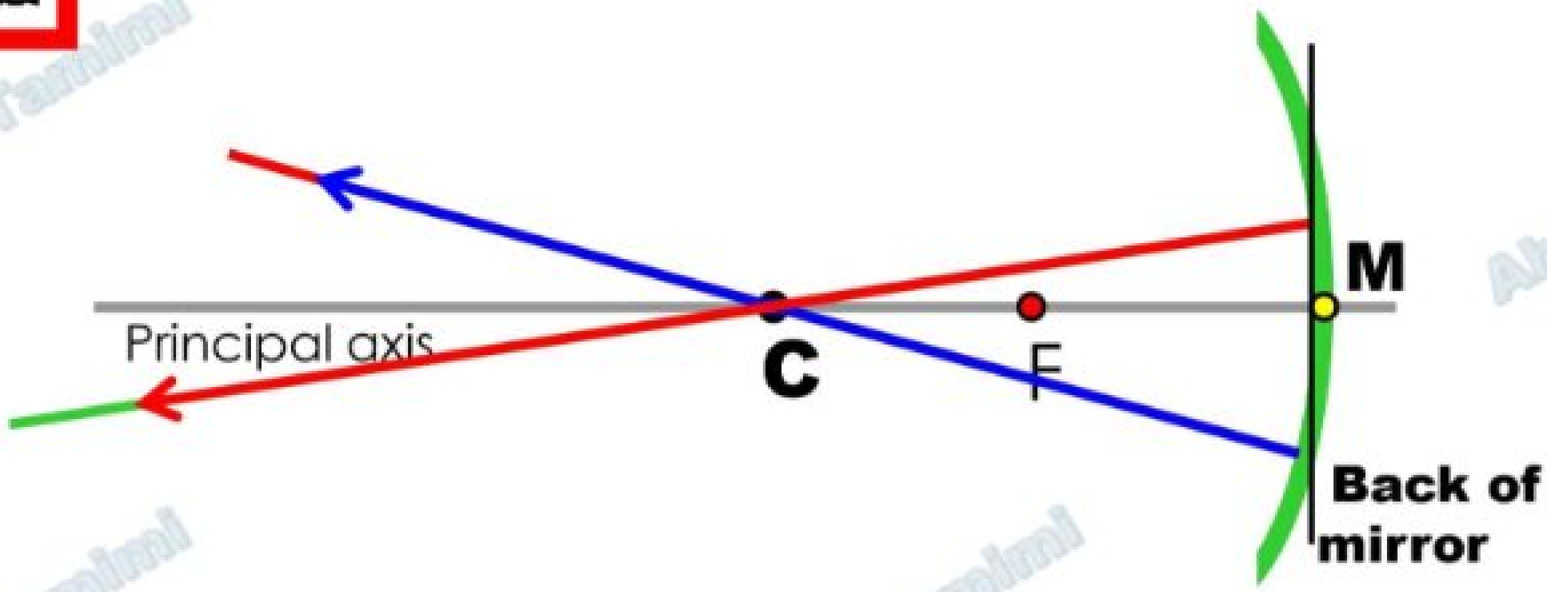
معلومة اضافية



In order to draw images formed by curved mirrors, remember that:

A ray that goes through C (the center of curvature) is reflected back along its own path.

معلومة اضافية



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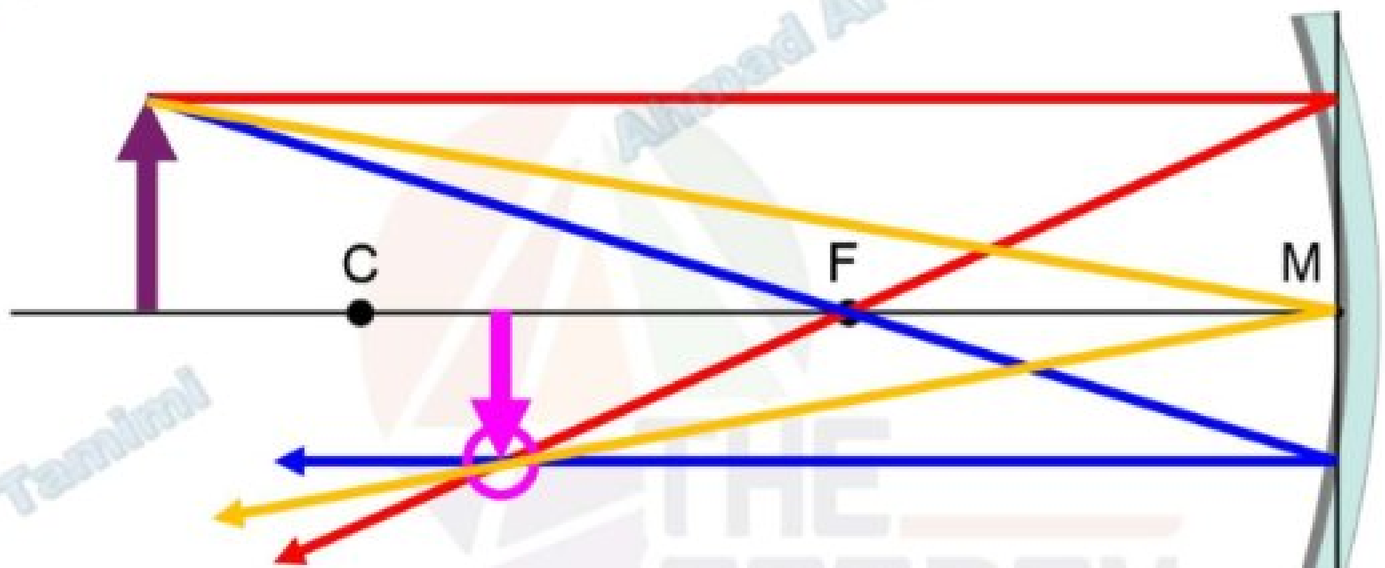
For each concave mirror shown, draw the image formed and describe the image properties

f	+
x_o	+
x_i	+
m	−

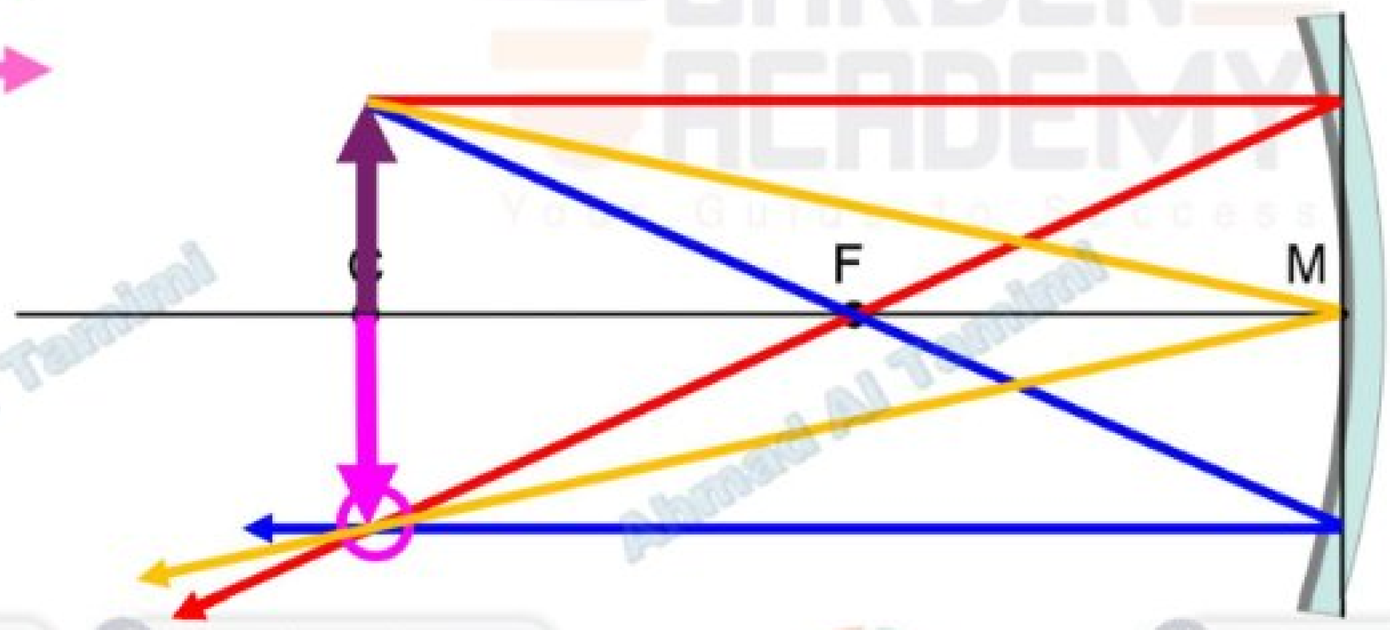


Properties of the image:	
Type	Real
Orientation	Inverted
Size	Reduced
Location	Between C & F

Object

Image

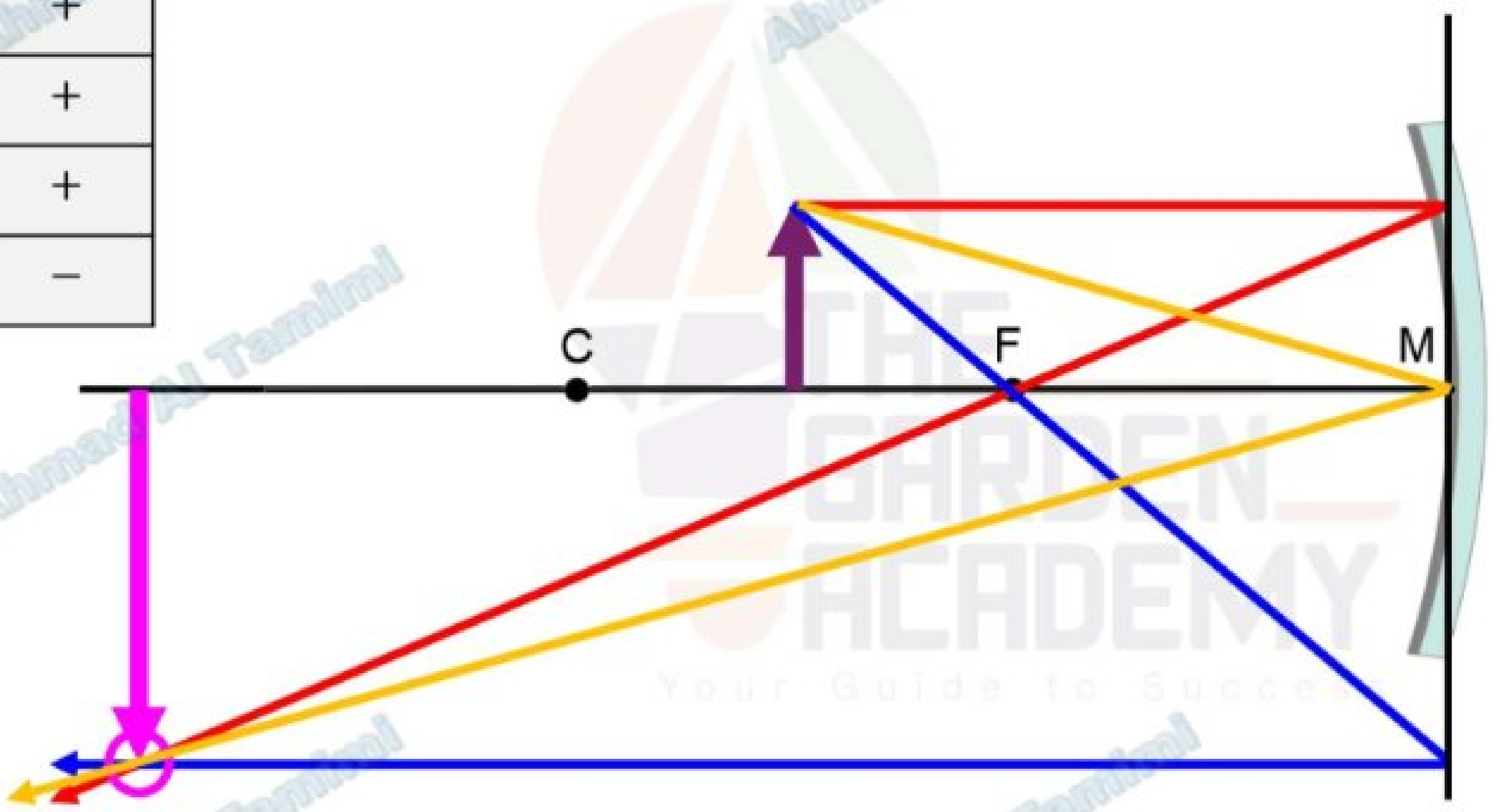
f	+
x_o	+
x_i	+
m	−



Properties of the image:	
Type	Real
Orientation	Inverted
Size	Same size
Location	At C

For each concave mirror shown, draw the image formed and describe the image properties

f	+
x_o	+
x_i	+
m	−



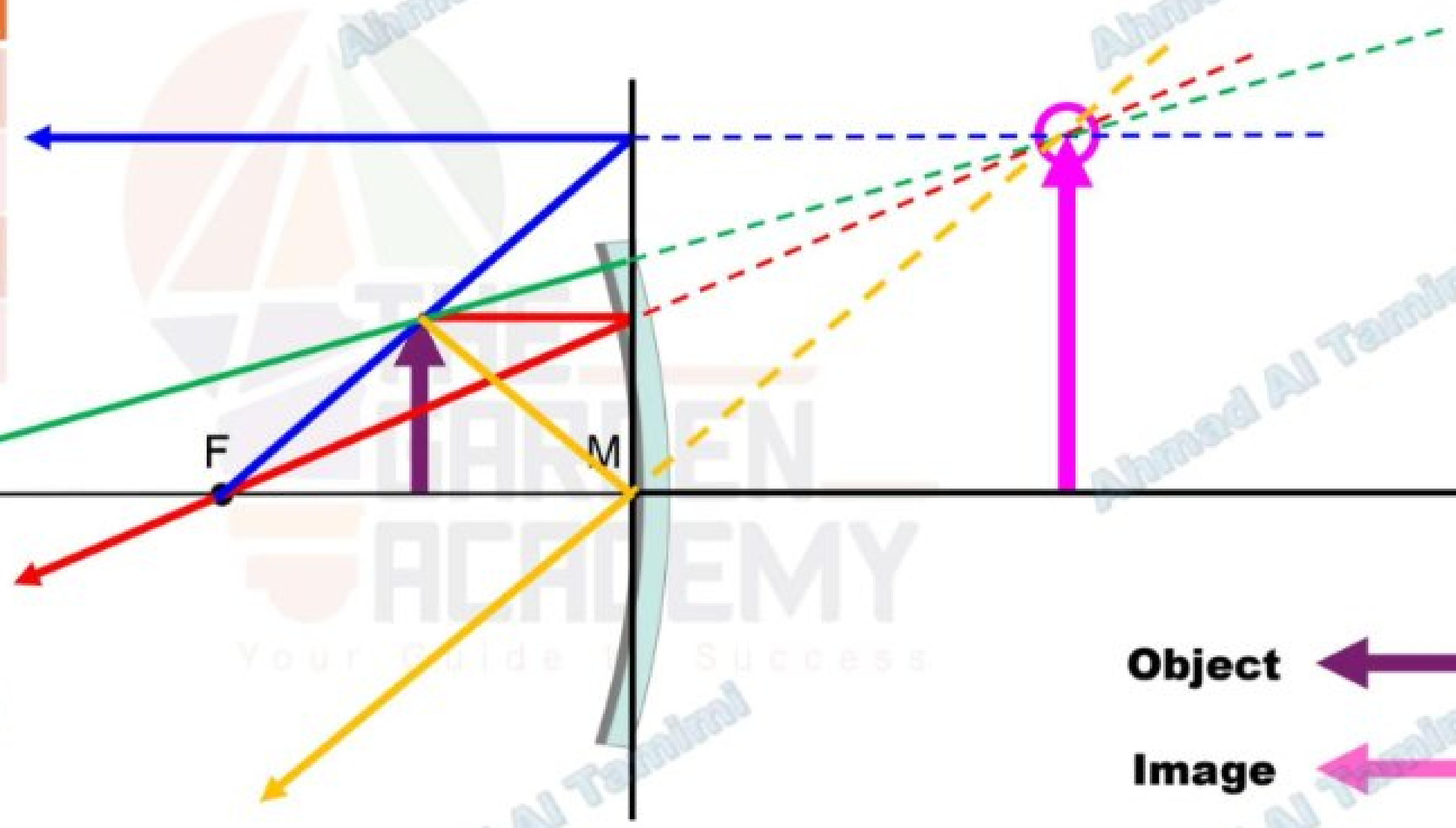
Properties of the image:	
Type	Real
Orientation	Inverted
Size	Larger (magnified)
Location	Beyond C

Object

Image

For each concave mirror shown, draw the image formed and describe the image properties

Properties of the image:	
Type	Virtual
Orientation	Upright
Size	Larger
Location	Behind mirror



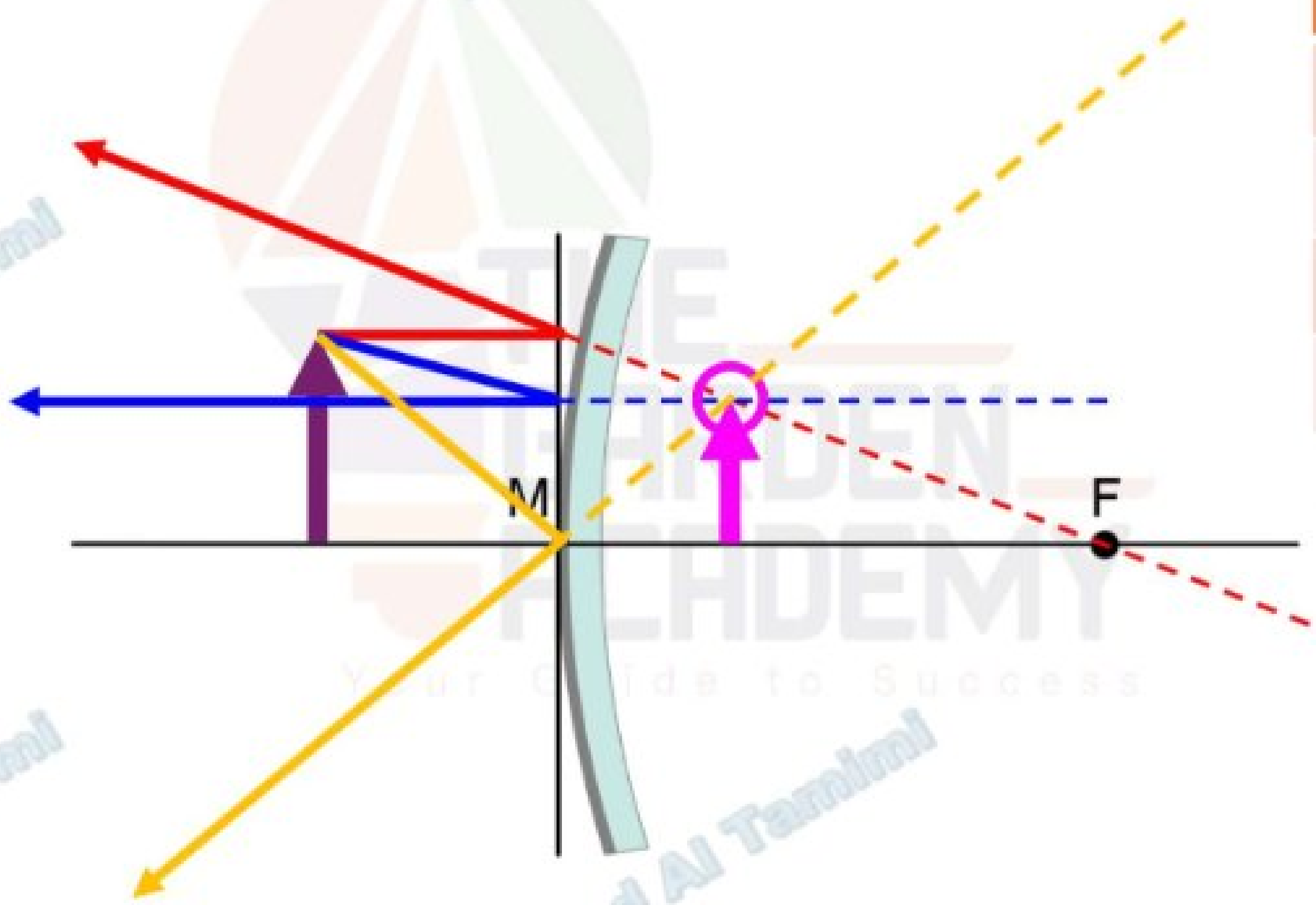
f	+
x_o	+
x_i	−
m	+

Object

Image

For each concave mirror shown, draw the image formed and describe the image properties

f	−
x_o	+
x_i	−
m	+



Properties of the image:	
Type	Virtual
Orientation	Upright
Size	reduced
Location	Behind mirror

Object

Image

Symbol	Meaning	Sign Convention
m	Magnification	+ → virtual image − → real image |m| < 1 → image smaller |m| > 1 → image larger
h_i	Image Height	+ → image is upright − → image is upside down (inverted)
h_o	Object Height	always positive
x_i	Image Position	+ → image in front of mirror (real) − → behind mirror (virtual)
x_o	Object Position	always positive

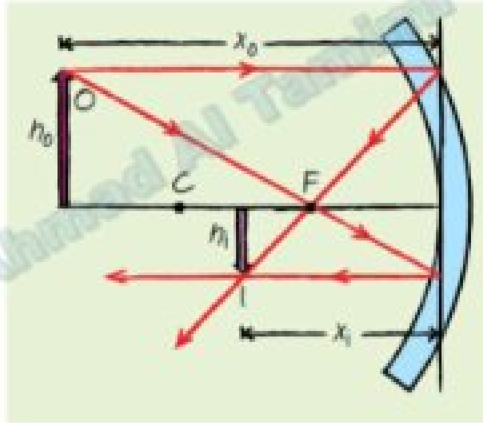
$$\text{magnification } (m) = \frac{h_i}{h_o} = -\frac{x_i}{x_o}$$

Sign conventions (we'll use these throughout)	
x_o	(+) always
x_i	(+) for **real** images, (-) for **virtual** images.
f	(+) for **concave** mirrors, (-) for **convex** mirrors.

Mirror equation: $\frac{1}{f} = \frac{1}{x_i} + \frac{1}{x_o}$

EXAMPLE Problem 2

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?



Mirror Type: Concave		
Symbol	**Sign**	**Value**
x_i	+	
x_o	+	
h_i	-	
h_o	+	
m	-	
f	+	

PRACTICE Problems
Page 41

12. Use a ray diagram drawn to scale to solve Example Problem 2.

Mirror Type: Concave		
Symbol	**Sign**	**Value**
x_i	+	15 cm
x_o	+	30 cm
h_i	-	1 cm
h_o	+	2 cm
f	+	10 cm

PRACTICE Problems Page 41

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

Mirror Type: Concave		
Symbol	**Sign**	**Value**
x_i	+	
h_i	-	
m	-	
f	+	

14. 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.

Mirror Type: Concave		
Symbol	**Sign**	**Value**
x_i	+	
h_i	-	
m	-	
f	+	

PRACTICE Problems Page 41

15. 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.

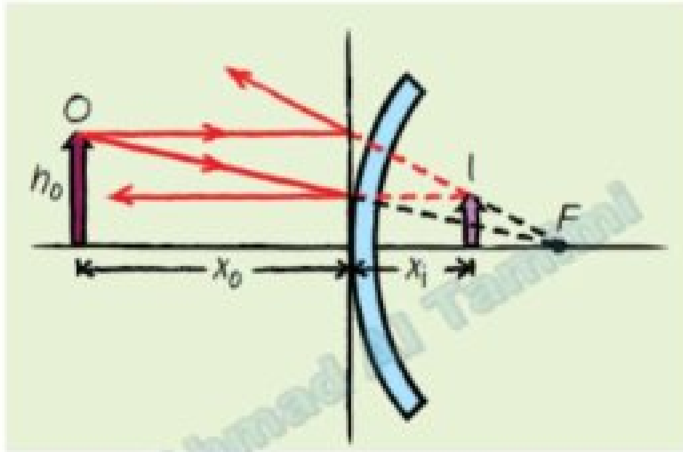
Mirror Type: Concave		
Symbol	**Sign**	**Value**
x_i	+	
h_i	-	
m	-	
f	+	

16. CHALLENGE You place an object near a concave mirror with a 10.0-cm focal length. The image is 3.0 cm tall, inverted, and 16.0 cm from the mirror. What are the object position and object height?

Mirror Type: Concave		
Symbol	**Sign**	**Value**
x_i	+	
h_i	-	
m	-	
f	+	

EXAMPLE Problem 3

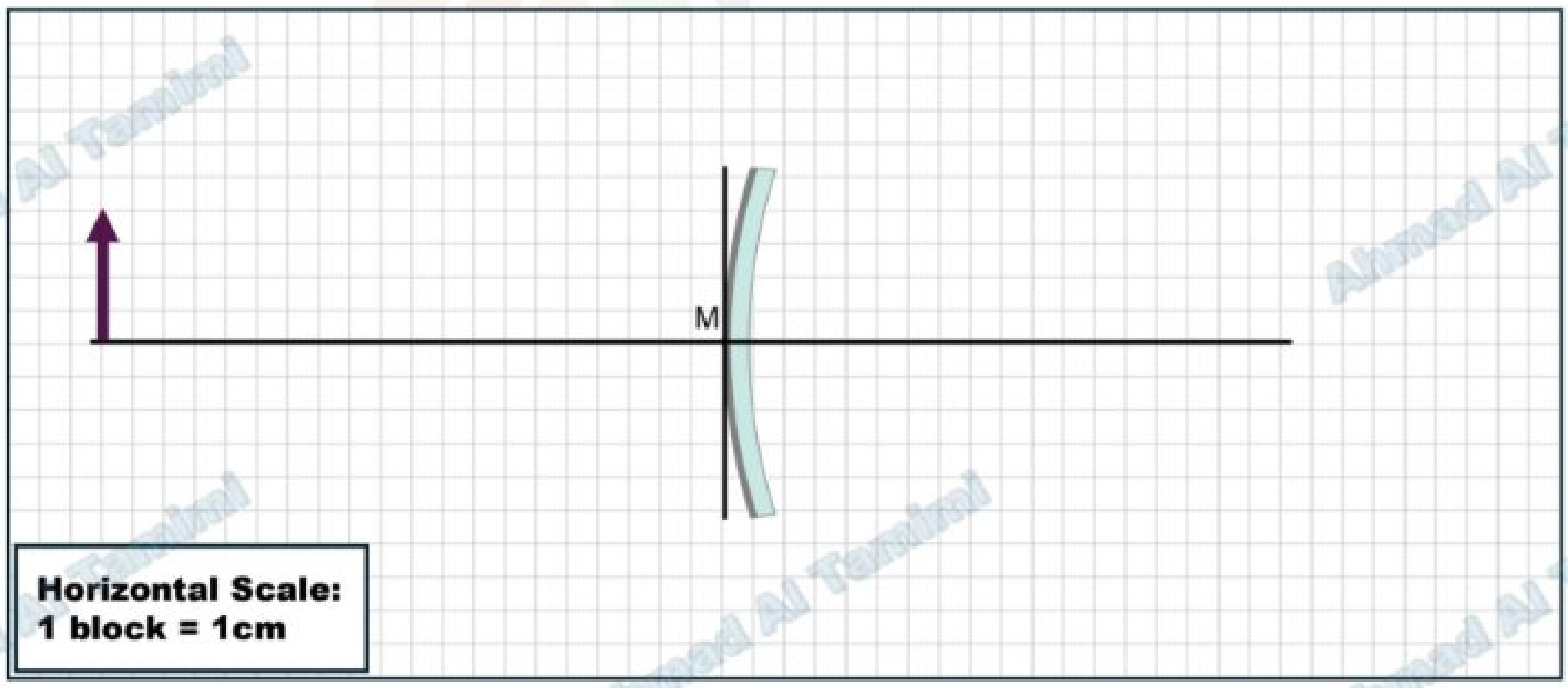
IMAGE IN A SECURITY MIRROR A convex security mirror in a warehouse has a −0.50-m focal length. A 2.0-m-tall forklift is 5.0 m from the mirror. What are the forklift's image position and image height?



Mirror Type: Convex		
Symbol	**Sign**	**Value**
x_i	-	
h_i	+	
m	+	
f	-	

PRACTICE Problems Page 42

17. You place an object 20.0 cm in front of a convex mirror with a −15.0-cm focal length. Find the image position using both a scale diagram and the mirror equation.



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18. A convex mirror has a focal length of −13.0 cm. You place a 6.0-cm diameter lightbulb 60.0 cm from that mirror. What are the lightbulb's image position and diameter?

Mirror Type: Convex		
Symbol	Sign	Value
x_i	-	
h_i	+	
m	+	
f	-	

19. A 7.6-cm-diameter ball is located 22.0 cm from a convex mirror with a radius of curvature of 60.0 cm. What are the ball's image position and diameter?

Mirror Type: Convex		
Symbol	Sign	Value
x_i	-	
h_i	+	
m	+	
f	-	

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20. A 1.8-m-tall girl stands 2.4 m from a store's security mirror. Her image appears to be 0.36 m tall.
   a. What is the image's distance?
   b. What is the focal length of the mirror?

Mirror Type: Convex		
Symbol	Sign	Value
x_i	-	
h_i	+	
m	+	
f	-	

21. **CHALLENGE** A convex mirror is needed to produce an image that is three-fourths the size of an object and located 24 cm behind the mirror.
   a. What is the object's distance?
   b. What focal length should be specified?

Check Your Progress Page 43

22. **Image Properties** If you know the focal length of a concave mirror, where should you place an object so that its image is upright and larger compared to the object? Will this produce a real or virtual image?

23. **Magnification** You place an object 20.0 cm in front of a concave mirror with a focal length of 9.0 cm. What is the magnification of the image?

24. **Object Position** The placement of an object in front of a concave mirror with a focal length of 12.0 cm forms a real image that is 22.3 cm from the mirror. What is the object's position?

Check Your Progress Page 43

25. **Image Position and Height** You place a 3.0-cm-tall object 22.0 cm in front of a concave mirror that has a focal length of 12.0 cm. Find the image position and height by drawing a ray diagram to scale. Verify your answer using the mirror and magnification equations.

26. **Ray Diagram** You place a 4.0-cm-tall object 14.0 cm from a convex mirror with a focal length of −12.0 cm. In a scale ray diagram show the image position and height. Verify your answer using the mirror and the magnification equations.

Check Your Progress — Page 43

27. **Radius of Curvature** You place a 6.0-cm-tall object 16.4 cm from a convex mirror. If the image of the object is 2.8 cm tall, what is the mirror's radius of curvature?

28. **Focal Length** A convex mirror is used to produce an image that is two-thirds the size of an object and located 12 cm behind the mirror. What is the focal length of the mirror?

29. **Critical Thinking** Would spherical aberration be less for a mirror whose height, compared to its radius of curvature, is small or large? Explain your answer.

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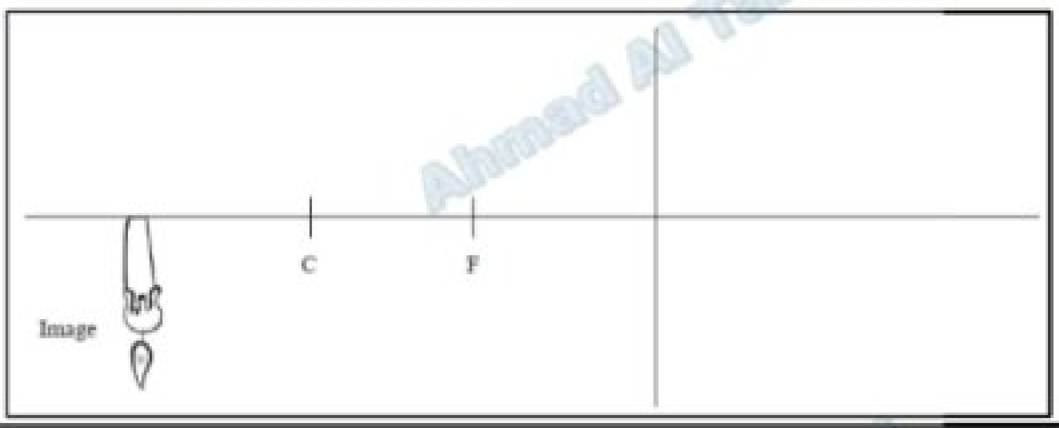
Question 191: The figure shows the image formed by a concave mirror that has a focal length of 8 cm. Using the scale provided in the diagram, determine both the position and height of the object so he properties of the image formed are as shown. Then, verify your results using the mirror equation and the magnification formula.

From drawing		
Symbol	Sign	Value
x_i	+	11 cm
x_o	+	29.3 cm
h_i	-	0.75 cm
h_o	+	2 cm
f	+	8 cm

Question 192

Khaled puts a candle in front of a curved mirror and sees the image of the candle on a screen in front of the mirror. The image is inverted and larger than the candle itself. The diagram shows the image of the candle which Jane observes. Complete the diagram by drawing suitable rays to show where the candle (object) was placed to get this image.



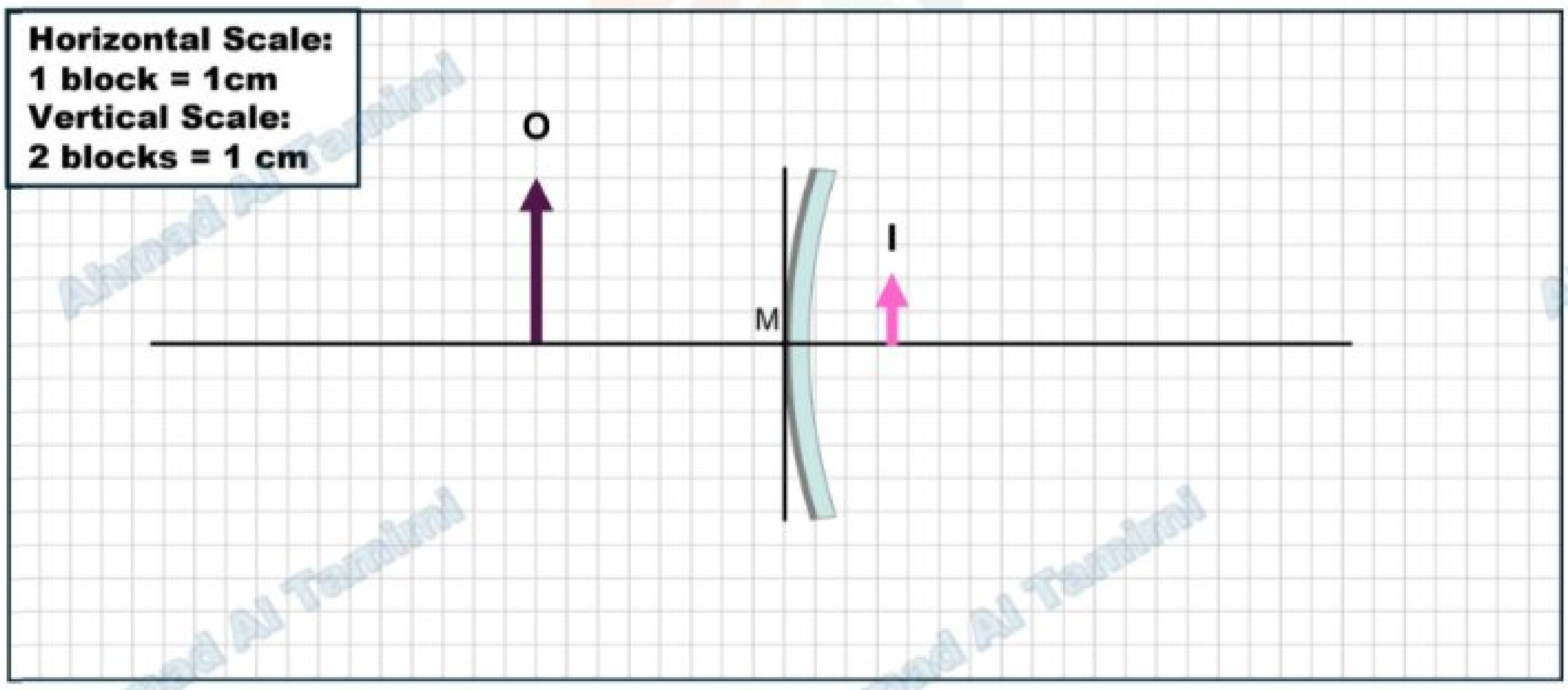
a) Name the type of mirror that can produce this image.

b) The focal length of the mirror is 24.0 cm and the image is 60.0 cm from the front of the mirror. Calculate the distance **the** object must be placed in front of the mirror to produce this image.

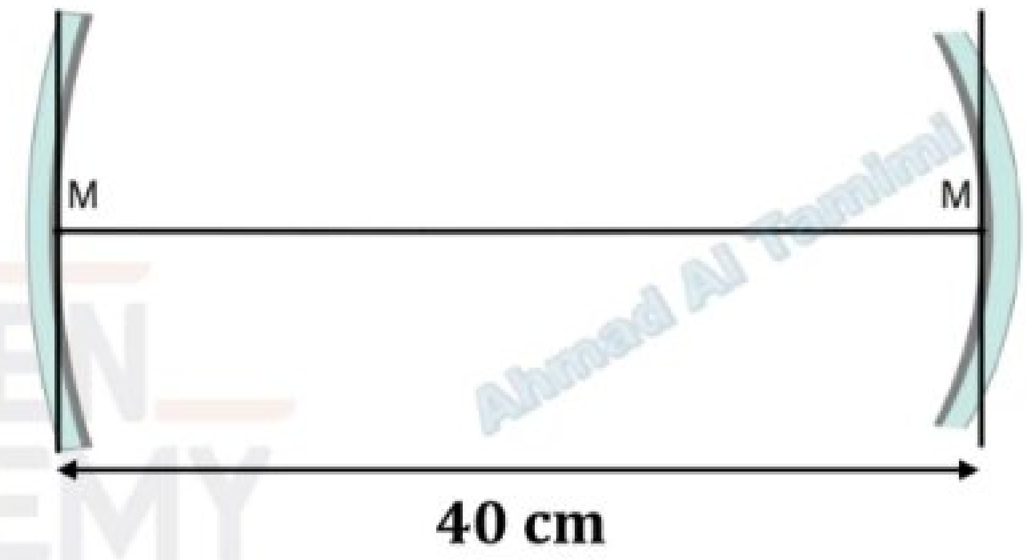
d) Find the magnification of the image

Question 193: The figure shows a convex mirror with an object placed in front of it and its corresponding image formed by the mirror.

a) Using the scale provided in the diagram, determine the focal length of the mirror.
b) By drawing the appropriate ray diagram, show how to locate the focal point on the figure.
c) Calculate the magnification produced by the mirror.



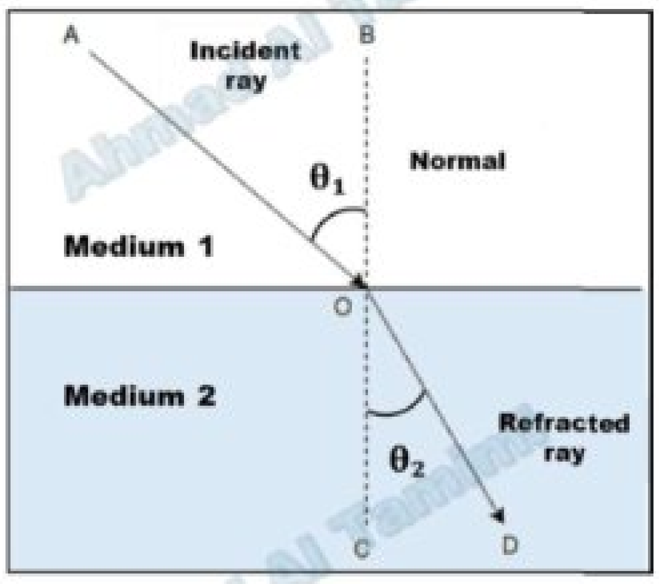
Question 194: two concave mirrors are placed 40 cm apart and face each other. A point object lies between them at a distance of 12 cm from the mirror whose focal length is 10 cm. The other mirror has a focal length of 15 cm. Find the position of the final image after reflection from the second mirror.



23	-Calculate the refractive index of a medium using a suitable mathematical representation (n = c/v). -State and apply Snell's law of refraction. -Calculate the critical angle using Snell's law.	Practice problems Student Textbook	46 47,48

Snell's Law of Refraction

$$\boxed{n_1 \sin\theta_1 = n_2 \sin\theta_2}$$



n_1: Index of refraction of the **first medium** (where the light comes from).

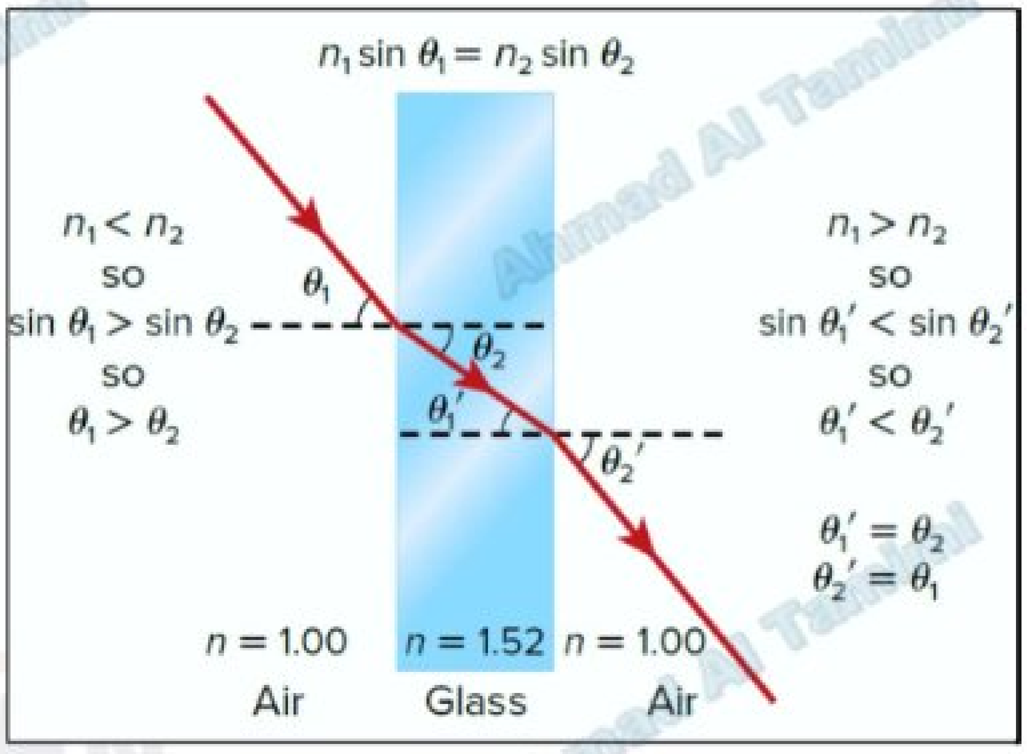
θ_1: Angle of incidence (measured between the incoming ray and the normal).

n_2: Index of refraction of the **second medium** (where the light enters).

θ_2: Angle of refraction (measured between the refracted ray and the normal).

Bending of Light & Index of Refraction

- When light enters a medium with a **higher index of refraction (n↑)** → it **slows down** and bends **towards the normal**.
- When light enters a medium with **a lower index of refraction (n↓)** → it **speeds up** and bends **away from the normal**.
- If light enters **perpendicular (along the normal)** → it passes **straight through** with **no bending**.



- At the boundary, **frequency does not change**.
- When light slows down in a medium, its **wavelength decreases**.
- The **speed of light** is always slower in a medium than in a vacuum.
- Therefore, the **wavelength in any medium is shorter than in a vacuum.**

To find index of Refraction:

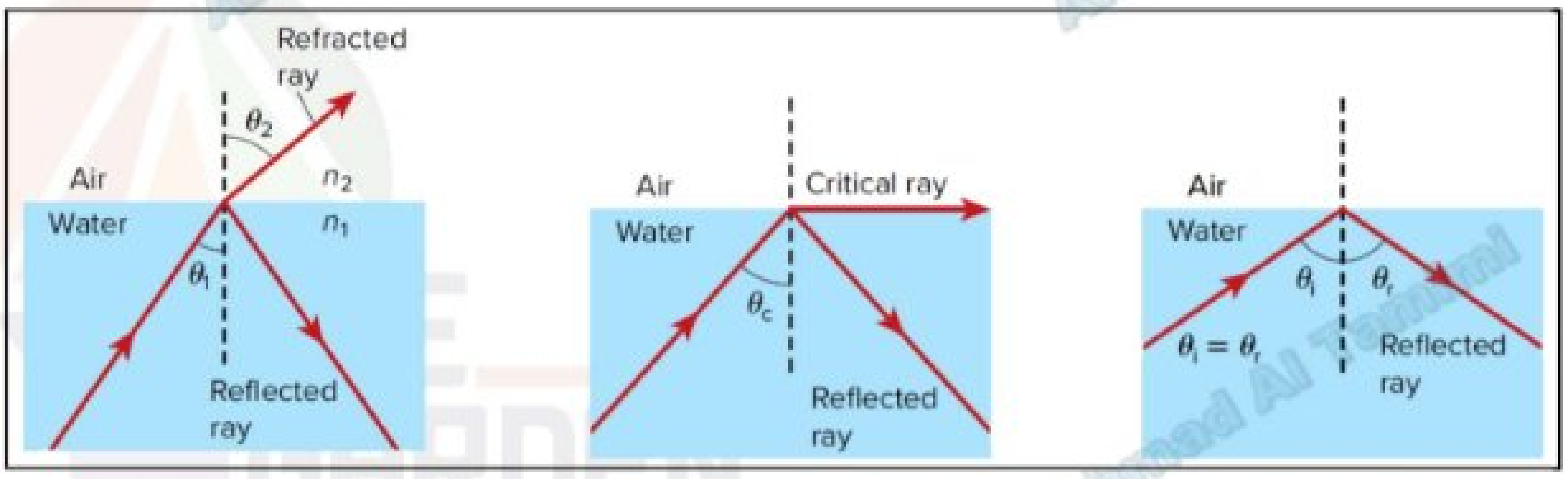
$$n = \frac{c}{v}$$

Where

c = speed of light in vacuum.
v = speed of light in the medium

- The **critical angle (θ_c)** is an angle of incidence that causes a ray to exit along the boundary between two mediums. ($\theta_r = 90°$)

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



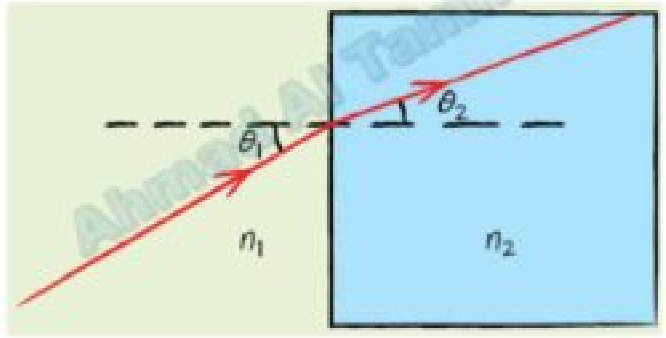
Total internal reflection happens when:

- Light goes from a medium with **higher index of refraction** → to a medium with **lower index of refraction.**
- The **angle of incidence θ_1 is greater than the critical angle θ_c.**

The light then reflects back inside the medium with the higher index of refraction.

EXAMPLE Problem 4

ANGLE OF REFRACTION A beam of light in air hits a sheet of float glass at an angle of 30.0°. What is the angle of refraction of the light ray?



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

PRACTICE Problems Page 46

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

30. A laser beam in air enters ethanol at an angle of incidence of 37.0°. What is the angle of refraction?

31. As light travels from air into water, the angle of refraction is 25.0° to the normal. Find the angle of incidence.

PRACTICE Problems Page 46

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

32. Light in air enters a diamond facet at 45.0°. What is the angle of refraction?

33. A block of unknown material is submerged in water. Light in the water enters the block at an angle of incidence of 31°. The angle of refraction of the light in the block is 27°. What is the index of refraction of the material of the block?

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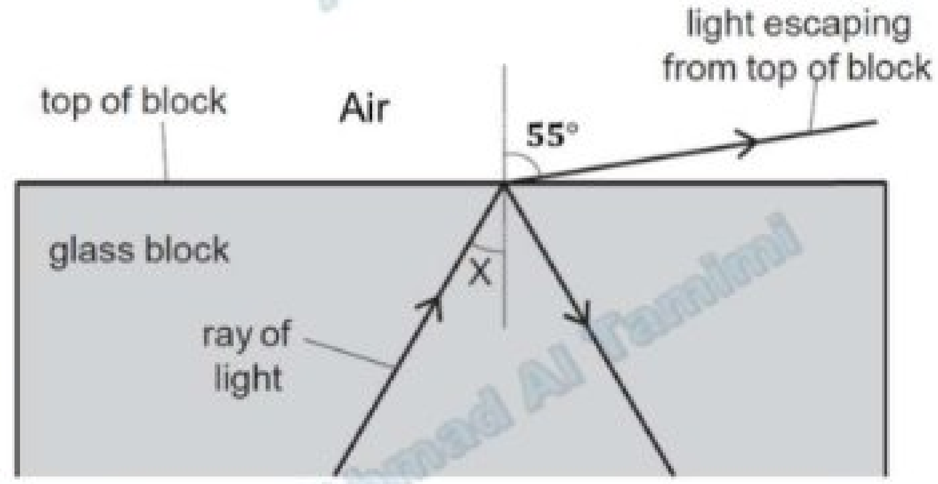
Medium	n
Vacuum	1.00
Air	1.0003*
Water	1.33
Ethanol	1.36
Float glass	1.52
Quartz	1.54
Flint glass	1.62
Diamond	2.42

34. CHALLENGE Light travels from air into another medium. The angle of incidence is 45.0° and the angle of refraction is 27.7°. What is the other medium?

Question 195: A ray of light travels inside a glass block (refractive index $n = 1.56$) and strikes the top surface at an angle X to the normal, as shown in the figure. The light escapes into air making an angle of 55°with the normal.

(a) Using **Snell's Law**, calculate the **angle** X shown in the figure.

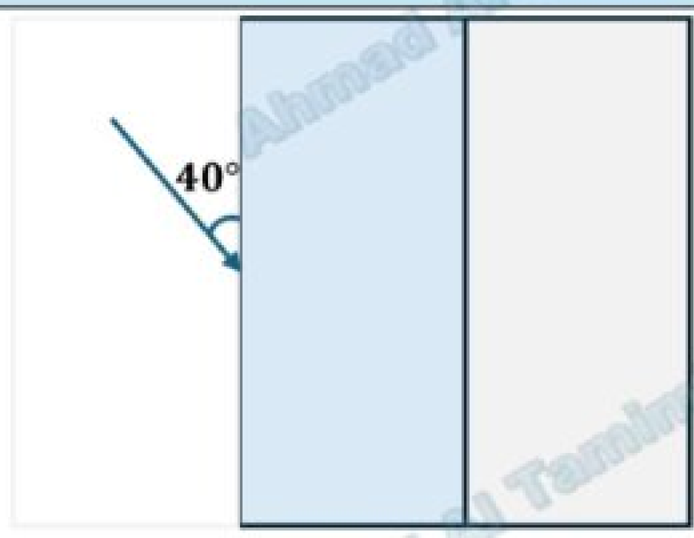


(b) Determine the **speed of light in the glass block.**

(c) Calculate the **critical angle** for the glass–air boundary.

Question 196: A light ray travels successively from air ($n = 1$) into water ($n = 1.33$) and then into flint glass ($n = 1.52$).

a) Calculate the speed of light in water and in flint glass.



b) The ray strikes the air-water interface with an angle of incidence $\theta_i = 40°$ with respect to the vertical. Find the angle of refraction in flint glass.

c) If the ray travels from flint glass to water and strikes the interface at angle of $\theta_i = 65°$. Describe what would happen the ray and explain your answer.

Question 197: A ray of light strikes a surface made of quartz (n=1.54) at angle $\theta_1 = 50°$ as shown in the figure. The quartz surface is placed on top of water surface (n=1.33), and the ray initially travels through air (n=1.00).

a) Calculate the speed of light in quartz

b) Find the angle of refraction of light as it enters the quartz surface.

c) Calculate the critical angle of the light ray as it strikes the boundary between quartz and water.

d) Will the ray pass through the water surface beneath quartz? Explain your answer.

24	-Draw a ray to find the image of an object located at different distances from a lens and determine the location and properties of the formed image. -Apply the thin lens equation to calculate the image distance, the object distance, or the focal length of a convex or a concave lens using appropriate algebraic signs for focal length and corresponding distances -Calculate the magnification produced by a thin convex or concave lens.	Student Textbook Example problem5 Practice problems Check your progress 45,55,51,55,56	52,53 55 60

Thin Lens Equation

- The problems that you will solve involve spherical thin lenses, lenses that have faces with the same curvature as a sphere.
- Based on the thin lens model, as well as the other simplifications used in solving problems for spherical mirrors, equations have been developed that look exactly like the equations for spherical mirrors.
- The **thin lens equation** relates the focal length of a spherical thin lens to the object position and the image position.

Sign conventions (we'll use these throughout)	
x_o	(+) always
x_i	(+) for **real** images, (-) for **virtual** images.
f	(+) for **convex** lenses, (-) for **concave** lenses.

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

Magnification

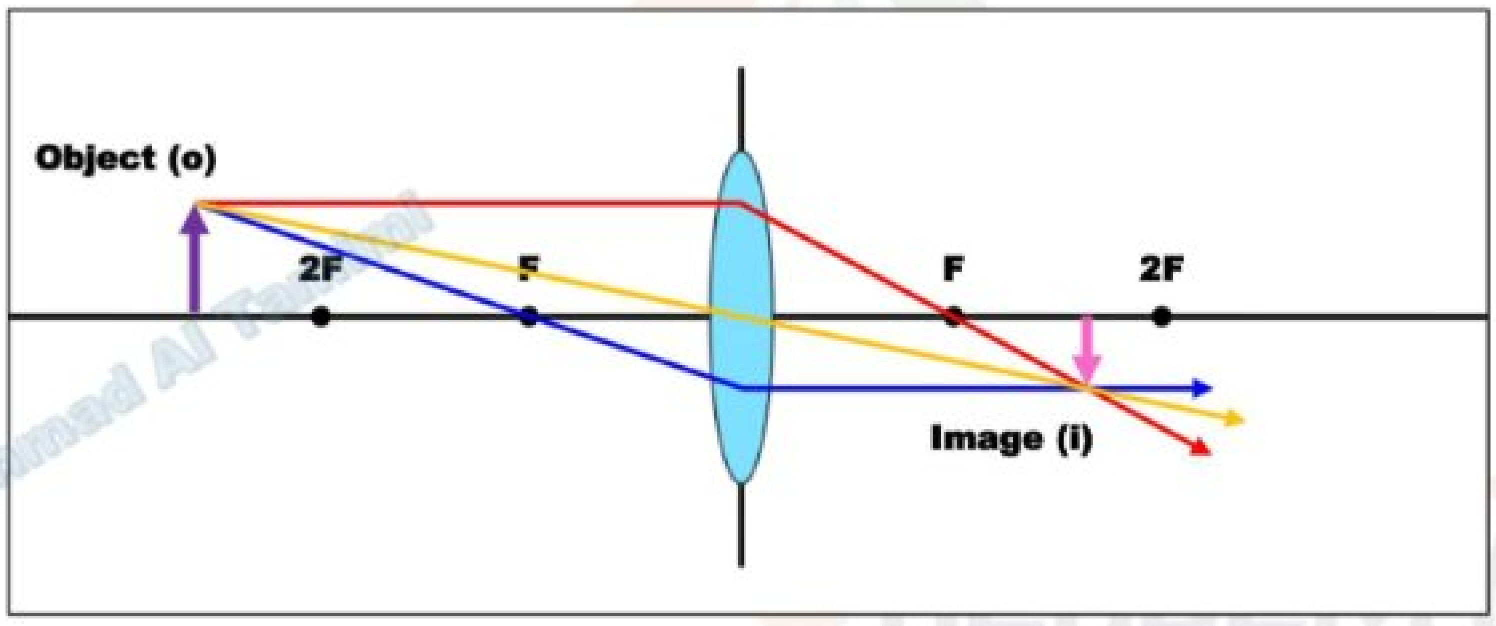
The magnification equation for spherical mirrors also can be used for spherical thin lenses.

Symbol	Meaning	Sign Convention
m	Magnification	+ → virtual image – → real image |m| < 1 → image smaller |m| > 1 → image larger
h_i	Image Height	+ → image is upright – → image is upside down (inverted)
h_0	Object Height	always positive
x_i	Image Position	+ → on the other side (real) – → on t he same side (virtual)
x_0	Object Position	always positive

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

Convex lenses

Case 1: If the object is located beyond (2F).



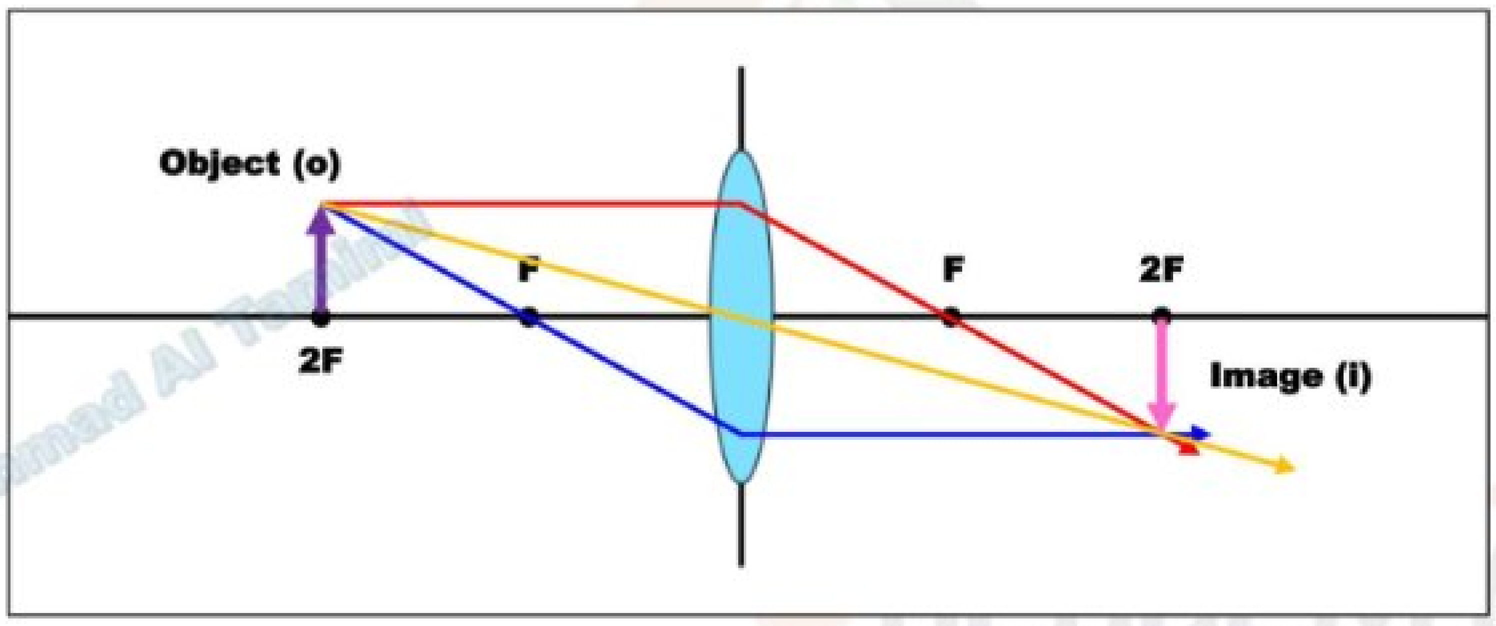
Properties of the image
Located between F and 2F
Reduced (diminished)
Inverted
Real

Quantity	+/–
f	+
x_o	+
x_i	+
m	–

- We will focus on **two principal rays** to locate the image:
  - **Parallel Ray** → refracts **through the focal point** on the other side.
  - **Focal Ray** → refracts **parallel to the principal axis** after passing through the lens.
- By tracing these two rays, we can determine the **position**, **size**, **orientation**, **and type** of the image.

Convex lenses

Case 2: If the object is located at (2F).



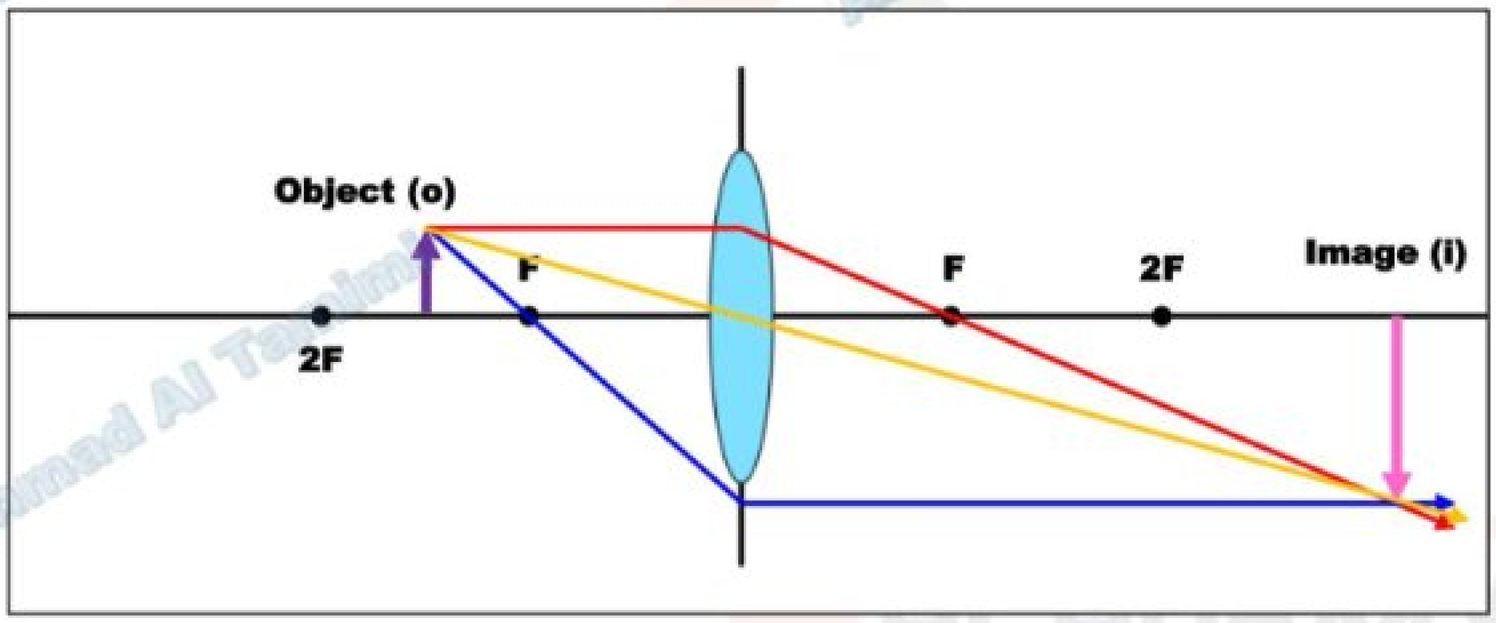
Properties of the image
Located at 2F
Same size
Inverted
Real

Quantity	+/−
f	+
x_o	+
x_i	+
m	−

- We will focus on **two principal rays** to locate the image:
  - **Parallel Ray** → refracts **through the focal point** on the other side.
  - **Focal Ray** → refracts **parallel to the principal axis** after passing through the lens.
- By tracing these two rays, we can determine the **position**, **size**, **orientation**, **and type** of the image.

Convex lenses

Case 3: If the object is located at between (2F) and (F).



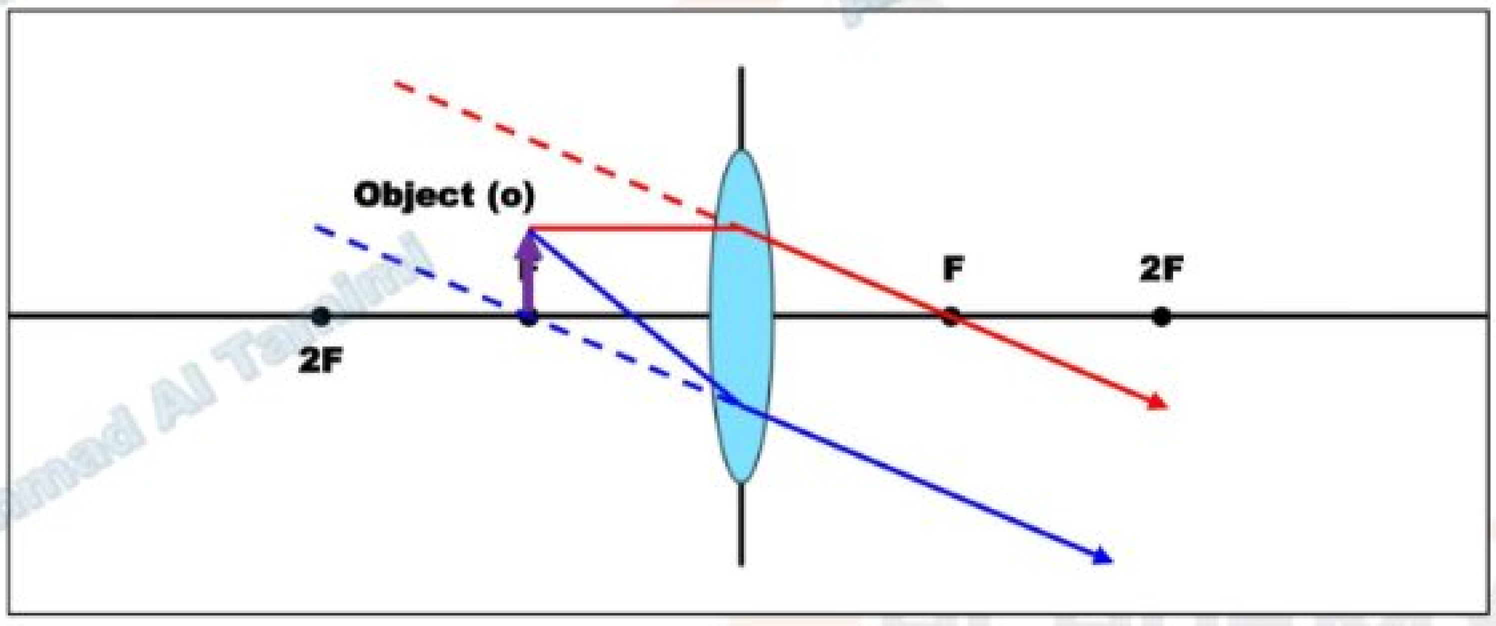
Properties of the image
Located Beyond 2F
Enlarged (magnified)
Inverted
Real

Quantity	+/−
f	+
x_o	+
x_i	+
m	−

- We will focus on **two principal rays** to locate the image:
  - **Parallel Ray** → refracts **through the focal point** on the other side.
  - **Focal Ray** → refracts **parallel to the principal axis** after passing through the lens.
- By tracing these two rays, we can determine the **position**, **size**, **orientation**, **and type** of the image.

Convex lenses

Case 4: If the object is located at (F).



Properties of the image
Located at infinity
Highly enlarged (infinite)
Inverted
Real

- We will focus on **two principal rays** to locate the image:
  - **Parallel Ray** → refracts **through the focal point** on the other side.
  - **Focal Ray** → refracts **parallel to the principal axis** after passing through the lens.
- By tracing these two rays, we can determine the **position**, **size**, **orientation**, **and type** of the image.

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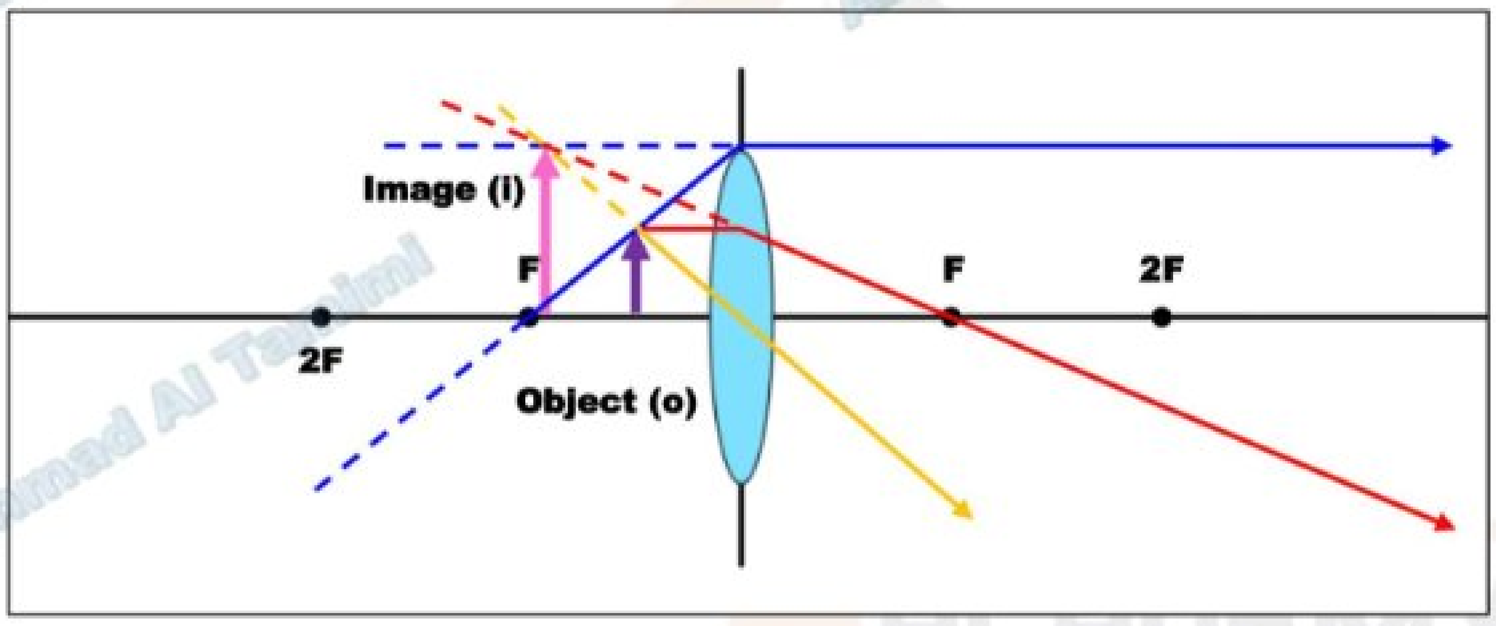
Convex lenses

Case 5: If the object is located at between (F) and the lens.



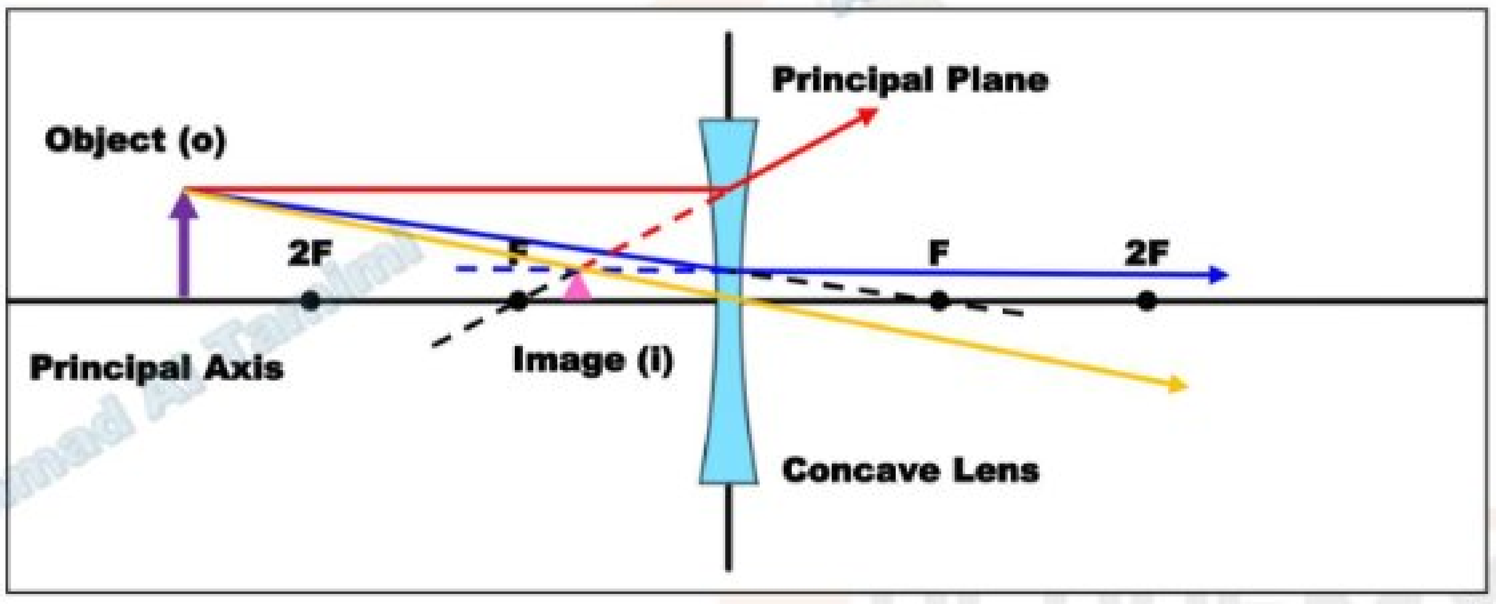
Properties of the image
Farther from the lens than the object
Enlarged (magnified)
Upright
Virtual

Quantity	+/−
f	+
x_o	+
x_i	−
m	+

- We will focus on **two principal rays** to locate the image:
  - **Parallel Ray** → refracts **through the focal point** on the other side.
  - **Focal Ray** → refracts **parallel to the principal axis** after passing through the lens.
- By tracing these two rays, we can determine the **position**, **size**, **orientation**, **and type** of the image.

Concave lenses

Regardless of where the object is placed, the image formed will be:



Properties of the image
Between F and the lens
Reduced (diminished)
Upright
Virtual

Quantity	+/−
f	−
x_o	+
x_i	−
m	+

- We will focus on **two principal rays** to locate the image:
  - **Parallel Ray** → refracts **through the focal point** on the other side.
  - **Focal Ray** → refracts **parallel to the principal axis** after passing through the lens.
- By tracing these two rays, we can determine the **position**, **size**, **orientation**, and **type** of the image.

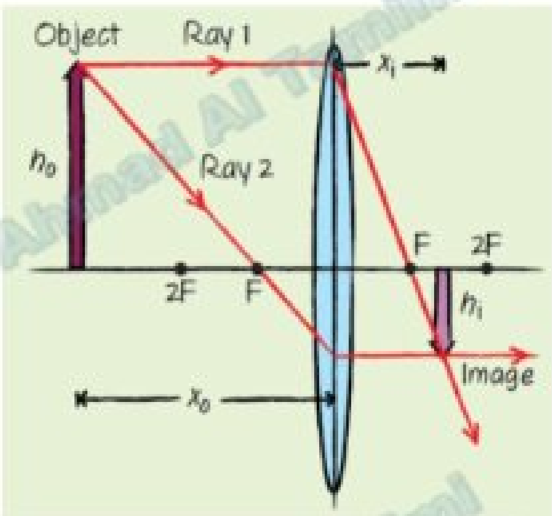
EXAMPLE Problem 5

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?



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43. A 2.25-cm-tall object is 8.5 cm to the left of a convex lens whose focal length is 5.5 cm. Find the image position and height.

44. 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?

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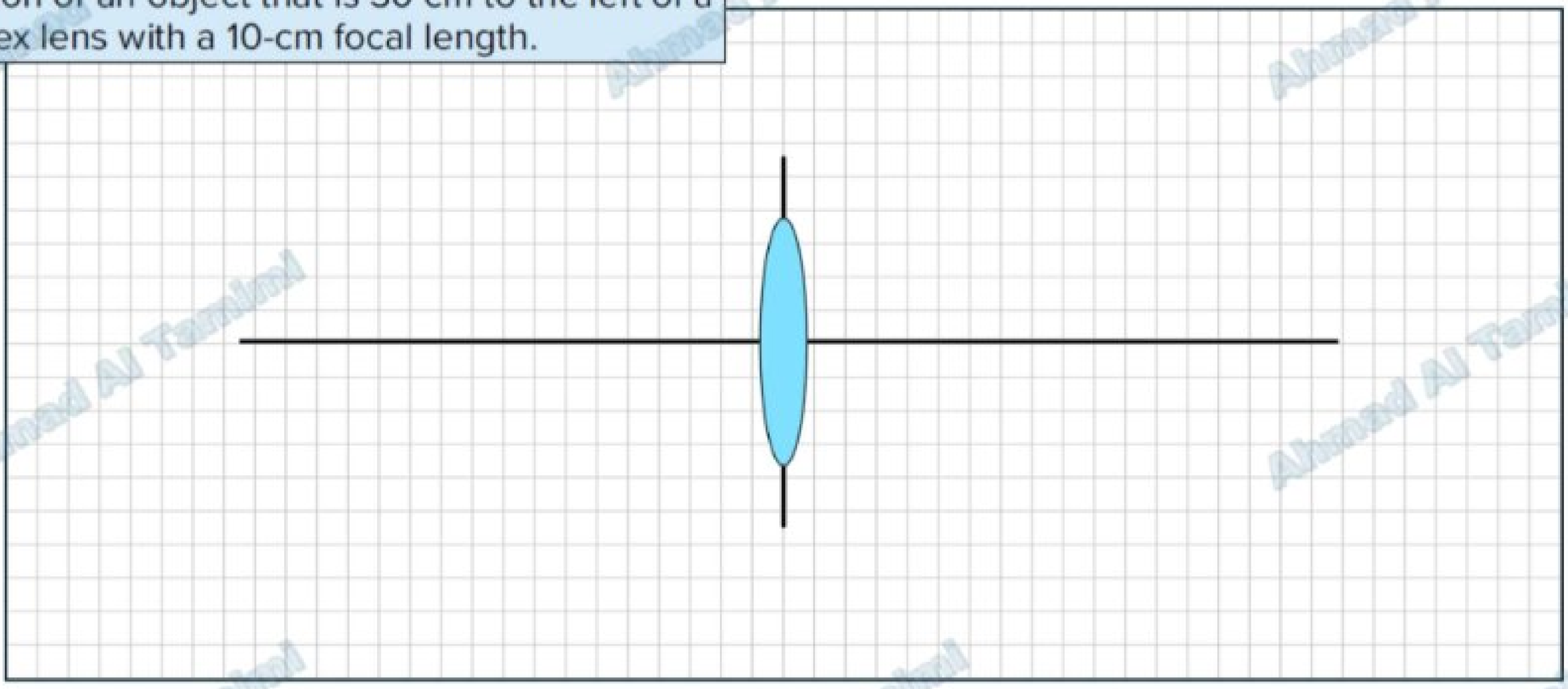
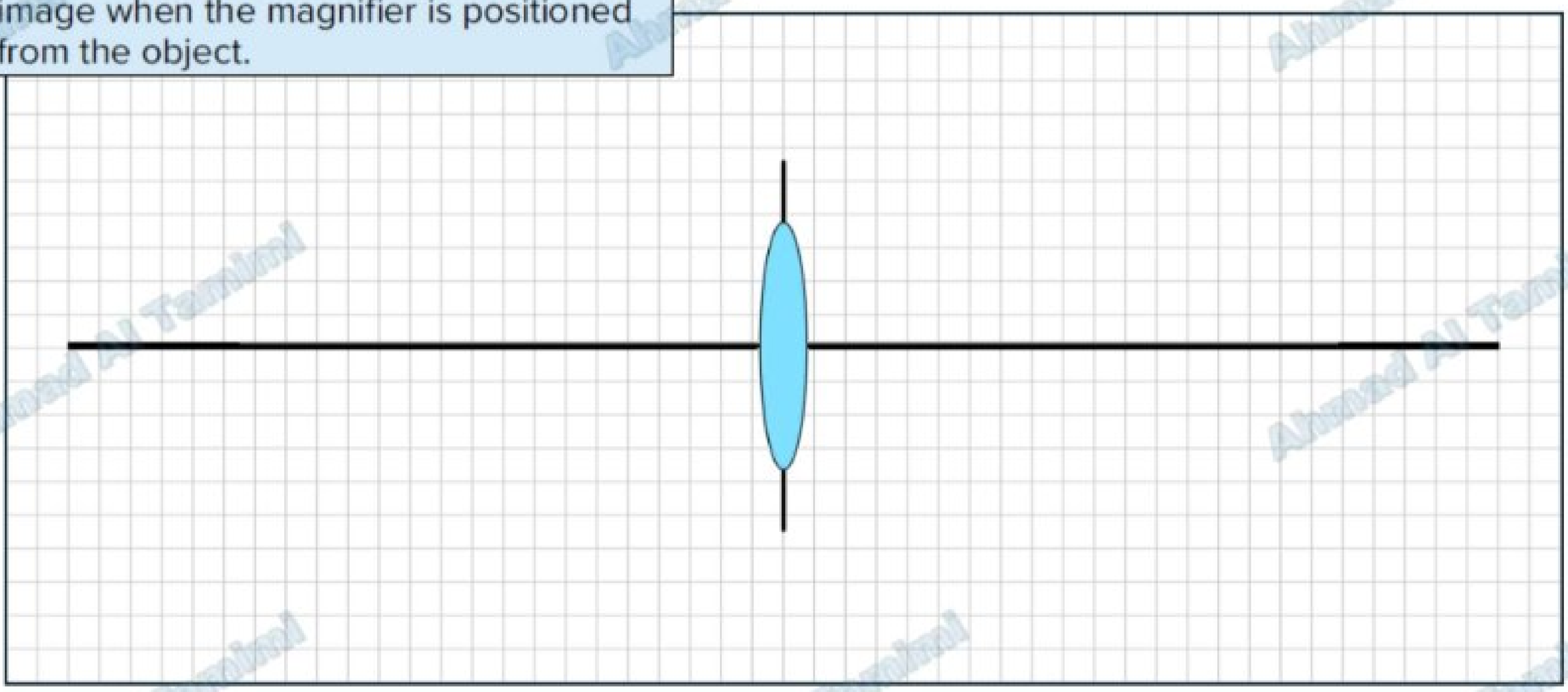
45. An object is placed to the left of a convex lens with a 25-mm focal length so that its image is the same size as the object. What are the image and object positions?

46. Calculate the image position and height of a 2.0-cm-tall object located 25 cm from a convex lens with a focal length of 5.0 cm. What is the orientation of the image?

47. Use a scale ray diagram to find the image position of an object that is 30 cm to the left of a convex lens with a 10-cm focal length.



48. CHALLENGE A magnifier with a focal length of 30 cm is used to view a 1-cm-tall object. Use a ray diagram to determine the location and size of the image when the magnifier is positioned 10 cm from the object.



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51. **Image Position and Height** An object is placed 1.5 m from a convex lens with a focal length of 1.0 m. Use the thin lens equation to determine the distance of the image from the lens. If the object height is 2.0 m, what is the image height? Is the image real or virtual? Is the image inverted or upright?

55. **Image Position and Height** A 6.0-cm-tall object is placed 5.0 cm from a convex lens with a focal length of 4.0 cm. Draw a ray diagram to determine the image location and size. Confirm your results using the thin lens equation and the magnification equation.

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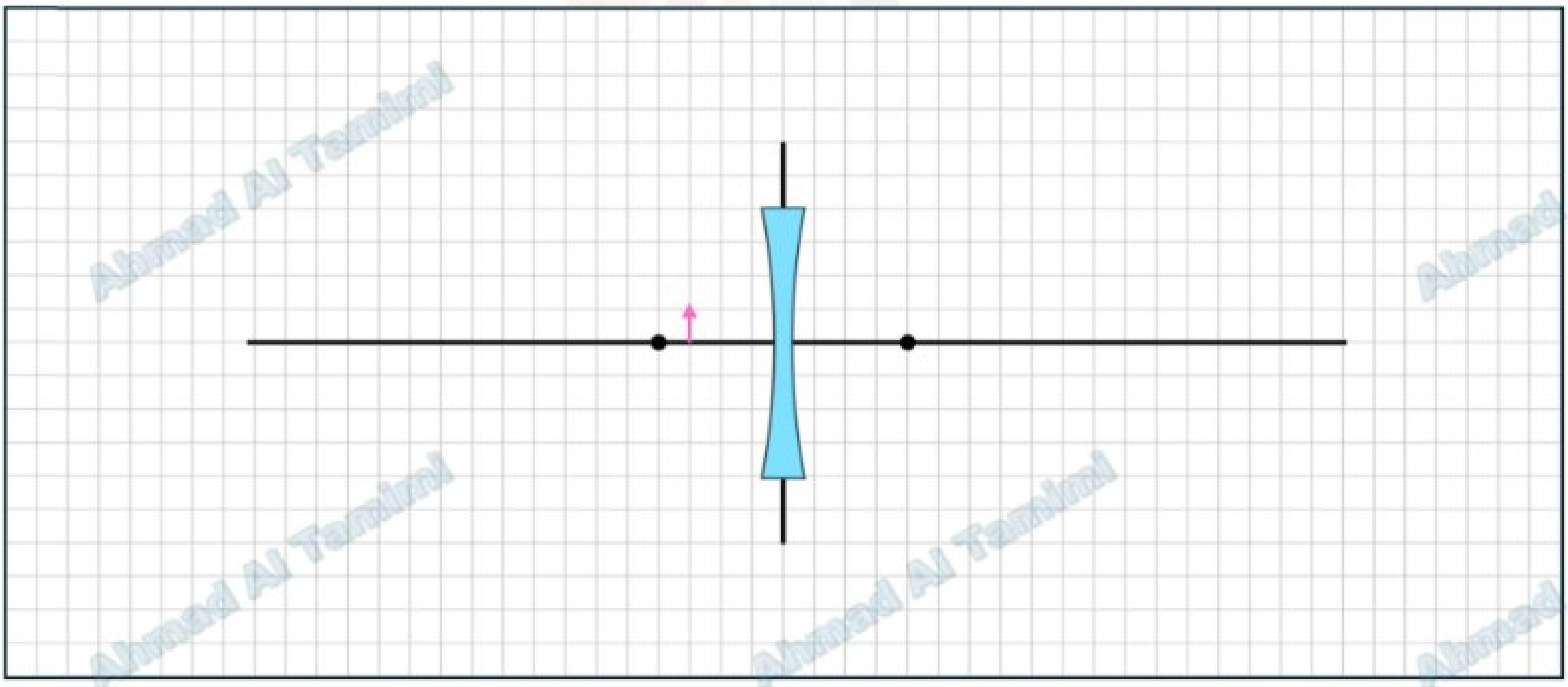
56. **Diverging Lens** A 6.5-cm-tall salt shaker is viewed through a diverging lens with a focal length of 5.0 cm.
    a. If the shaker is 6.0 cm from the lens, what is the image distance from the lens? Is the image virtual or real?
    b. What is the magnification? Is the image smaller or larger than the object?
    c. The salt shaker is now 4 cm from the lens. What is the distance of the image from the lens? The magnification? Is the image now smaller or larger than the object?

Question 198:

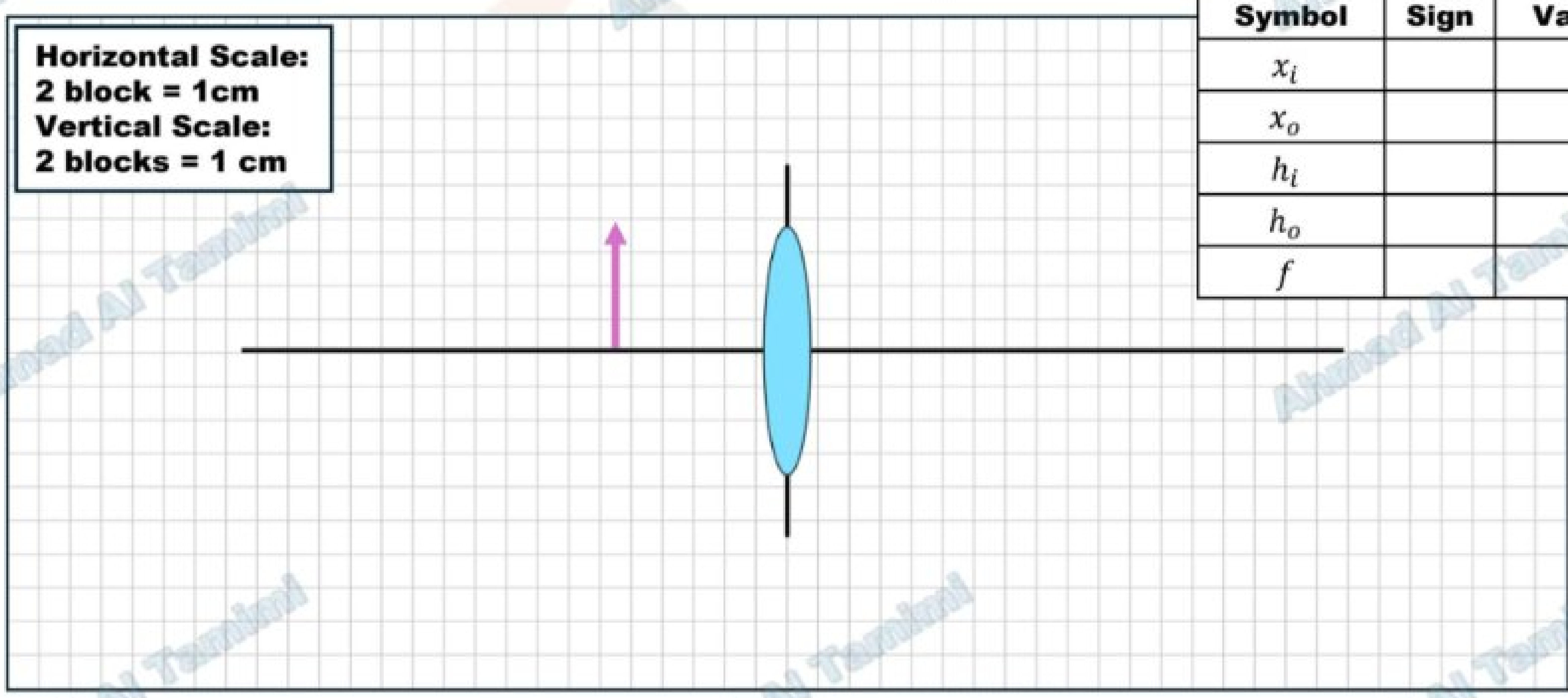
Part (A): A concave lens has a focal length of 10 cm. An object 3.0 cm tall is placed 20 cm in front of the lens. Find the location of the image and determine its height.

Part (B): the figure below shows the image formed by a concave lens. Using ray diagram construction, locate the position of the object to form the shown image.

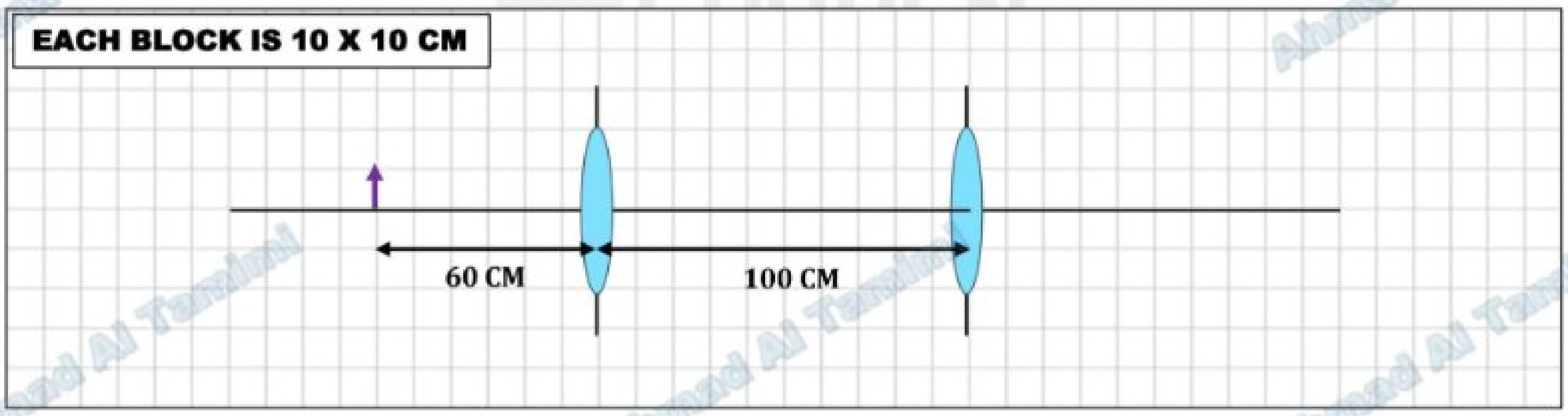


Question 199: The figure shows the image formed by a convex lens that has a focal length of 12 cm. Using the scale provided in the diagram, determine both the position and height of the object so that the properties of the image formed are as shown. Then, verify your results using the mirror equation and the magnification formula.

From drawing		
Symbol	**Sign**	**Value**
x_i		
x_o		
h_i		
h_o		
f		



Question 200: Two convex lenses, each with a focal length of 30 cm, are placed 100 cm apart. An object is placed 60 cm in front of the first lens. Determine the position and magnification of the final image formed by the two-lens system.



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Question 201: A convex lens of focal length +3.0 cm and a concave lens of focal length –4.0 cm are placed 18 cm apart on a common principal axis. An object of height 2.0 cm is placed 6.0 cm in front of the convex lens.

a) Find the position of the final image formed by the two-lens system.
b) Calculate the overall magnification of the final image.
c) Draw a ray diagram showing the formation of the image and indicate its position, orientation, and size.