مذكرة شاملة وحدات الفصل منهج انسباير

احجز مكانك واستعد للامتحان بثقة كاملة

ملزمة الفيزياء الفصل الثاني

10 Inspire متقدم لعام 2026

تنويه:

تم إنشاء هذه الملزمة لمساعدتك، ولكن المرجع الرئيسي هو الكتاب،
وسيكون هناك ملف إضافي للأمثلة.

NOLOGIA™

Module (15): Fundamentals of Light

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02 Second Lesson:
The Wave Nature of Light

Decoding the Wave Nature of Light

A Comprehensive Guide by Mr. Mohamad

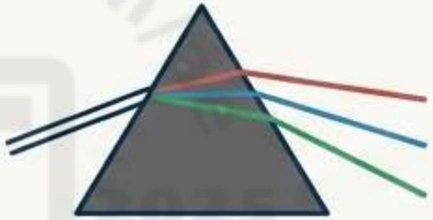
Prepared for Mr. Mohamad's Students

Our Journey Through Light

We will explore the fundamental behaviors of light as a wave, moving from how it bends and shows color to how we use its properties to understand the motion of the most distant galaxies.

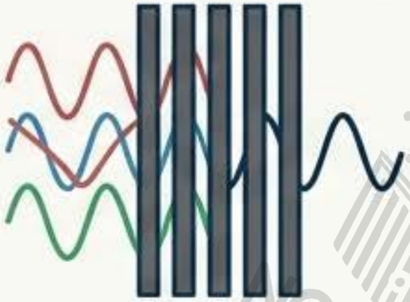
1. Light's Flexibility

How light bends around obstacles (Diffraction & Huygens' Principle).



2. Light's Palette

The science behind the colors we see (Additive & Subtractive Color).



3. Light's Direction

How to filter and control light waves (Polarization & Malus's Law).

4. Light's Motion

Using light to measure the movement of stars (The Doppler Effect).

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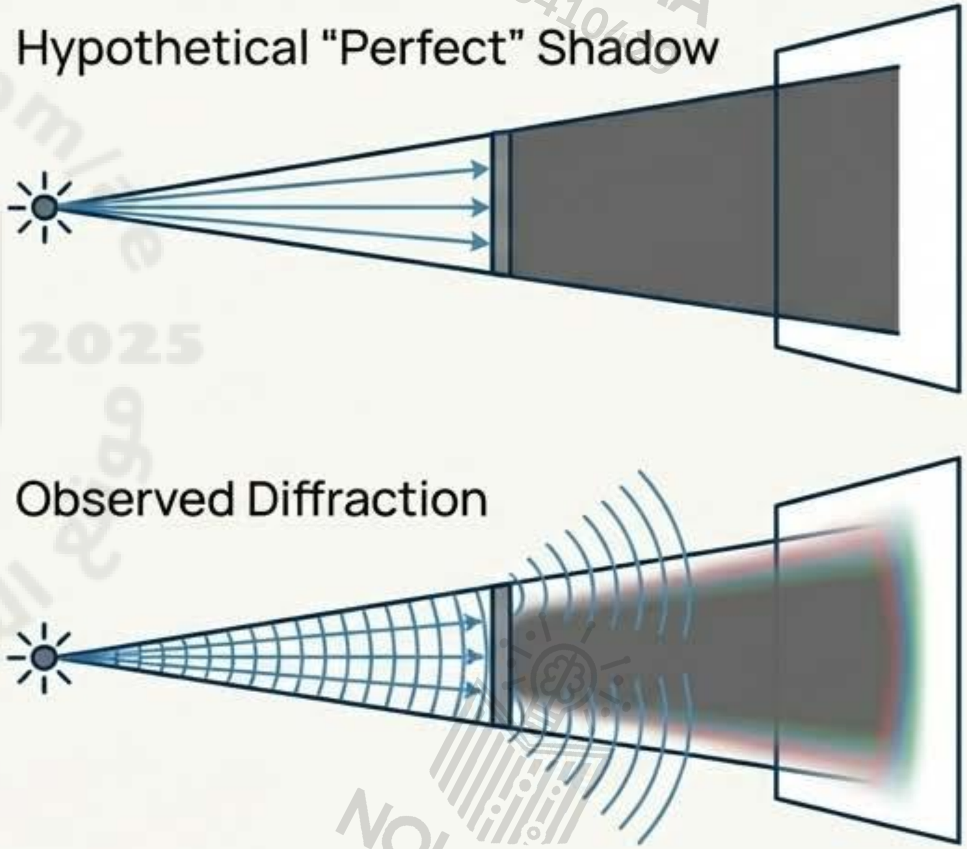
Part 1: Light Bends Around Corners – An Introduction to Diffraction

Main Point: In 1665, Francesco Maria Grimaldi observed that the edges of shadows are not perfectly sharp. This phenomenon, where light bends as it passes the edge of a barrier, is called **diffraction.**

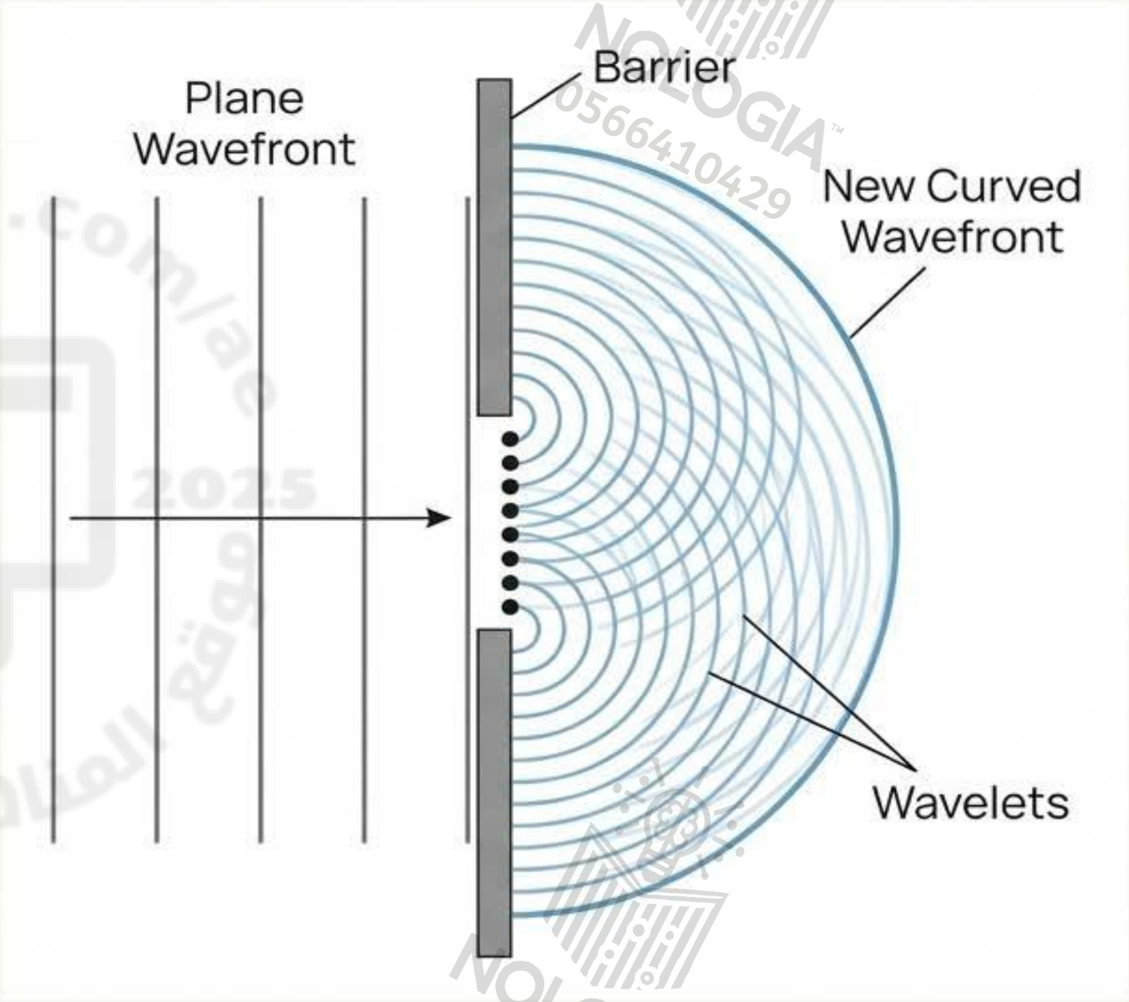
Supporting Text: Grimaldi noticed that when a narrow beam of light was cast on a white surface, the shadow's edge was bordered by colored bands. This couldn't be explained if light only traveled in a straight line; it proved that light bends.



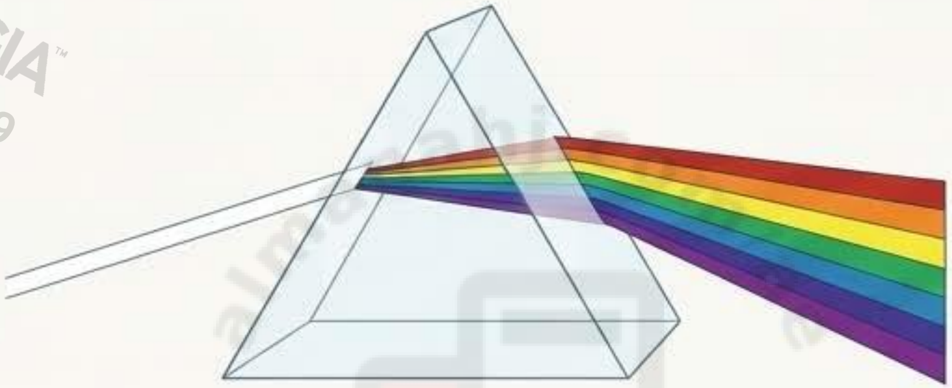
The Mechanism of Bending: Huygens' Principle

Core Concept:
In 1678, Christiaan Huygens proposed a model to explain diffraction. According to **Huygens' principle**, all points of a wavefront can be thought of as new sources of smaller waves, called wavelets.

Explanation:
- These wavelets expand in every direction.
- A flat, or plane, wavefront consists of an infinite number of point sources in a line.
- When a wavefront passes an edge, the wavelets at the edge spread out in a circular manner, causing the wave to bend.



Part 2: Unlocking the Spectrum of Color



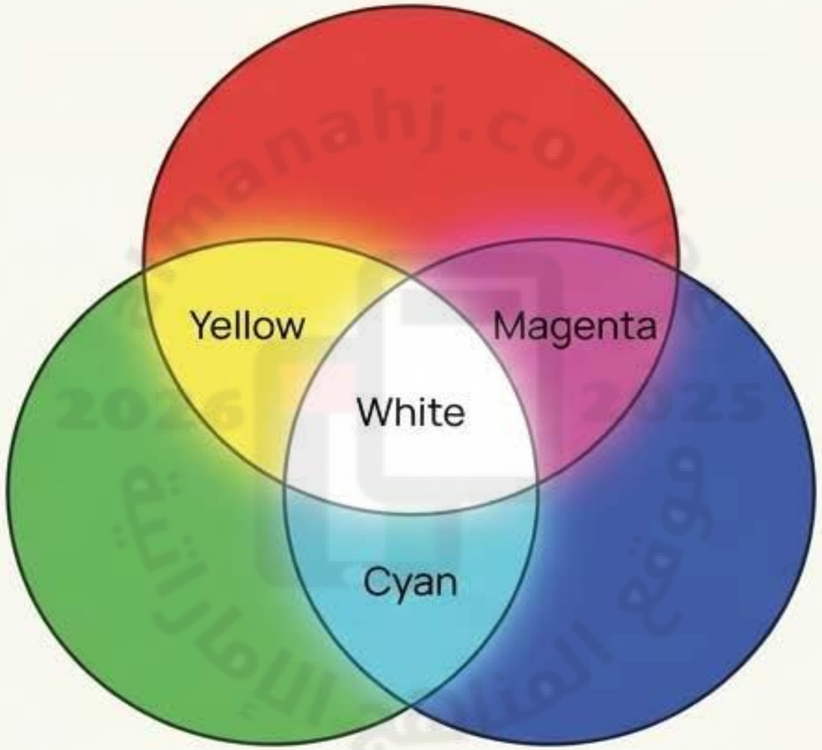
Main Point: In 1666, Isaac Newton demonstrated that white light is not a single entity but is composed of a spectrum of colors.

Experiment Explained:

- Newton passed a narrow beam of sunlight through a glass prism.
- The prism separated the white light into an ordered arrangement of colors, from red to violet.
- He concluded that the different colors of light are bent at slightly different angles by the prism because they have different wavelengths.

Creating Color with Light: The Additive Process

Core Concept:
White light can be formed from colored light. When the correct intensities of red, green, and blue light are projected onto a white screen, the area where they overlap appears white. This is the **additive color process.**



Primary Colors (Light):
Red, Green, and Blue.

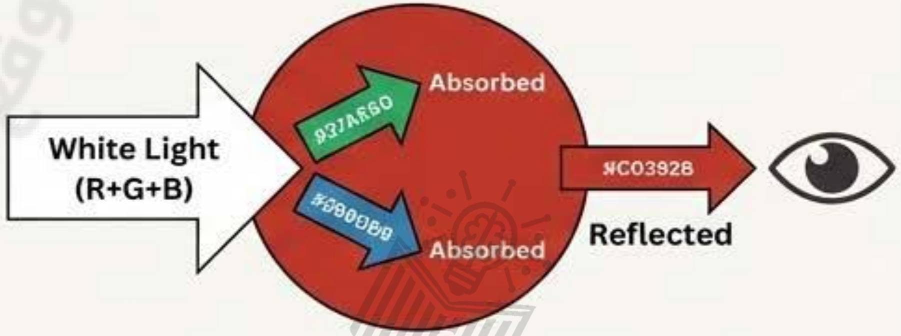
Secondary Colors (Light):
Red + Green = Yellow;
Green + Blue = Cyan;
Blue + Red = Magenta

Application: This process is used in television and computer screens to produce the colors you see.

How Objects Have Color: The Subtractive Process

Core Concept: The color of an object depends on which wavelengths of light it absorbs and which it reflects. This is the principle of **color by**
reflects. This is the principle of **color by**
subtraction.

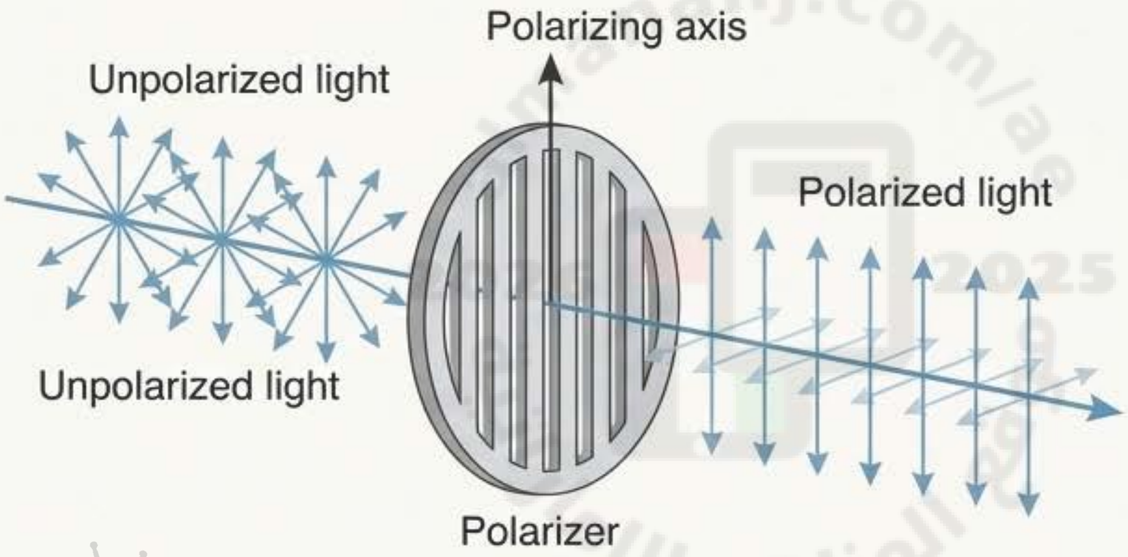
- **Dyes and Pigments:** These are molecules that absorb certain wavelengths of light and transmit or reflect others.
- **Example:** A red shirt appears red because its dye molecules absorb most of the blue and green light, reflecting mostly red light to our eyes.

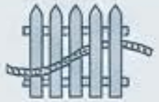


Primary Pigments: Cyan, Magenta, and Yellow are the primary colors for pigments. They work by subtracting (absorbing) one of the primary colors of light.

Part 3: Filtering Light's Direction - An Introduction to Polarization

Core Concept: Light is a transverse wave, meaning its electric field oscillates perpendicular to its direction of travel.





Analogy: Think of it like a rope passing through the slats of a fence. Only vertical waves can pass through a vertical fence.

Unpolarized Light: The electric field oscillates in random directions (all perpendicular to the direction of travel).

Polarization: The production of light with a specific pattern of oscillation. A polarizing filter blocks light waves oscillating in one plane while letting waves oscillating in another plane pass through.

The Rule of Two Filters: Malus's Law

Core Concept: Malus's Law describes the intensity of light passing through a second polarizing filter (an analyzer).

$$I_2 = I_1 \cos^2\theta$$

I_1 = The intensity of polarized light entering the second filter.
I_2 = The intensity of light that passes through the second filter.
θ = The angle between the polarizing axes of the two filters.

$\theta = 0°$ (Axes Parallel)
$\cos^2(0) = 1$. All light passes through ($I_2 = I_1$).

$\theta = 45°$
$\cos^2(45) = 0.5$. Half the intensity passes through ($I_2 = 0.5 * I_1$).

$\theta = 90°$ (Axes Perpendicular)
$\cos^2(90) = 0$. No light passes through ($I_2 = 0$).

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Polarization in Action: Sunglasses and Photography

Without Polarizing Filter

With Polarizing Filter

Main Application: Reducing Glare

- Light that reflects off non-metallic surfaces like glass or water becomes partially polarized parallel to the surface.
- *Polarizing Sunglasses**: The filters are oriented vertically to block this horizontally polarized glare, making it easier to see.
- "Photography": Photographers use polarizing filters on their camera lenses to reduce reflections and enhance the contrast and color of skies.

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Part 4: Light in Motion - The Doppler Effect

Core Concept: Just like with sound, the observed frequency and wavelength of light change when there is relative motion between the source of the light and the observer.

Redshift

When a light source moves **away** from an observer, the observed wavelength appears longer (shifted toward the red end of the spectrum). The observed frequency is lower.

Blueshift

When a light source moves **toward** an observer, the observed wavelength appears shorter (shifted toward the blue end of the spectrum). The observed frequency is higher.

Quantifying the Shift: The Doppler Formulas

Key Relationship: For light in a vacuum, speed (c), frequency (f), and wavelength (λ) are related: $\mathbf{c = f\lambda}$

Observed Frequency (for $v \ll c$):

$$F_{obs} = f\left(1 \pm \frac{v}{c}\right)$$

+ for an approaching source (**blueshift**).
- for a receding source (**redshift**).

Doppler Shift in Wavelength:

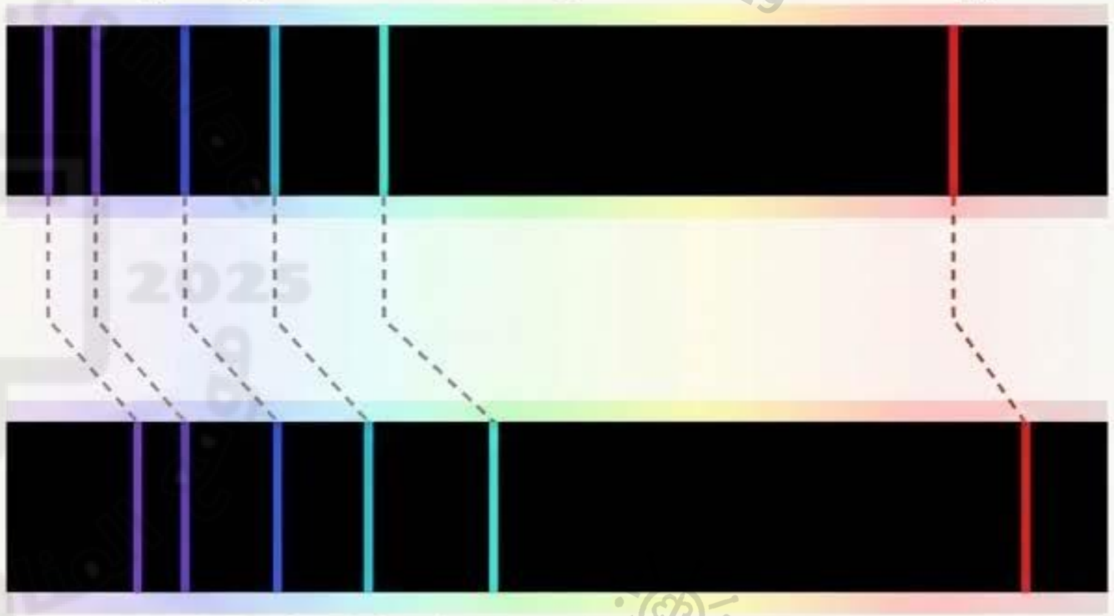
$$\Delta\lambda = \lambda_{obs} - \lambda = \pm(v/c)\lambda$$

Where v is the **relative speed** along the axis between the source and observer.

Reading the Cosmos: How Astronomy Uses the Doppler Shift

Application:
Astronomers can determine how celestial objects, such as galaxies, are moving relative to Earth by observing the Doppler shift of their light.

How It's Done:
1. Elements, like hydrogen, emit light at specific, known wavelengths (an emission spectrum).
2. Scientists measure the spectrum of light from a distant galaxy.
3. They compare the galaxy's spectrum to the known laboratory spectrum.
4. If the spectral lines are shifted toward the red end, the galaxy is moving away from us.



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Hubble's Discovery: A Universe in Expansion

Key Finding: In 1929, astronomer Edwin Hubble analyzed the light from many galaxies. He observed that the spectral lines from almost all of them were **redshifted**.

The Conclusion: The more distant a galaxy, the greater its redshift. This observation provided the first strong evidence that galaxies are moving away from us and that the **universe is expanding**.

Modern Impact: This foundational discovery, made possible by understanding the wave nature of light and the Doppler effect, is the cornerstone of modern cosmology.

Hubble concluded that galaxies are moving away from Earth and supported the conclusion that the universe is expanding.

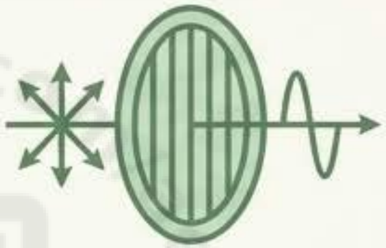
Key Takeaways: The Power of the Wave Model

Diffraction

Light doesn't always travel in a straight line; it bends around edges, a behavior explained explained by every point on a wavefront acting as a new source.

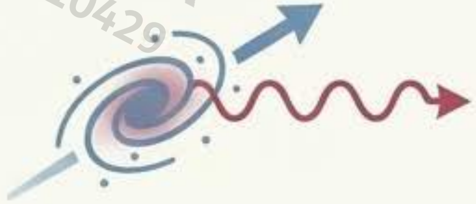
Color

White light is a mixture of a spectrum of colors. spectrum of colors. Additive mixing (light) creates white, while subtractive mixing (pigment) creates black.



Polarization

Light's transverse oscillations can be filtered to a single plane, a principle used to reduce glare in sunglasses and cameras.



Doppler Effect

The wavelength of light shifts based on relative based on relative motion, allowing us to measure the speed of distant galaxies and conclude that our universe is expanding.

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Module (16): Reflection and Refraction

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01 First Lesson: Reflection of Light

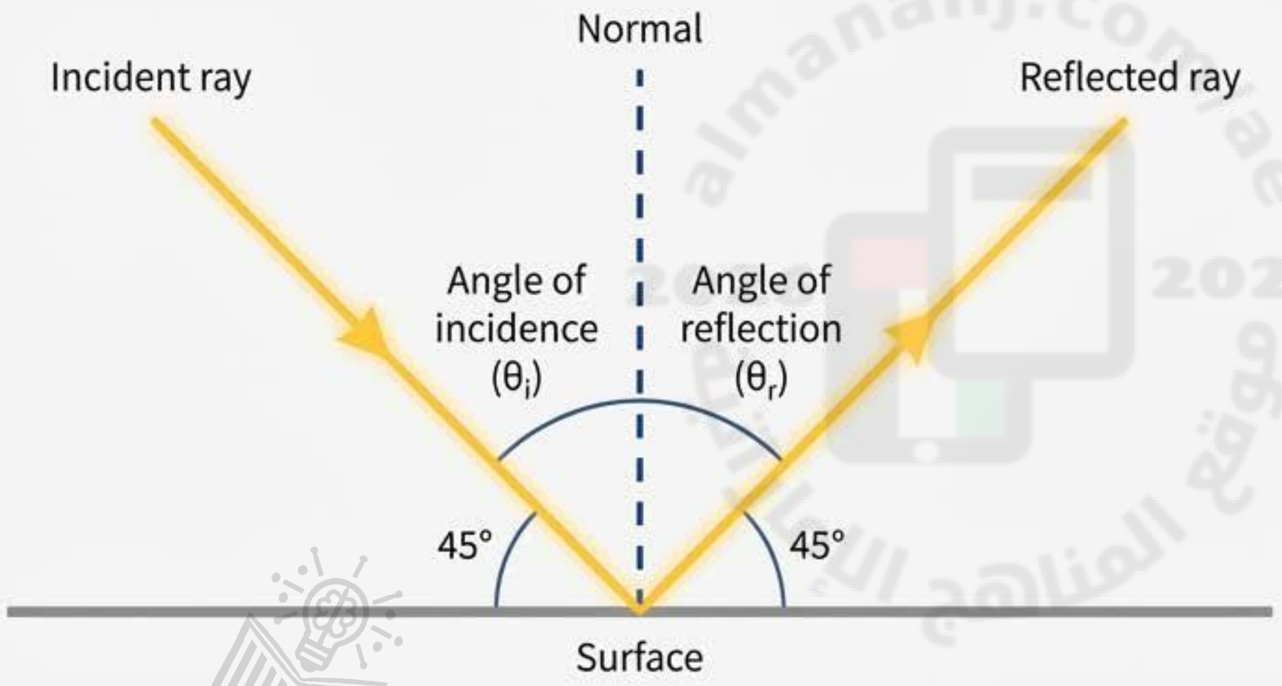
The Physics of Reflection

Seeing a Clearer Picture

Two Surfaces. Two Different Stories.

Why does a smooth surface like a mirror create a clear image, while a rough surface like paper reflects light but forms no image at all?

One Law Governs All Reflection



The angle of incidence always equals the angle of reflection.

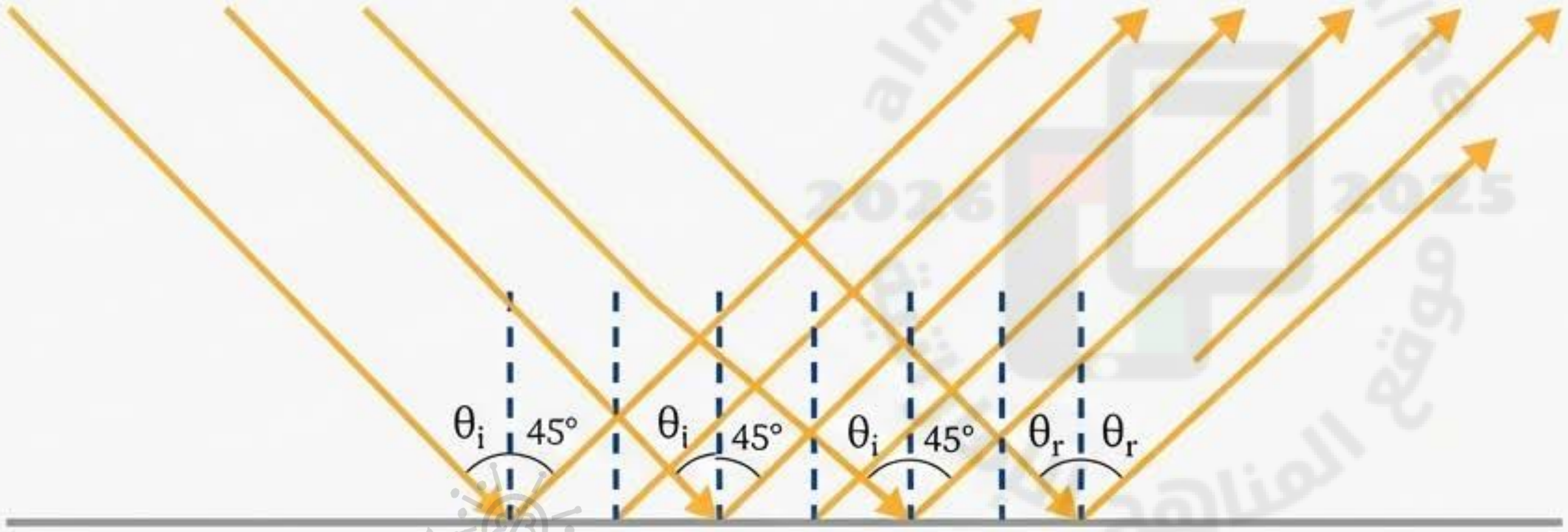
$$\theta_i = \theta_r$$

The incident ray, the normal, and the reflected ray all lie in the same plane.

The Secret is in the Surface.

Smoothness is relative. For a surface to be smooth, its variations must be small compared to the wavelength of light. The law of reflection applies to both surfaces, but the microscopic texture dictates the outcome.

Specular Reflection: Order from a Smooth Surface

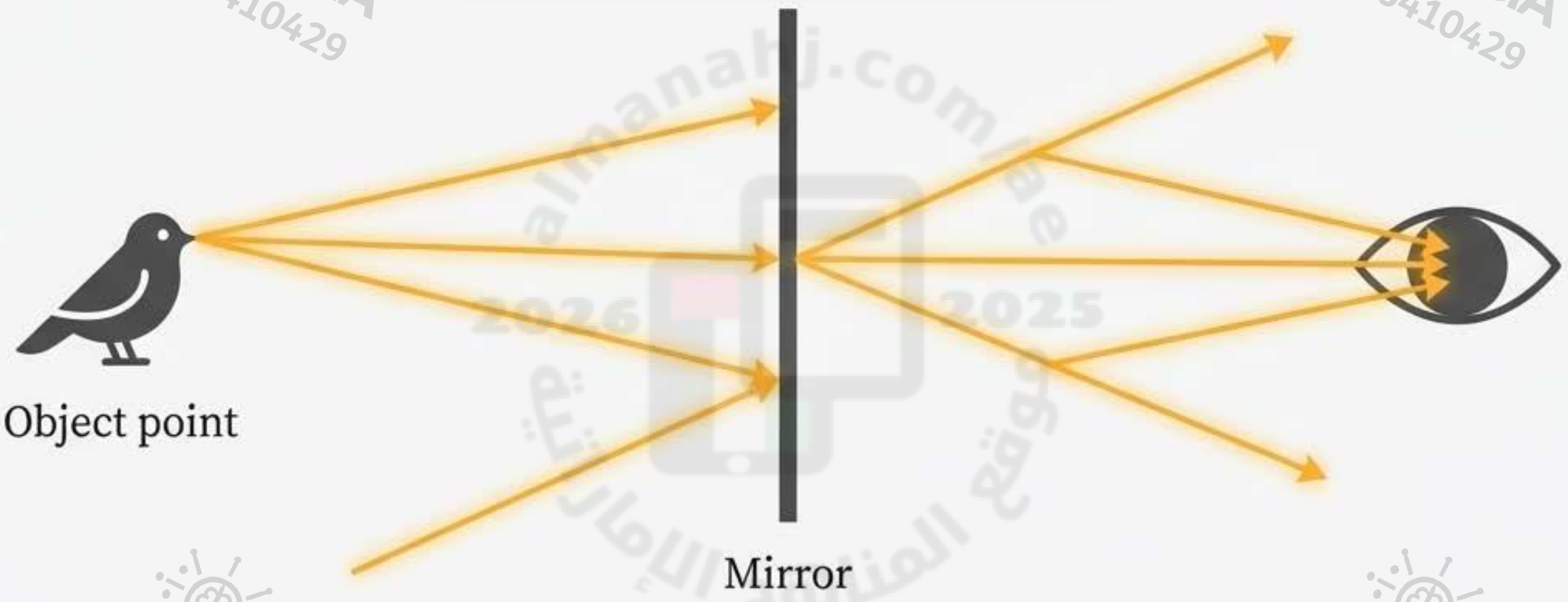


On a smooth surface like a mirror, parallel light rays reflect in a single direction, remaining parallel. This preserves the information contained in the light, forming a coherent image.

Diffuse Reflection: Chaos from a Rough Surface

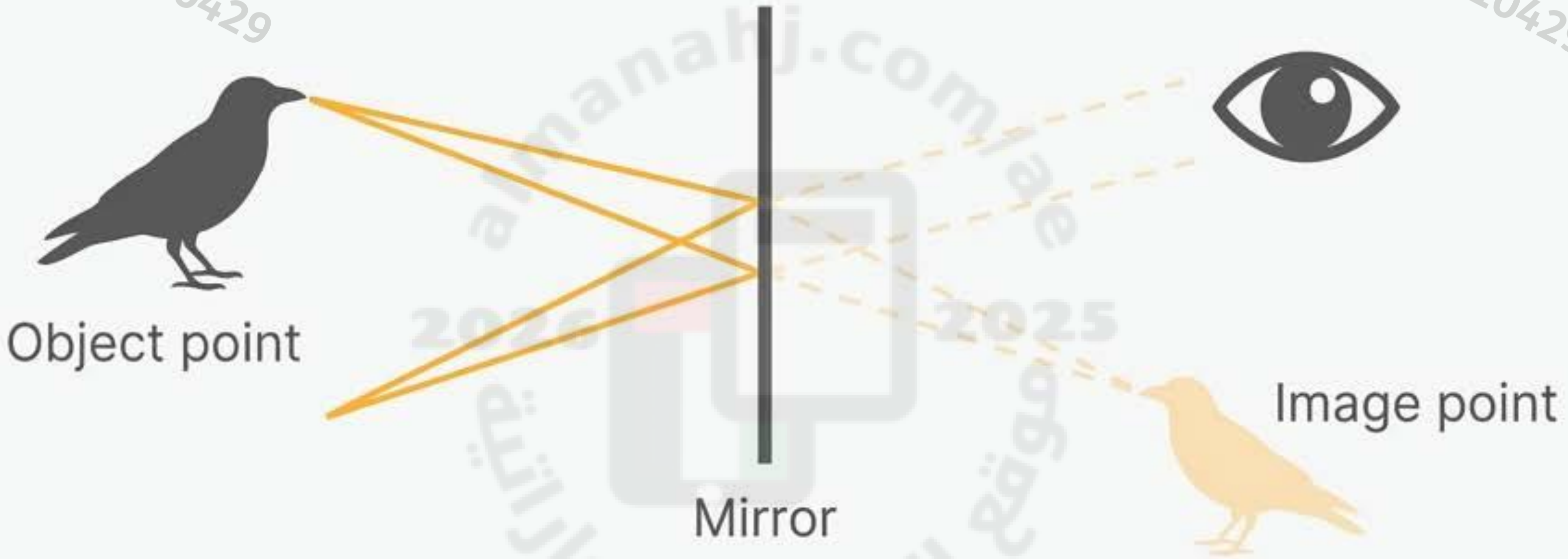
On a rough surface, the law of reflection holds true for every individual ray, but each ray hits a surface with a different orientation. The result is light scattered in all directions. You can see the illuminated paper, but you can't see an image in it.

How Your Brain Perceives an Image



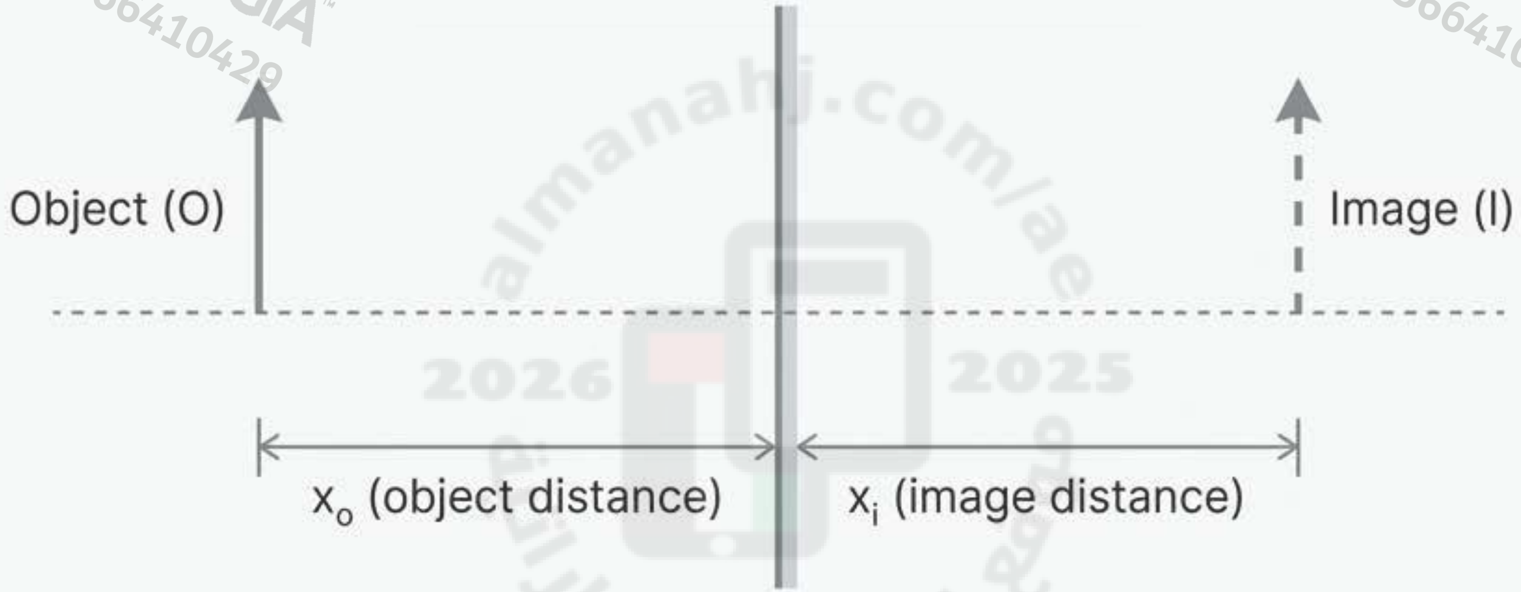
Your eyes collect the diverging rays of light reflected from the mirror. Because your brain processes information as if light travels in a straight line, it it traces these rays backward to a point where they appear to originate.

Real Light, Virtual Location



The point where the rays appear to originate is the **image point**. This image appears to be behind the mirror, where no light from the object actually goes. This is called a **virtual image**. You cannot project it onto a screen.

Property 1: A Perfect Balance of Distance



The image is located as far behind the mirror as the object is in front of it.

$$x_i = -x_o$$

The negative sign indicates that the image is virtual, meaning it is located on the opposite side of the mirror from the object.

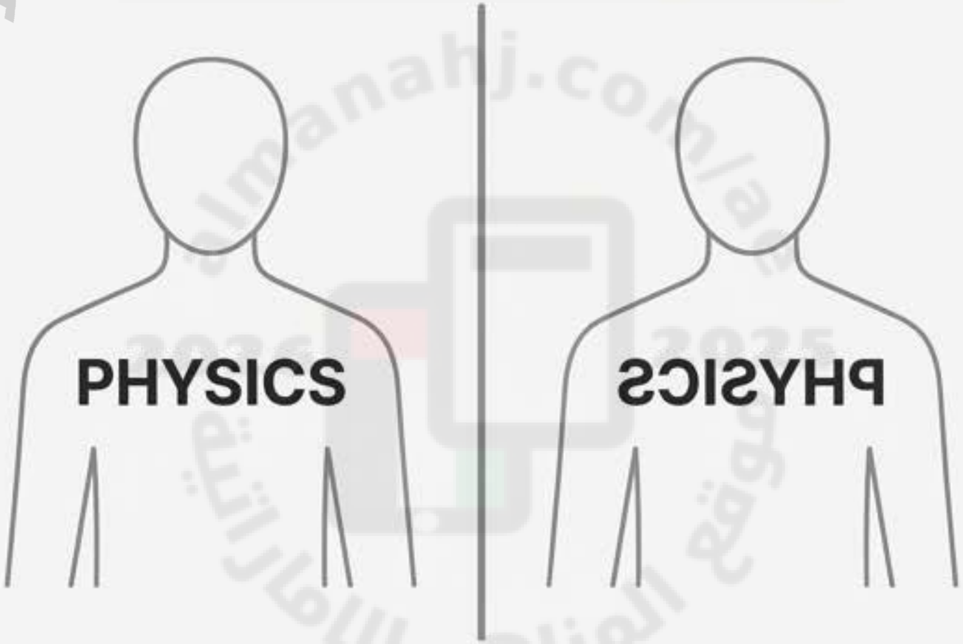
Mr. Mohamad

Property 2 & 3: Same Size, Standing Tall

The image formed by a plane mirror is the same size as the object and has the same upright orientation.

$$h_i = h_o$$

The ‘Left-Right’ Reversal Is a Myth

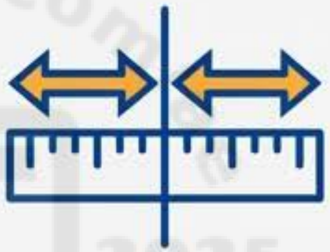


A plane mirror does not reverse left and right. It reverses **front and back**. The part of an object closest to the mirror corresponds to the part of the image closest to the mirror. Your reflection is your “twin” facing the opposite direction.

The Plane Mirror Image: A Summary

Type

Virtual (Light rays do not actually pass through the image location).

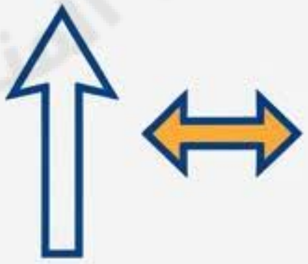


Position

Located behind the mirror, at the same distance as the object in front ($x_i = -x_o$).

Size

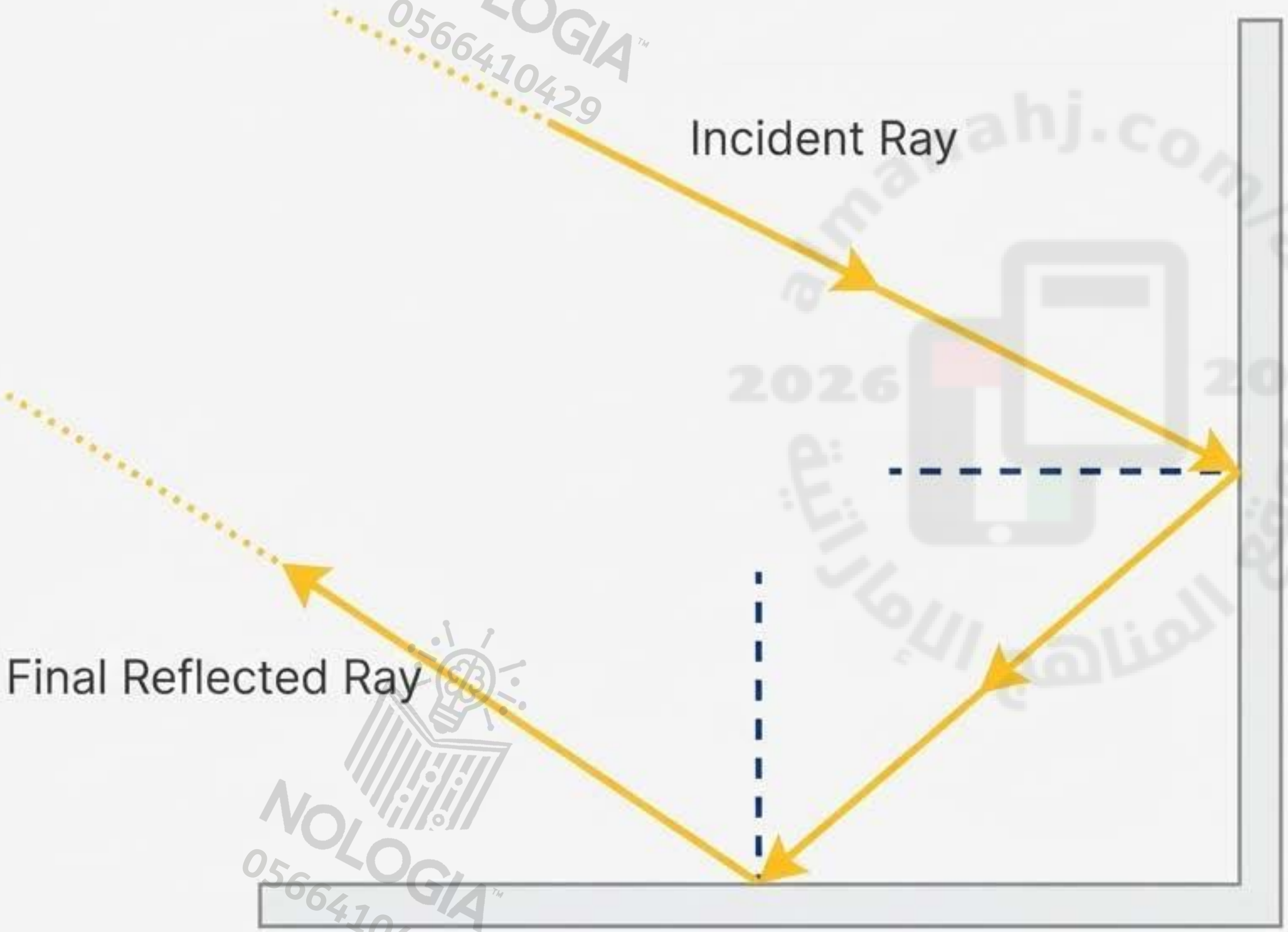
Same size as the object ($h_i = h_o$).



Orientation

Upright, with front-to-back reversal.

Knowledge in Action: The Retroreflector



By precisely arranging two mirrors, we can direct a beam of light 180° back toward its source. This principle of retroreflection is crucial for things like bicycle reflectors and road signs.

From One Simple Law, a World of Images

The simple rule that the angle of incidence equals the angle of reflection is the foundaton for how we see ourselves, navigate our world, and engineer the technologies that shape our lives.

The Physics of Reflection.

Module (16): Reflection and Refraction

02 Second Lesson: Curved Mirrors

Beyond the Looking Glass: The Physics of Curved Mirrors

An Introduction to Concave and Convex Optics

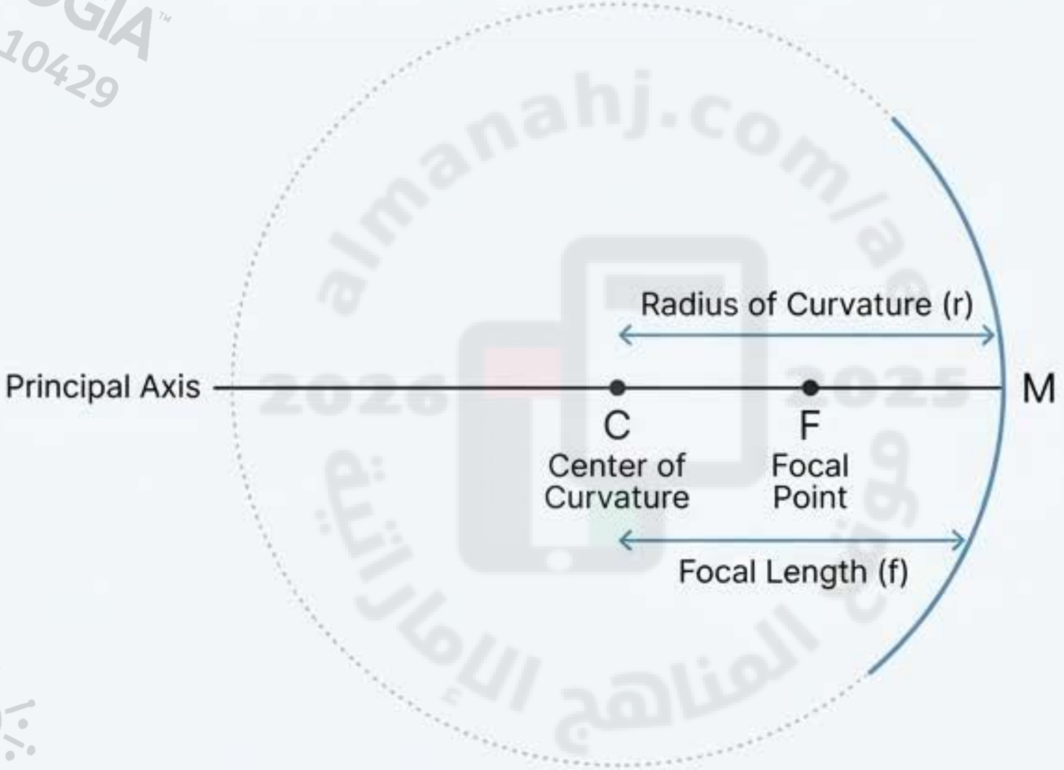
It Starts with a Spoon

Ever noticed your reflection in a spoon? Look at your image on both sides. Your image may appear larger or smaller, or it may even be inverted. The inside surface acts as a concave mirror, while the outside acts as a convex mirror.

This simple object is our starting point for understanding powerful optics.

The Anatomy of a Curve

To understand how curved mirrors form images, we first need to define their geometry. Every spherical mirror is a slice of a sphere, giving it a predictable structure.



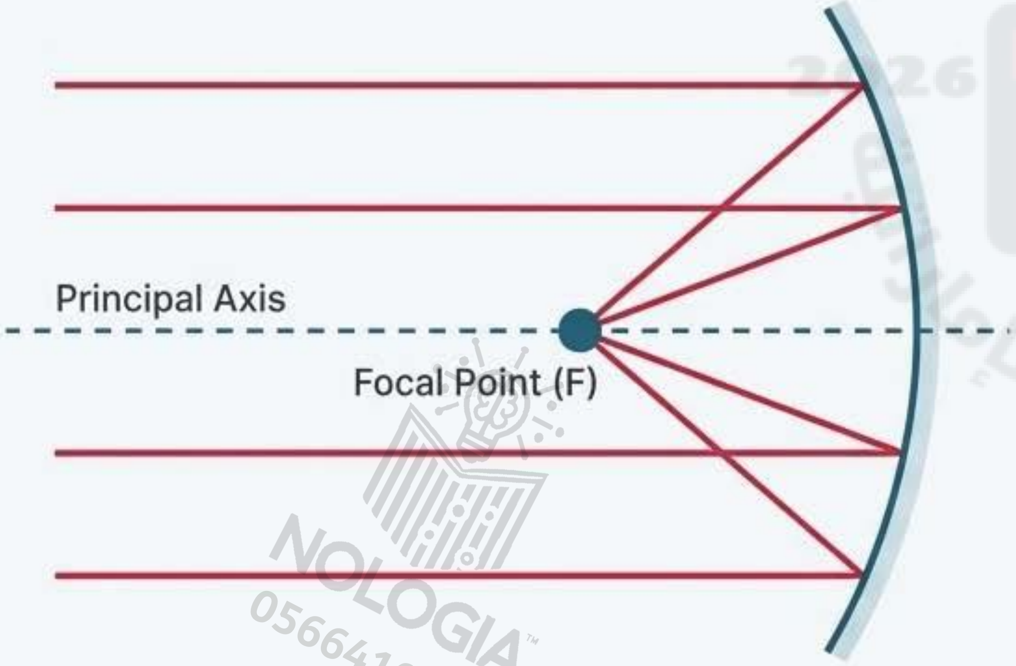
$$f = r / 2$$

The focal length is half the radius of curvature.

A Tale of Two Mirrors: Converging vs. Diverging

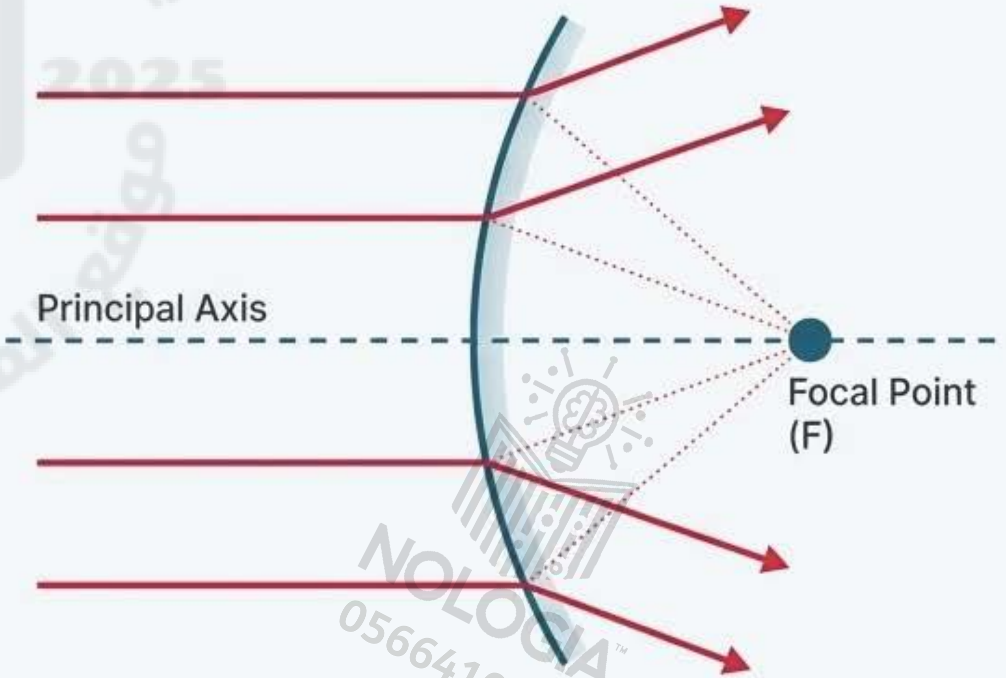
Concave: The Converger

An inwardly curving reflective surface. Incident light rays parallel to the principal axis are reflected and intersect at the focal point.



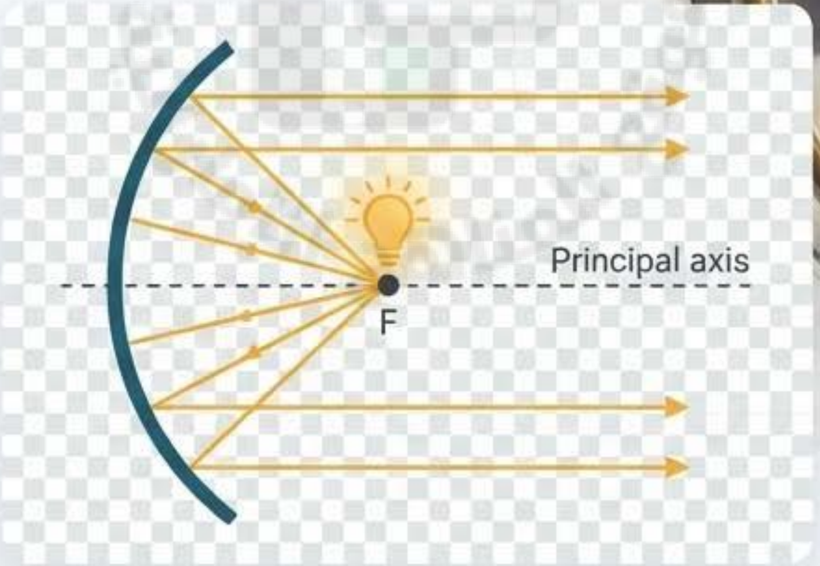
Convex: The Diverger

An outwardly curving reflective surface. Incident light rays parallel to the principal axis are reflected and spread out as if they originated from a focal point behind the mirror.



Real World Impact I: The Power of Concave Mirrors

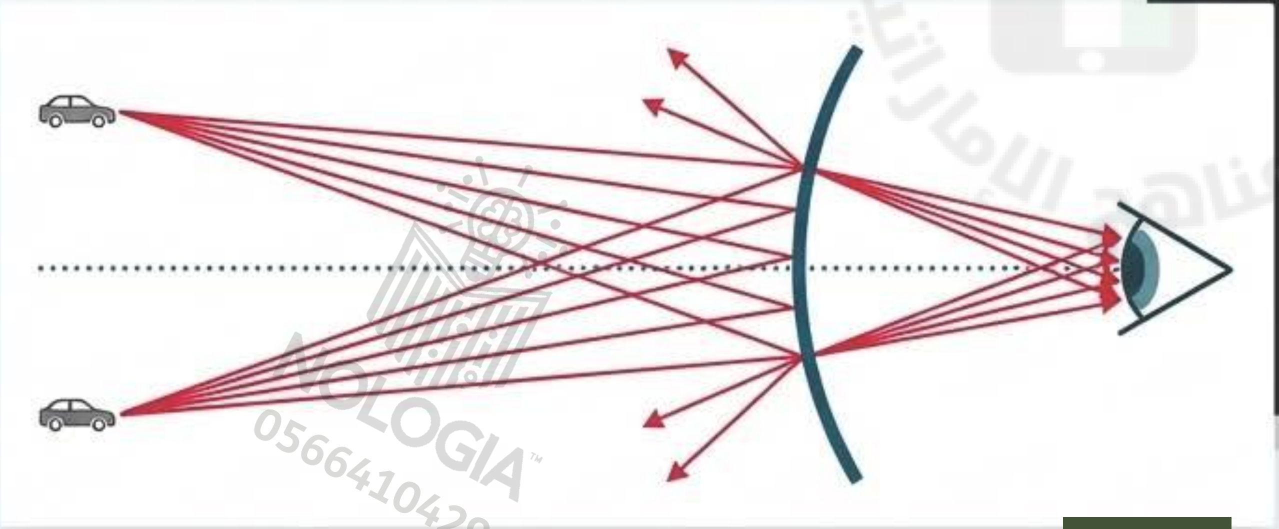
Because concave mirrors gather parallel light rays to a single focal point, they are perfect for **creating powerful, focused beams.** By placing a light source *at* the focal point, the mirror **reflects the light** into a **parallel beam.**



Reflecting Telescope:
Collecting light from distant stars.

Real World Impact II: The Power of Convex Mirrors

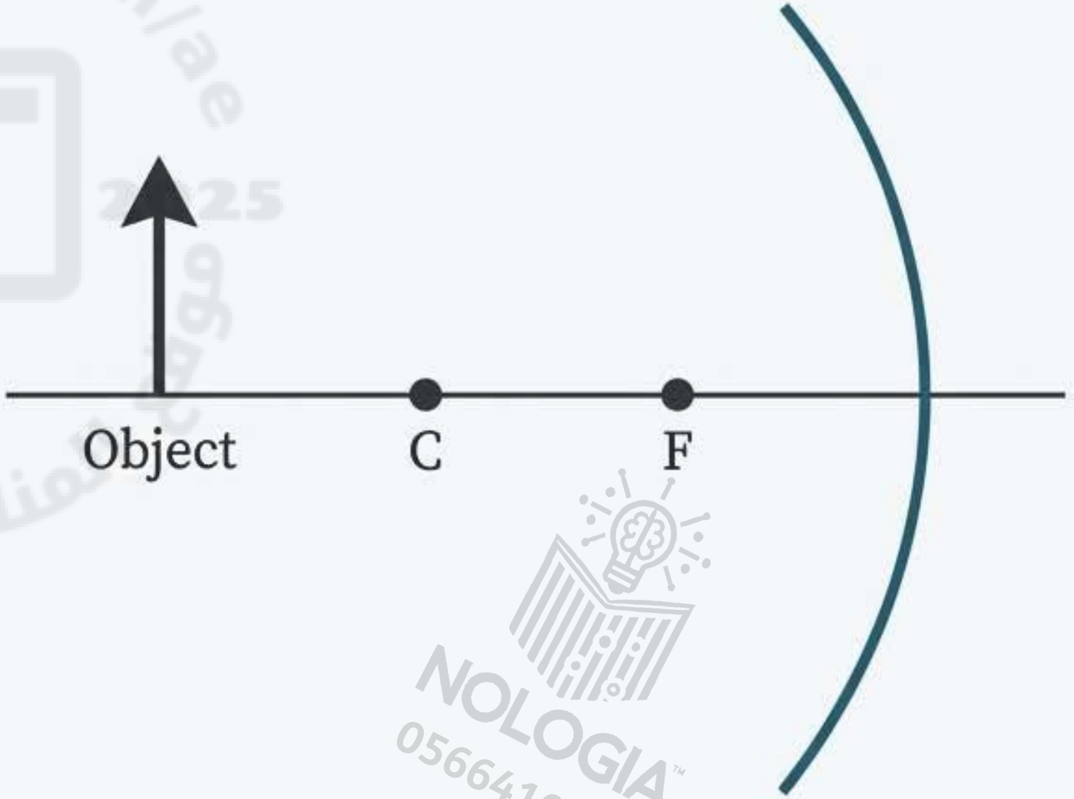
Because convex mirrors diverge light, they provide a wider field of view than a plane mirror. They form smaller images, which allows an observer to see a larger area. This is why they are crucial for safety and security.



The Physicist's Toolkit: Predicting Images with Ray Diagrams

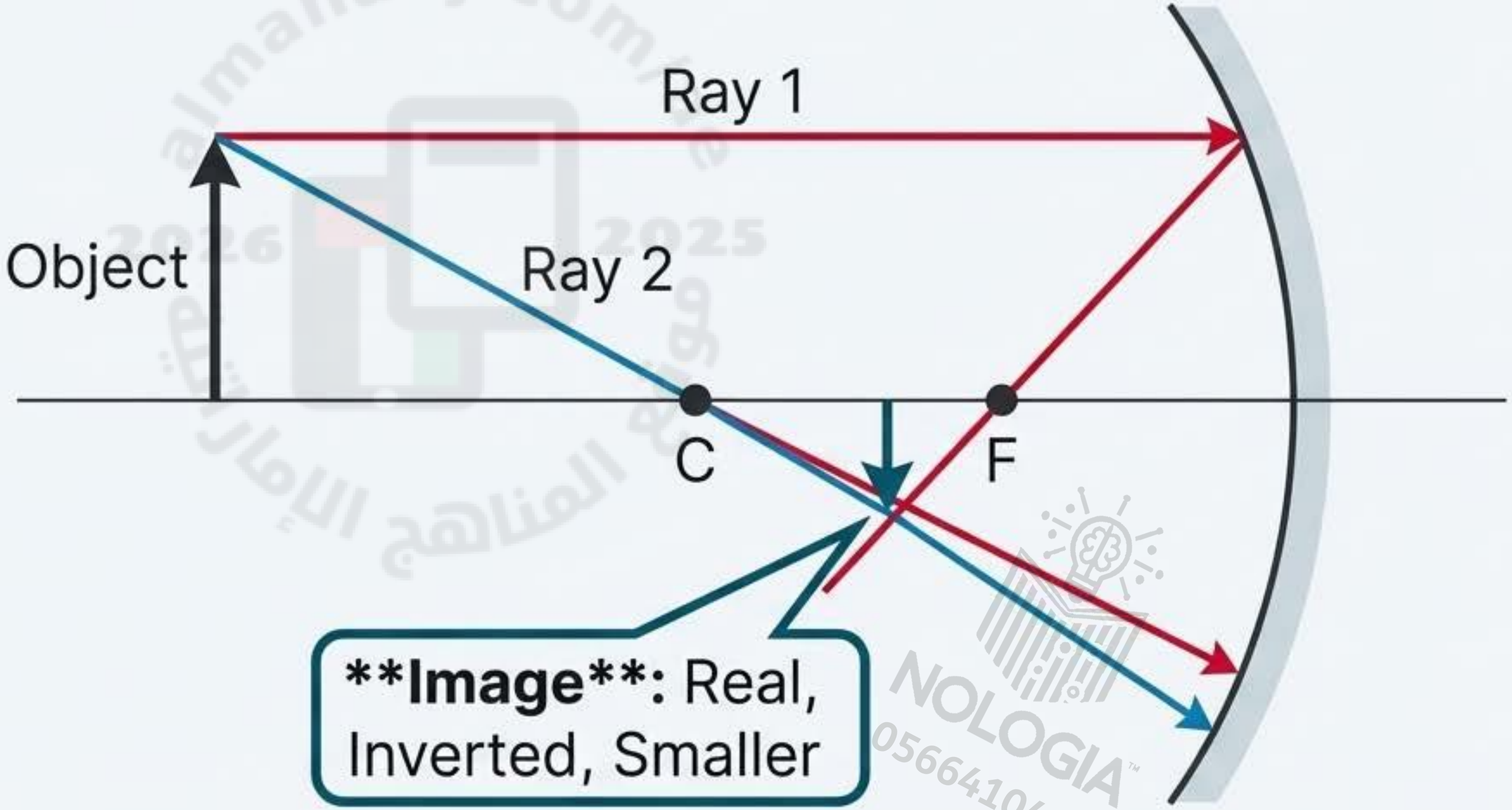
We can precisely locate the image formed by a curved mirror by drawing the path of a few key light rays. These predictable paths are the rules of ray tracing.

1. **The Parallel Ray:** A ray traveling parallel to the principal axis reflects through the focal point (F).
2. **The Focal Ray:** A ray traveling through the focal point (F) reflects parallel to the principal axis.



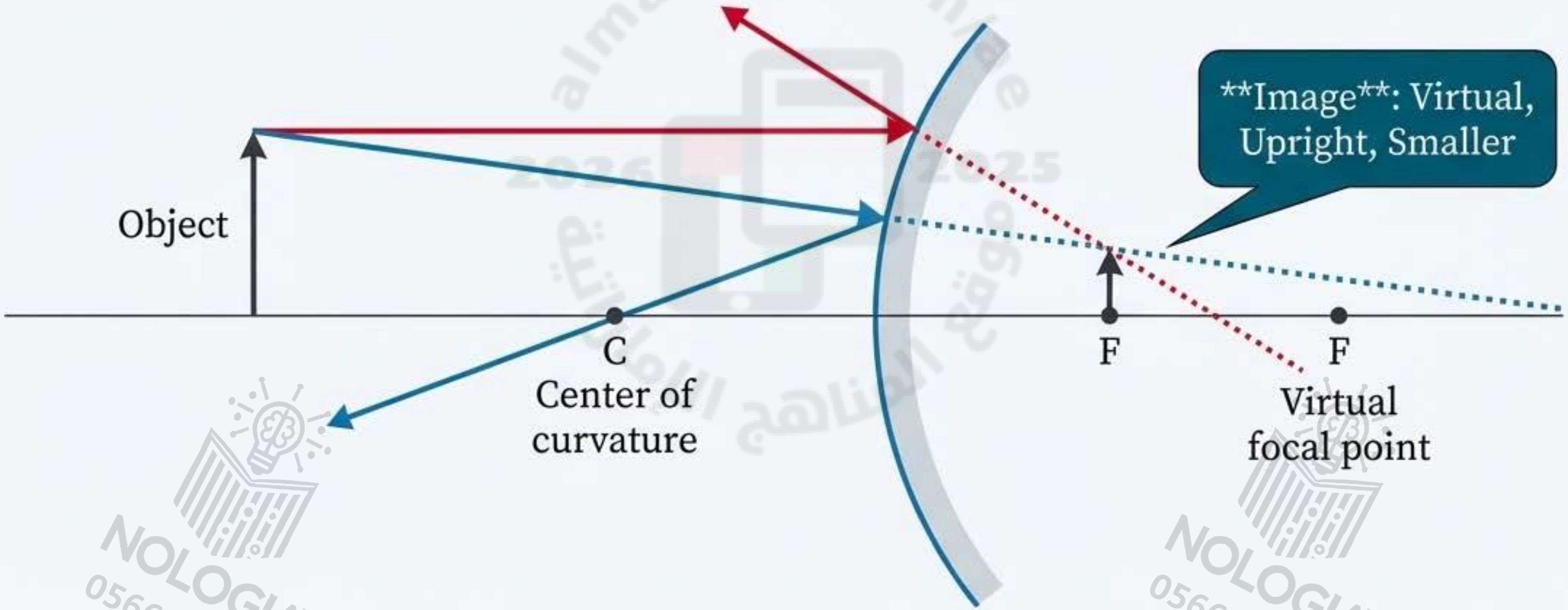
Ray Tracing in Action: The Concave Mirror

Let’s trace the rays for an object placed beyond the center of curvature (C). The intersection of the reflected rays shows us exactly where the image forms and what its properties are.



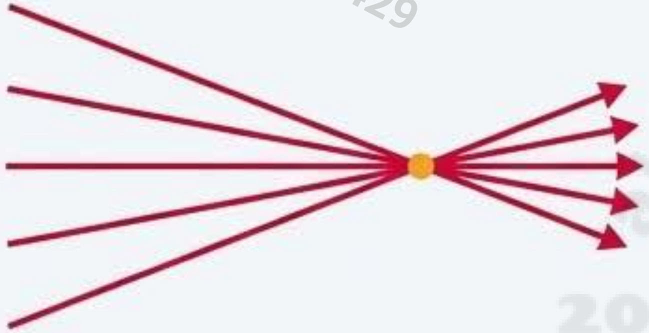
Ray Tracing in Action: The Convex Mirror

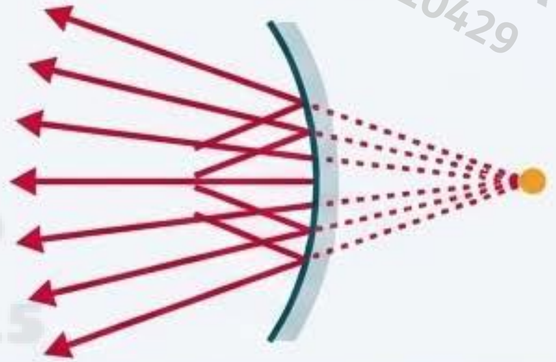
Unlike a concave mirror, a convex mirror always produces the same type of image, regardless of the object's position. Let's trace the rays to see why.



Real vs. Virtual: A Critical Distinction

The most important difference is whether the light rays *actually* converge at the image location. This determines if the image can be formed on a screen.





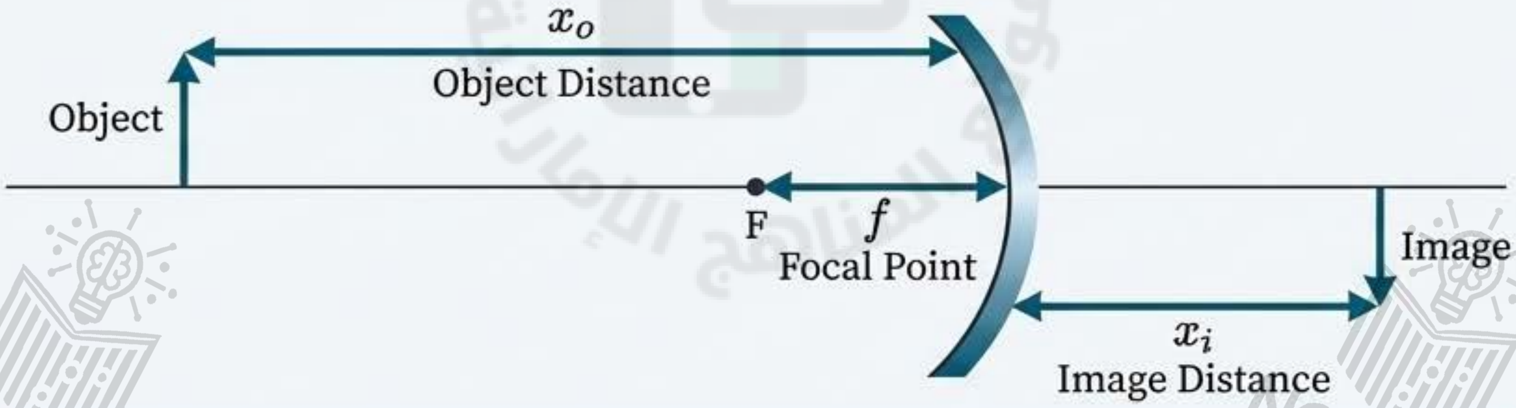
REAL: Light rays actually converge here. A reaal image can be projected onto a screen.

VIRTUAL: Light rays only *appear* to diverge from here. A virtual image cannot be projected.

From Pictures to Precision: The Mirror Equation

Ray diagrams provide a great visual understanding. For precise calculations of image location, we use a simple, powerful formula that relates the object distance, image distance, and focal length.

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

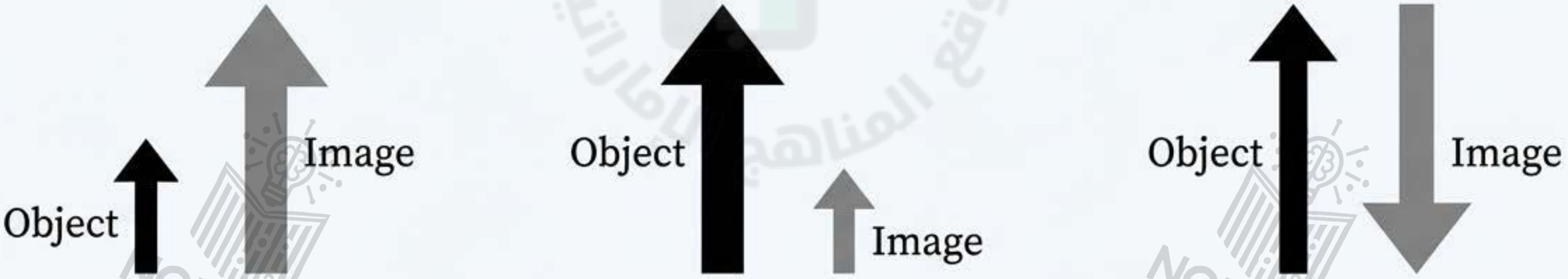


By convention, f is positive for concave mirrors and negative for convex mirrors.
A negative x_i indicates a virtual image located behind the mirror.

Sizing Up the Image: Magnification

The magnification equation tells us the image's size relative to the object and its orientation (upright or inverted). The sign is crucial: a negative value for m means the image is inverted.

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



$|m| > 1$ = Enlarged

$|m| < 1$ = Reduced

m is negative = Inverted

Putting the Toolkit to Work: A Case Study

Let's find the image position and height for an object placed in front of a concave mirror.

Problem Setup

Given

- Mirror Type: Concave
- Radius of Curvature (r): 20.0 cm
- Object Distance (x_o): 30.0 cm
- Object Height (h_o): 2.0 cm

Find

- Image Distance (x_i)
- Image Height (h_i)

Step-by-Step Solution

1. Find Focal Length (f)

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

2. Use Mirror Equation to find x_i

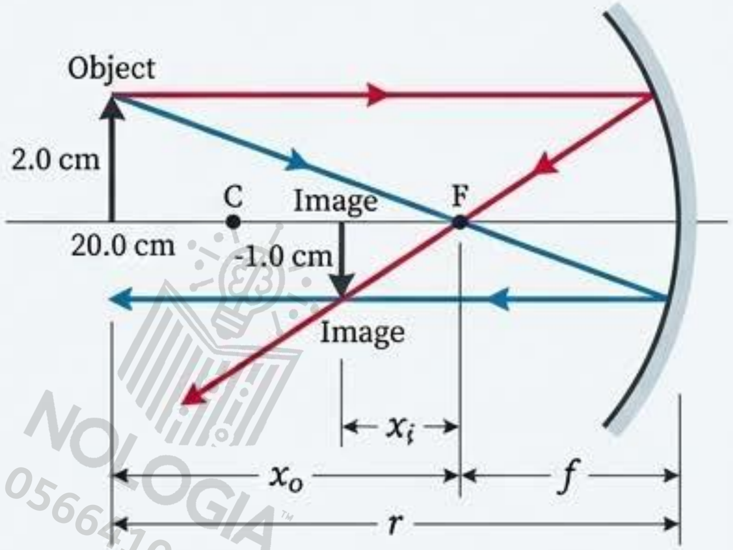
$$\frac{1}{10.0} = \frac{1}{30.0} + \frac{1}{x_i}$$
$$\frac{1}{x_i} = \frac{1}{10.0} - \frac{1}{30.0} = \frac{2}{30.0}$$
$$x_i = 15.0\text{ cm}$$

3. Use Magnification Equation to find h_i

$$m = \frac{-x_i}{x_o} = \frac{-15.0}{30.0} = -0.5$$
$$h_i = m * h_o = -0.5 * 2.0\text{ cm}$$
$$h_i = -1.0\text{ cm}$$

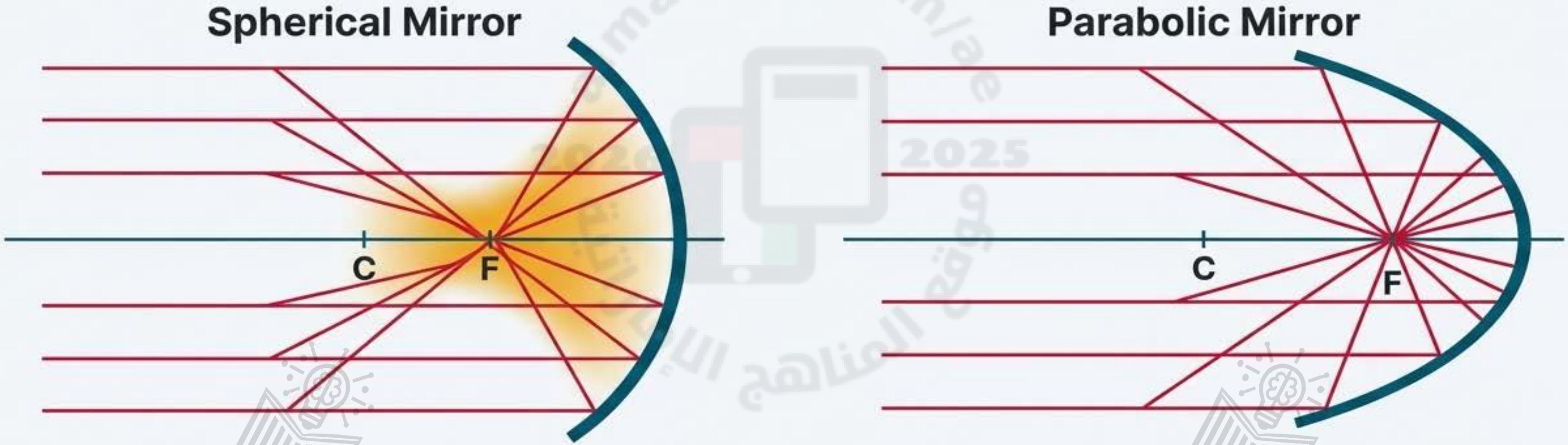
Conclusion & Visual Confirmation

The image is located at 15.0 cm (real), is 1.0 cm tall, and is inverted (due to the negative sign).



A Flaw in the Design: Spherical Aberration

In reality, spherical mirrors have a slight defect. Parallel light rays that strike the mirror far from the principal axis do not reflect through the exact focal point. This blurring effect is called spherical aberration. For high-precision optics, a different shape is needed.



This is why world-class instruments like the Hubble Space Telescope use precisely engineered parabolic mirrors to produce perfectly clear images of distant galaxies.

The World in a Curve: A Summary

Mirror Type	Focal Length (f)	Image Characteristics	Key Applications
Plane	Infinite (∞)	Virtual, Upright, Same Size	Bathroom mirrors, Periscopes
Concave	Positive (+)	Can be Real or Virtual, Inverted or Upright, Enlarged or Reduced	Flashlights, Telescopes, Makeup mirrors
Convex	Negative (-)	Always Virtual, Upright, Reduced	Security mirrors, Vehicle side-mirrors

From the simple reflection in a spoon to the vast images captured by the Hubble Telescope, understanding the physics of curved mirrors allows us to manipulate light to explore and shape our world.

ختاماً، نسأل اللّه أن يوفقكم، وأن
تكون هذه الملزمة قد حققت
الفائدة المرجوة ❤