

LIGHT – REFLECTION AND REFRACTION

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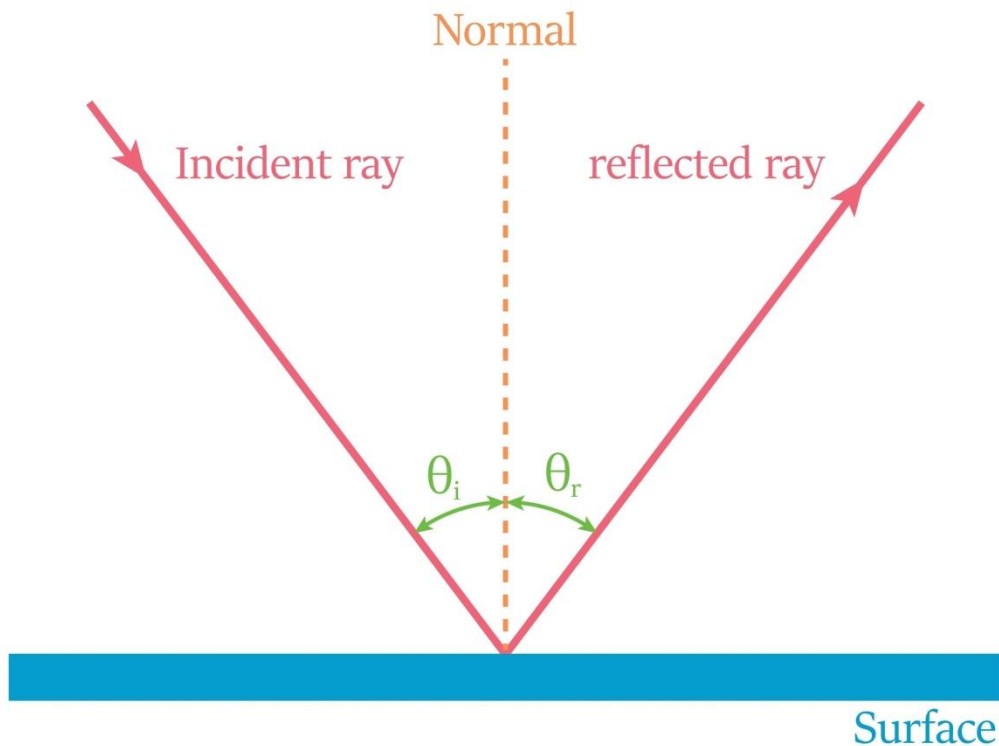
Reflection of Light – Laws of Reflection

Based on the text you provided, you are looking at the fundamental concepts of light reflection, moving from standard plane mirrors to the more complex behavior of spherical mirrors (like a spoon).

Here is a structured breakdown of these concepts to help you study or understand them better.

1. The Laws of Reflection

These are the universal rules that light follows when it hits a polished surface, whether that surface is flat (plane) or curved (spherical).



- First Law: The angle of incidence (θ_i) is always equal to the angle of reflection (θ_r).

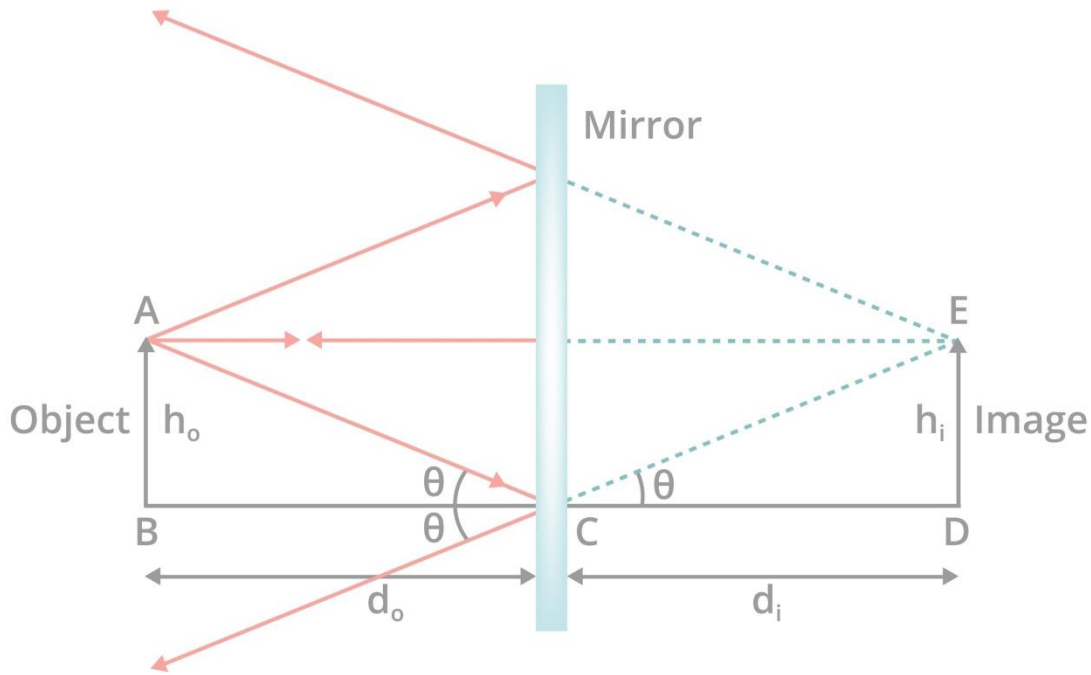
$$\theta_i = \theta_r$$

- **Second Law:** The incident ray, the normal (a line perpendicular to the surface at the point of impact), and the reflected ray all lie in the **same plane**.

2. Recap: Images in Plane Mirrors

Before moving to curved surfaces, the text reminds us of how a standard flat mirror works.

Plane Mirror



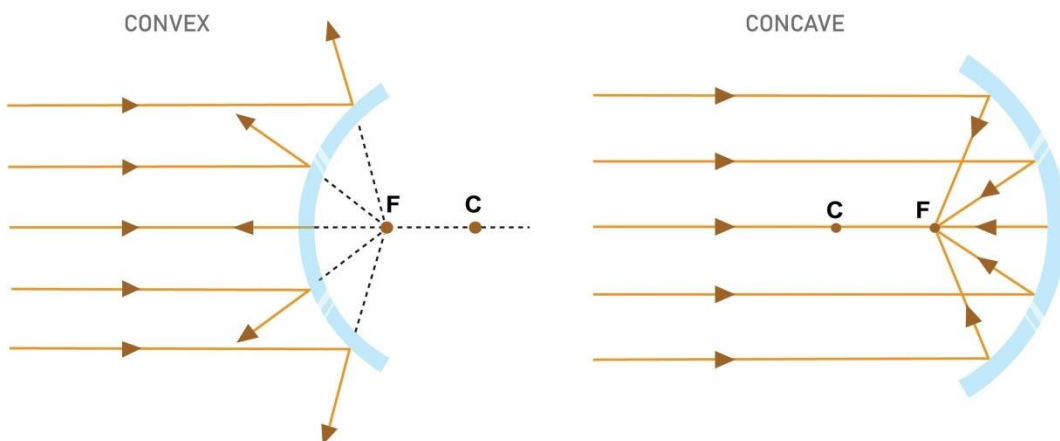
Characteristics of the Image:

- **Virtual & Erect:** It appears upright and cannot be caught on a screen.
- **Same Size:** The image is the exact same size as the object.
- **Equidistant:** The image appears to be the same distance *behind* the mirror as the object is *in front* of it.
- **Laterally Inverted:** Left appears as Right, and Right appears as Left (e.g., how "AMBULANCE" is written).

3. Activity 10.1: The Spoon Experiment

This activity is designed to introduce you to **Spherical Mirrors** using a common household object. A spoon acts as a double-sided spherical mirror.

REFLECTION OF LIGHT ON MIRROR



Here is what happens when you perform the activity:

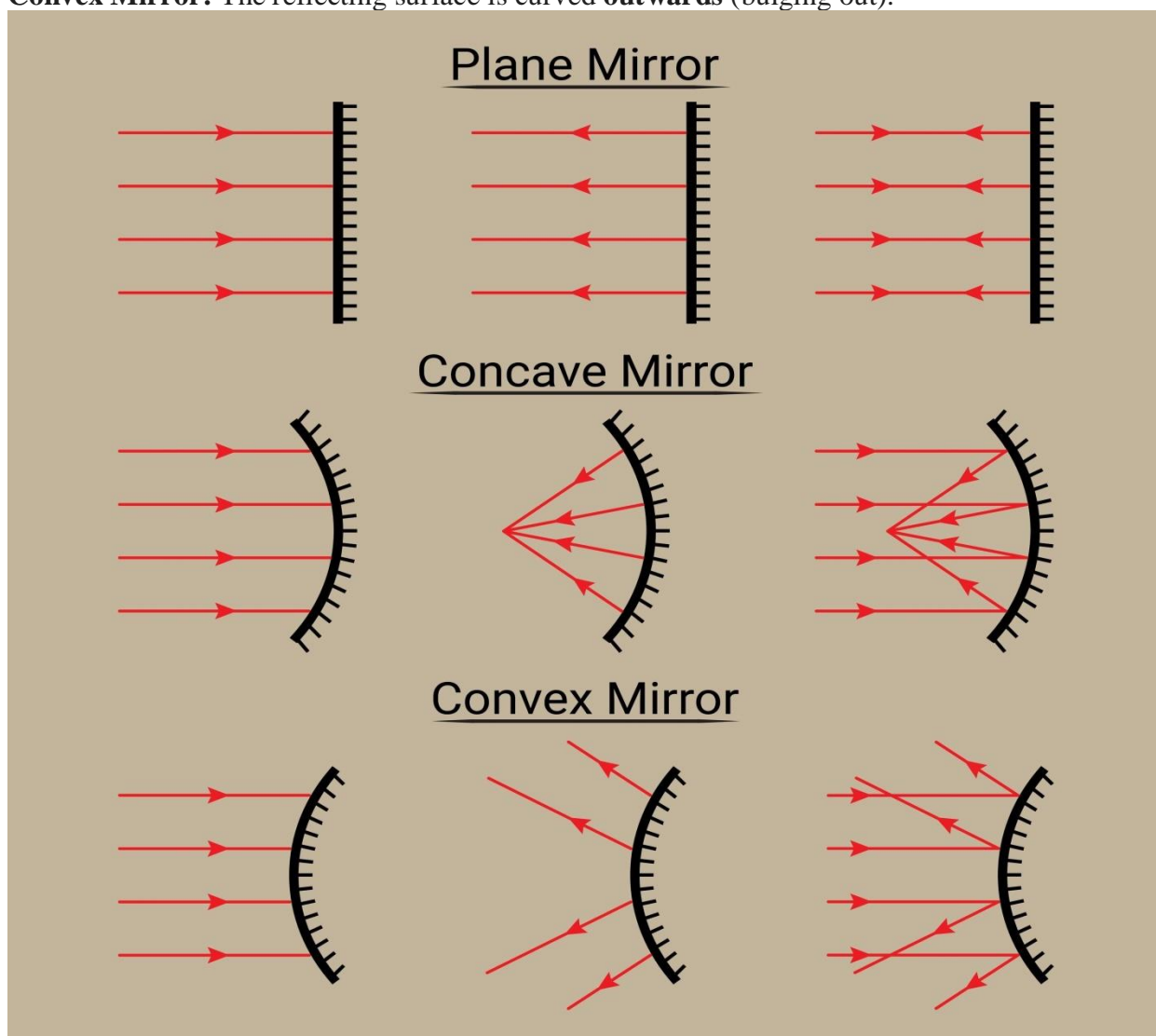
Spoon Surface	Acts As	Observation (Close Up)	Observation (Moving Away)
Inner Curve (The side holding soup)	Concave Mirror	You see an image that is large and upright.	As you move it away, the image likely flips upside down (inverted).
Outer Curve (The back of the spoon)	Convex Mirror	You see an image that is upright (erect) but smaller (diminished).	The image remains upright and small as you move away.

Key Insight: The curvature of the surface changes how light reflects, which alters the size and orientation of the image.

4. Introduction to Spherical Mirrors

The text concludes by defining spherical mirrors. These are mirrors where the reflecting surface is part of a hollow sphere.

- **Concave Mirror:** The reflecting surface is curved **inwards** (like a cave).
- **Convex Mirror:** The reflecting surface is curved **outwards** (bulging out).



What comes next?

Now that you have defined spherical mirrors, the next logical step in your study is usually understanding the specific terminology used for them (Pole, Centre of Curvature, Radius, Principal Axis, and Focus).

Would you like me to explain the terms "Centre of Curvature" and "Principal Focus" for these mirrors?

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Spherical Mirrors – Concave and Convex Mirrors

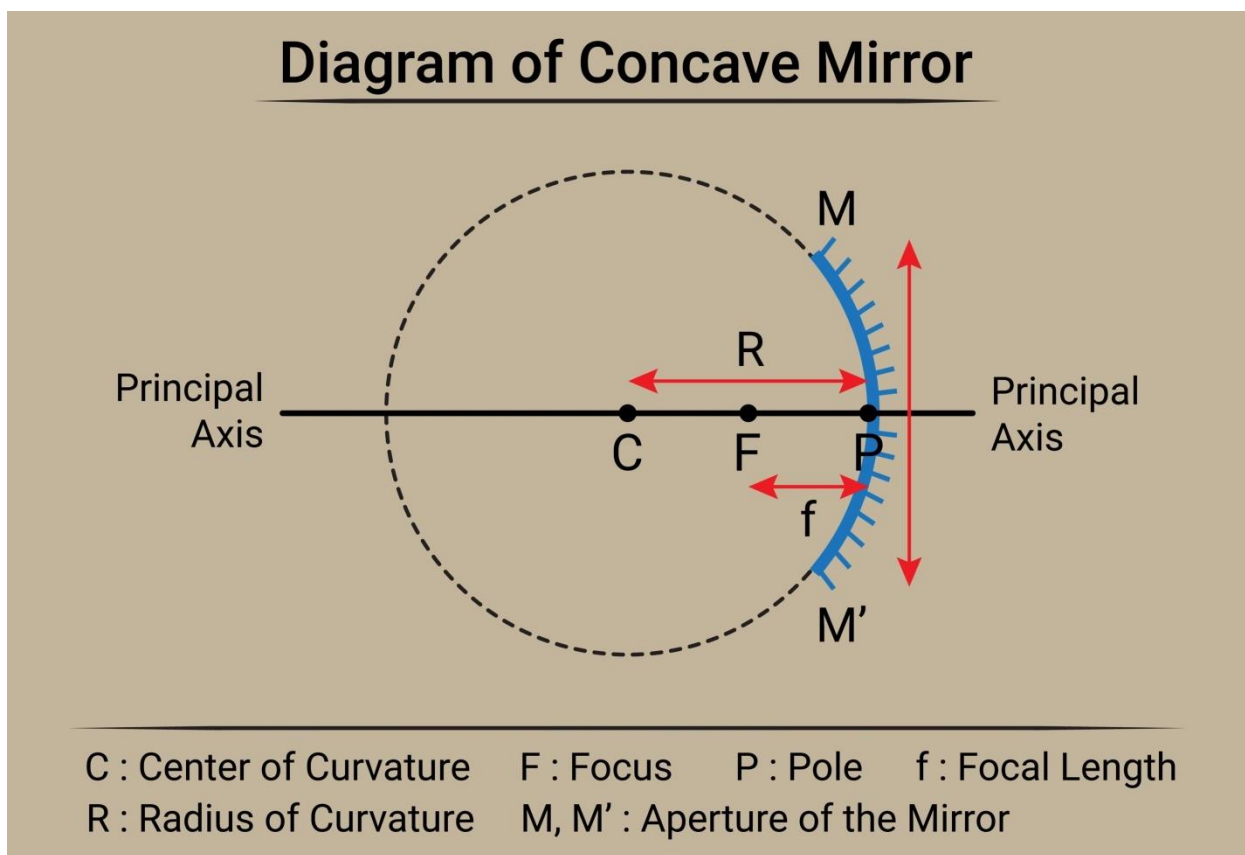
Based on the detailed text you provided, we are now diving into the specific geometry and terminology of spherical mirrors. This is the "vocabulary" you need to understand before drawing ray diagrams.

Here is a breakdown of the key terms and concepts regarding Concave and Convex mirrors.

1. Types of Spherical Mirrors

Think of these as sections cut from a hollow glass sphere.

- **Concave Mirror:** The reflecting surface curves **inwards** (faces the center of the sphere).
 - *Memory Tip:* It goes in like a "cave".
 - *Example:* The inner side of a spoon.
- **Convex Mirror:** The reflecting surface curves **outwards**.
 - *Example:* The back of a spoon.



2. Key Terminology (The Anatomy of a Mirror)

To understand how images form, you must know these specific points and lines:

Term	Symbol	Definition	Position Note
Pole	P	The exact center point of the reflecting surface.	Lies on the mirror surface.
Centre of Curvature	C	The center of the imaginary sphere the mirror was cut from.	Lies outside the mirror. • Concave: In front of mirror. • Convex: Behind mirror.
Radius of Curvature	R	The radius of that imaginary sphere (Distance from P to C).	$SPC = R$
Principal Axis	—	A straight, imaginary line passing through the Pole and Centre of Curvature.	It is perpendicular (normal) to the mirror at the Pole.
Aperture	—	The diameter of the reflecting surface (the size of the "dish").	We assume aperture is much smaller than R .

3. Principal Focus and Focal Length

This is the most critical concept introduced in your text. The behavior of light rays parallel to the principal axis defines the "Focus."

The Concave Mirror (Converging)

As described in **Activity 10.2** (burning the paper), when sunlight (parallel rays) hits a concave mirror, the rays bounce off and come together at a single point.

- **Principal Focus (F):** The point *in front* of the mirror where parallel rays intersect (converge).
- **Real Focus:** The rays actually meet here, which is why the heat concentrates and burns the paper.

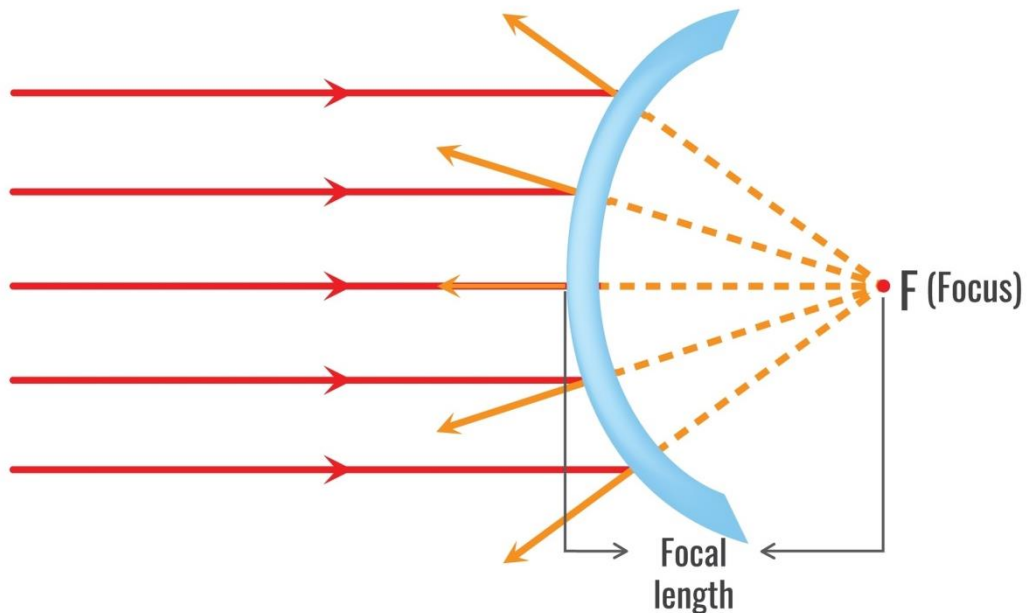
The Convex Mirror (Diverging)

When parallel rays hit a convex mirror, they scatter (diverge).

- **Principal Focus (F):** A point *behind* the mirror where the reflected rays *appear* to come from.

- **Virtual Focus:** The rays do not actually meet here; our eyes just trace the path backward to this point.

Convex mirror (Diverging mirror)



Convex (Diverging mirror)

Parallel rays of light appear to be reflected from the principle focus

Focal Length (f)

This is the distance between the Pole (P) and the Principal Focus (F).

4. The Relationship between R and f

For spherical mirrors with small apertures, there is a simple mathematical relationship between the Radius of Curvature and the Focal Length. The Focus lies exactly midway between the Pole and the Centre of Curvature.

The formula is:

$$R = 2f$$

- Where R is the Radius of Curvature.
- Where f is the Focal Length.

What comes next?

Now that you know where the Focus (F) and Centre (C) are, the next step is usually learning the Rules for Drawing Ray Diagrams (e.g., "A ray passing through the focus becomes parallel...").

Would you like me to outline the standard rules for drawing these ray diagrams?

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Image formation by Spherical Mirrors

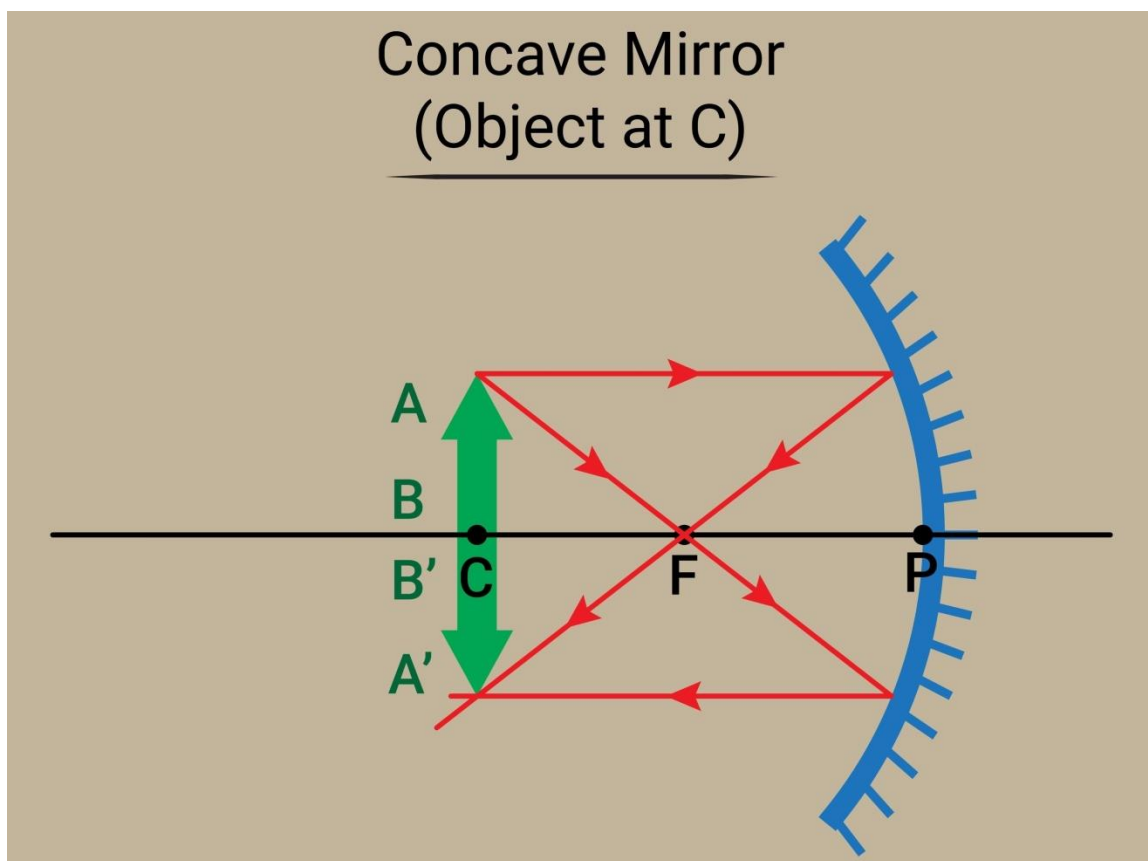
This section of your study bridges the gap between theory and real-world observation. You are essentially setting up a "optical bench" using simple tools (chalk, table, mirror) to map out exactly how a concave mirror behaves.

Here is a breakdown of the experiment and the **Table 10.1** referenced in your text, which summarizes the results you would see.

1. The Experiment Setup (Activity 10.3)

The goal is to move an object (candle) through different "zones" in front of the mirror and see how the image changes.

- **The Zones:** You marked lines on the table to define specific regions:
 - **P (Pole):** The mirror's position (0 distance).
 - **F (Focus):** The focal length (f).
 - **C (Centre of Curvature):** Twice the focal length (2f).



2. Experimental Observations

As you move the candle closer to the mirror, the image changes dramatically. Here is the reconstruction of the summary table mentioned in your text.

Table 10.1: Image Formation by a Concave Mirror

Position of the Object	Position of the Image	Relative Size of Image	Nature of Image
At Infinity	At the Focus (F)	Highly diminished (point-sized)	Real and Inverted
Beyond C	Between F and C	Diminished (Smaller)	Real and Inverted
At C	At C	Same Size	Real and Inverted
Between C and F	Beyond C	Enlarged (Magnified)	Real and Inverted
At Focus (F)	At Infinity	Highly Enlarged	Real and Inverted
Between P and F	Behind the Mirror	Enlarged	Virtual and Erect

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3. Key Takeaways from the Activity

1. The "Turning Point" (Center of Curvature - C): Notice that when the object is at **C**, the image is also at **C** and is the **same size**. This is a critical reference point.

- If the object is *outside C* (further away), the image is *smaller*.
- If the object is *inside C* (closer), the image is *larger*.

2. Real vs. Virtual:

- **Real Images:** In the first 5 cases (from Infinity down to F), the image can be caught on a screen (paper). These are always **Inverted** (upside down).
- **Virtual Image:** In the last case (**Between P and F**), you cannot catch the image on the screen. You have to look *into* the mirror to see it. It appears upright (**Erect**) and larger.

Note on the "Missing" Image: The text mentions: "*In one of the cases, you may not get the image on the screen.*" This refers to the last case (**Between P and F**). This is how shaving mirrors or makeup mirrors work—you get close to them (inside the focus) to see a magnified, upright face.

What comes next? Now that you have the observations (the "What"), the next step in physics is usually the "How." We do this by drawing **Ray Diagrams** to geometrically prove why the image forms where it does.

Would you like me to explain the "Rules for Representation of Images by Spherical Mirrors" (the specific rays used to draw these diagrams)?

Drawing Ray Diagrams

That's an excellent segment outlining the **Ray Rules**—the indispensable guidelines for geometrically constructing images formed by spherical mirrors.

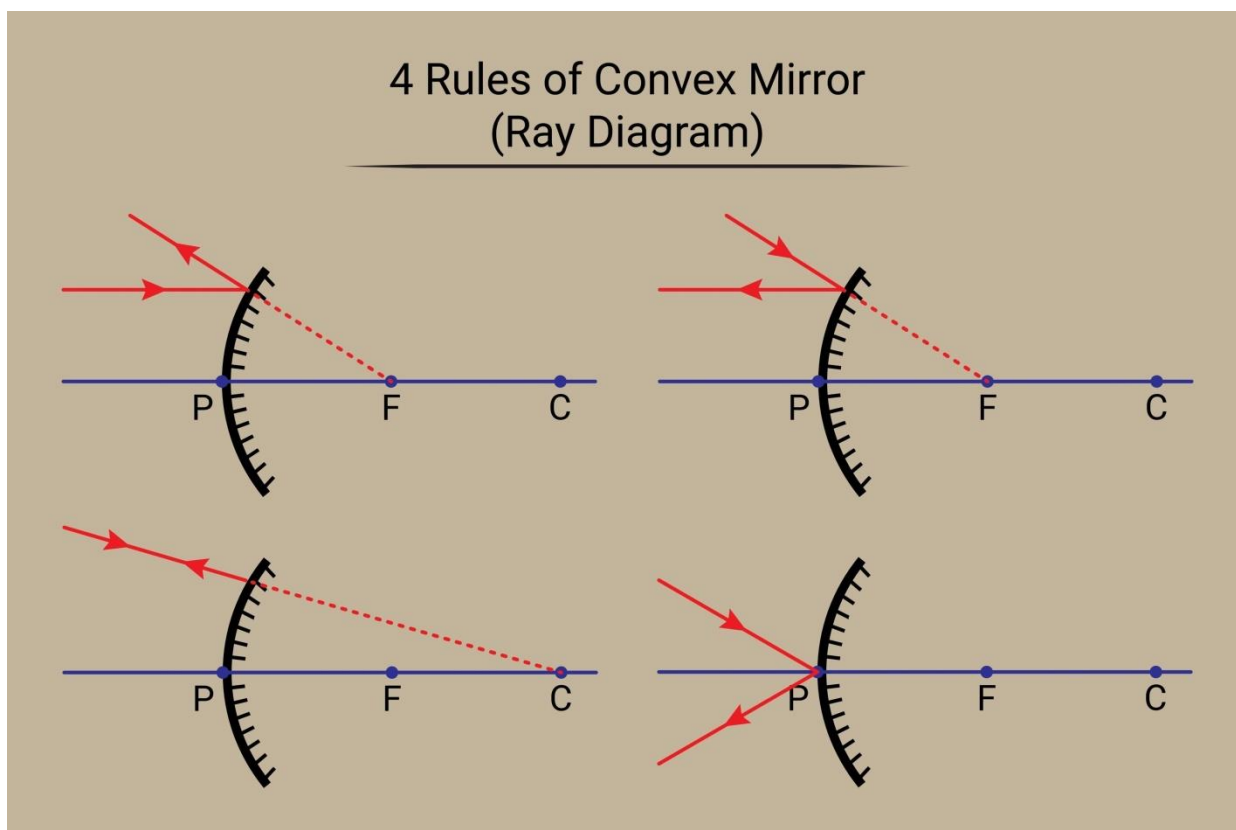
To locate the image of any point on an object, you only need to use **any two** of these four easy-to-trace rays.

Here is a summary of the four key rules for drawing ray diagrams for both **Concave** and **Convex** mirrors.

✦The Four Ray Diagram Rules

Rule 1: The Parallel Ray

- **Ray In:** A ray traveling **parallel** to the principal axis.
- **Ray Out:**
 - **Concave Mirror:** Passes directly through the **Principal Focus** (F) after reflection.
 - **Convex Mirror:** Appears to diverge (come) from the **Principal Focus** (F) after reflection.



Rule 2: The Focus Ray

This rule is the **reverse** of Rule 1.

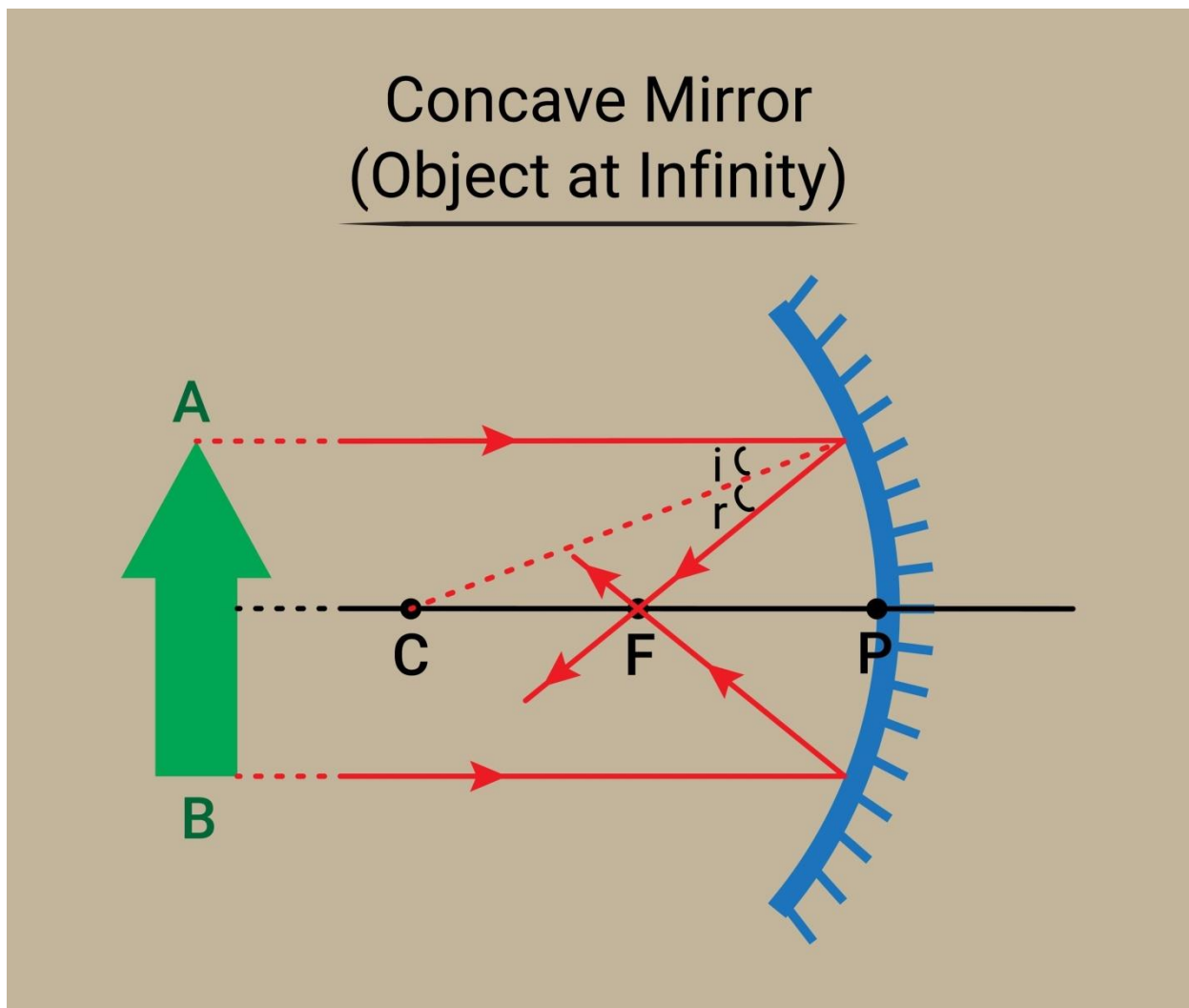
- **Ray In:** A ray passing through (Concave) or directed towards (Convex) the **Principal Focus** (F).

- **Ray Out:** Emerges **parallel** to the principal axis after reflection.

Rule 3: The Center of Curvature Ray

This ray is special because it follows the path of the **Normal** at the point where it strikes the mirror.

- **Ray In:** A ray passing through (Concave) or directed towards (Convex) the **Centre of Curvature** (C).
- **Ray Out:** It is reflected **back along the same path**.
 - *Reason:* Because the ray hits the mirror surface at a 90° angle (along the normal), the angle of incidence is 0° , so the angle of reflection is also 0° .

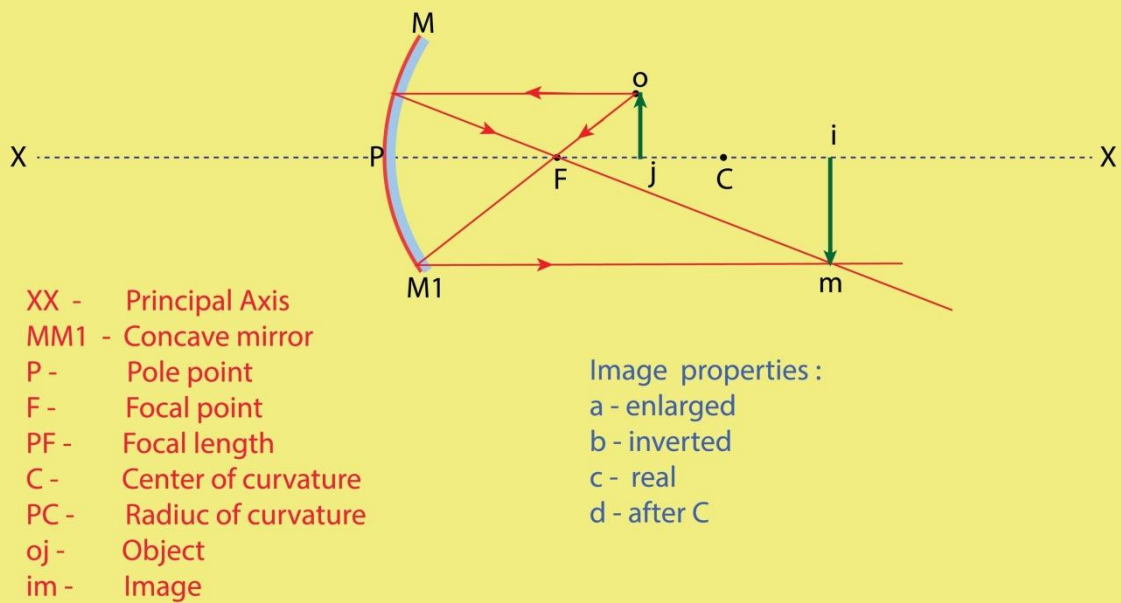


Rule 4: The Pole Ray

This rule simply applies the standard Law of Reflection ($\angle i = \angle r$) at the Pole.

- **Ray In:** A ray incident **obliquely** (at an angle) toward the **Pole** (P).
- **Ray Out:** It is reflected **obliquely**, such that the angle it makes with the principal axis upon incidence is equal to the angle it makes upon reflection.

Line diagram to show the properties of image when Object placed at 'between F-C' of the concave mirror



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Summary for Image Construction

To find the location and size of an image, you must:

1. Draw the **Principal Axis**, the **Mirror**, and mark **P, F, and C**.
2. Draw the object (usually an arrow).
3. Choose **any two** of the four rays above starting from the top of the object.
4. The point where the two **reflected rays** actually meet (Real image) or appear to meet (Virtual image) is the location of the top of the image.

Would you like me to walk through an example of drawing a ray diagram for a specific object position (e.g., placing the object between C and F for a concave mirror)?

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Image formation by Concave Mirrors

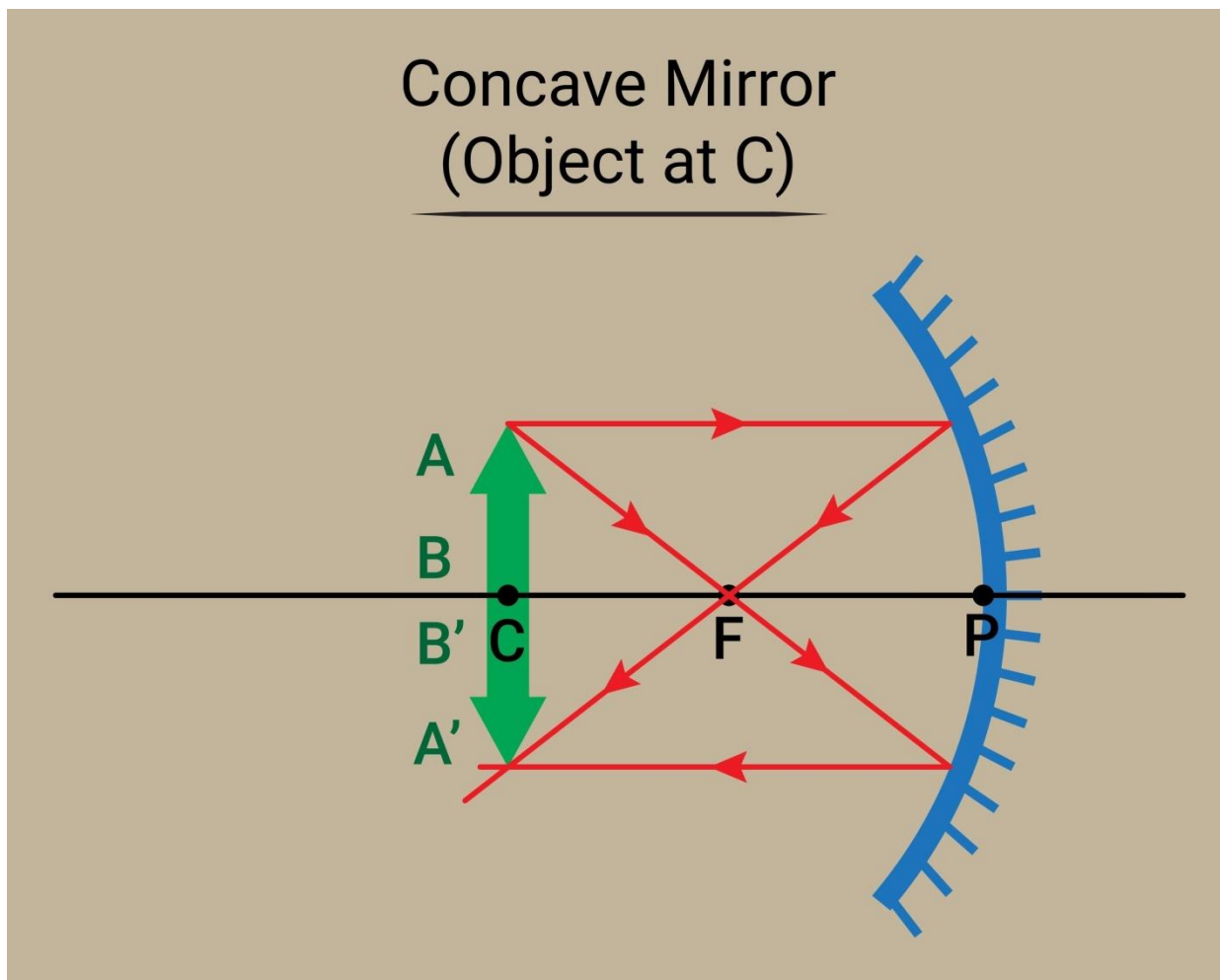
That text summarizes the final step in understanding concave mirrors: **using ray diagrams to visually confirm the image properties** (nature, position, and size) you previously observed in Activity 10.3 and the detailed uses of these mirrors.

Here is a consolidated explanation of the image formation process and the practical applications of concave mirrors.

Image Formation by Concave Mirrors (Ray Diagram Summary)

The activity asks you to draw ray diagrams to confirm the results from **Table 10.1**. The intersection of at least two of the four standard rays determines the image location.

The image provided in the context, Figure 10.7, illustrates these six key cases of image formation.



Summary of Image Characteristics

Position of the Object	Position of the Image	Relative Size of Image	Nature of Image	Ray Diagram Case
1. At Infinity	At the Focus (F)	Highly Diminished	Real and Inverted	(a)
2. Beyond C	Between F and C	Diminished	Real and Inverted	(b)
3. At C	At C	Same Size	Real and	(c)

Position of the Object	Position of the Image	Relative Size of Image	Nature of Image	Ray Diagram Case
			Inverted	
4. Between C and F	Beyond C	Enlarged	Real and Inverted	(d)
5. At Focus (F)	At Infinity	Highly Enlarged	Real and Inverted	(e)
6. Between P and F	Behind the Mirror	Enlarged	Virtual and Erect	(f)

Uses of Concave Mirrors

Concave mirrors are also known as **converging mirrors** because they bring parallel light rays to a single point (the focus). This unique ability to either converge light powerfully or produce a large, virtual image leads to their diverse applications:

1. Generating Powerful, Parallel Beams (Ray Reversal Principle)

This application utilizes the reversal of Rule 2: If a light source is placed at the **Principal Focus** (F), the rays will reflect off the mirror and emerge as a powerful, **parallel beam**.

- **Torches and Searchlights:** The bulb is placed at F .
- **Vehicle Headlights:** The light source is placed at F to project a strong, directional beam.

2. Magnification (The Virtual Image Case)

This application uses the special Case 6 (Object between P and F), where the image is large, upright, and behind the mirror (Virtual).

- **Shaving Mirrors:** Holding the mirror close to the face (inside F) gives a **larger, erect image** of the face for precise shaving.
- **Dentist Mirrors:** Dentists use them to see a **magnified** image of a patient's tooth.

3. Concentrating Solar Energy (The Real Image Case)

This application uses the convergence property from Rule 1.

- **Solar Furnaces:** Large concave mirrors are used to focus massive amounts of sunlight (which are parallel rays from infinity) onto a small area, the **Focus** (F). This concentrates the solar energy, producing enough heat to ignite materials or power a furnace.

Would you like to move on to the formation of images by a Convex Mirror, which has fewer cases and always forms virtual images?

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Image formation by Convex Mirrors

You're moving on to **Convex Mirrors**, which are simpler than concave mirrors because they only form one type of image regardless of the object's position.

Here is a summary of the image formation by convex mirrors (Activity 10.5 and Table 10.2) and their practical uses.

Image Formation by a Convex Mirror

Convex mirrors are also known as **diverging mirrors** because they spread out incoming parallel rays. Because the focus (F) and the center of curvature (C) are always *behind* the mirror, they only form **Virtual** images.

Activity 10.5: Observing the Pencil

When you hold a pencil in front of a convex mirror, you will observe the following:

- The image is always **Erect** (upright).
- The image is always **Diminished** (smaller than the object).
- As you move the pencil **away** from the mirror, the image becomes **smaller** and moves **closer to the Focus (F)** (but it never reaches it).

Two Cases of Image Formation

For a convex mirror, there are only two general cases, both resulting in the same *nature* of the image:

Table 10.2: Image Formation by a Convex Mirror

Position of the Object	Position of the Image	Relative Size of Image	Nature of Image
1. At Infinity	At the Focus (F), behind the mirror	Highly diminished (point-sized)	Virtual and Erect
2. Between Infinity and the Pole (P)	Between P and F , behind the mirror	Diminished	Virtual and Erect

🔗 Uses of Convex Mirrors

Convex mirrors are highly valued because they reliably provide a **wide field of view** and always produce an **erect** image.

1. Rear-View Mirrors in Vehicles (Wing Mirrors)

This is the most common use. Convex mirrors are preferred over plane mirrors because:

- They always produce an **Erect** (upright) image, which is crucial for drivers' orientation.
- They are curved outwards, allowing them to gather light from a very wide area. This provides the driver with a **much wider field of view** than a flat mirror, enabling safe observation of traffic behind the vehicle.

2. Security and Surveillance

- **Shop Security Mirrors:** Used in retail stores to view wide aisles from a single point.
- **Blind Corner Mirrors:** Installed at dangerous street corners or in large warehouses to help drivers see around sharp bends.

🔗 Activity 10.6: Seeing the Full Picture

The activity asks which mirror (plane, concave, or convex) gives the **full-length image** of a large, distant object like a tree.

The answer is the **Convex Mirror**.

- **Concave Mirror:** If the tree is far away (at infinity), the image is point-sized and inverted at f . If the object is close, the image is often inverted. You cannot see the full image easily.
- **Plane Mirror:** To see a full-length image of a large object, you would need a plane mirror that is at least half the height of the object, which is impractical for a distant tree. The field of view is too narrow.
- **Convex Mirror:** Because it produces a **diminished** image, the entire large object is squeezed into a small area behind the mirror, giving a **full-length, small, and upright image**. This is why the mirror at Agra Fort can show the full Taj Mahal.

Would you like to review the sign convention and mirror formula, which are the next steps in solving numerical problems related to these mirrors?

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Sign Convention for Spherical Lenses

The text you've provided discusses the **Sign Convention, Lens Formula, and Magnification**—the essential mathematical tools for solving problems involving spherical lenses.

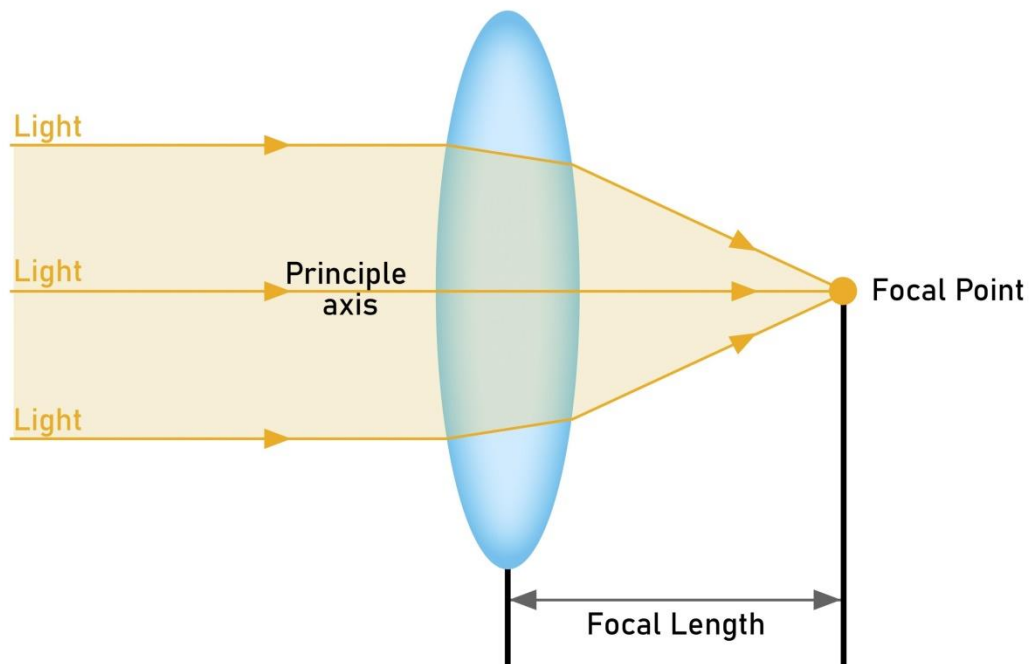
While your text specifically mentions *lenses*, the fundamental **New Cartesian Sign Convention** and the concepts of the Lens Formula and Magnification are direct parallels to the Mirror Formula you studied previously.

Here is a breakdown of these key concepts.

1. The New Cartesian Sign Convention

This convention establishes a uniform system for measuring all distances, ensuring consistency in numerical problems.

Converging Lens



- **Origin:** All distances are measured from the **Optical Centre (O)** of the lens (similar to the Pole P for mirrors).
- **Incident Light Direction:** The direction of the incident light is taken as **Positive** (usually left to right).
- **Opposite Direction:** Distances measured against the direction of incident light (to the left) are taken as **Negative**.
- **Principal Axis:** Heights measured **upward** and perpendicular to the axis are **Positive** ($+h$). Heights measured **downward** are **Negative** ($-h$).

Focal Length Sign Summary (\boldsymbol{f})

Lens Type	Nature	Focal Length (f)
Convex Lens (Converging)	Real Focus	Positive (+)
Concave Lens (Diverging)	Virtual Focus	Negative (-)

2. The Lens Formula

The Lens Formula relates the object distance (u), image distance (v), and focal length (f).

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

Variable	Description	Sign Convention
u	Object Distance	Always Negative for real objects (since the object is always placed to the left).
v	Image Distance	Positive for real images (formed on the right side). Negative for virtual images (formed on the left side).
f	Focal Length	Positive for Convex, Negative for Concave.

Key Difference from Mirror Formula: The Lens Formula uses a minus sign ($\frac{1}{v} - \frac{1}{u}$), unlike the Mirror Formula, which uses a plus sign ($\frac{1}{v} + \frac{1}{u}$).

3. Magnification (m)

Magnification describes the **relative size** and **orientation** of the image compared to the object.

Magnification is defined as the ratio of the image height (h') to the object height (h):

$$m = \frac{\text{Height of the Image } (h')}{\text{Height of the Object } (h)}$$

Magnification is also related to the image and object distances:

$$m = \frac{v}{u}$$

Interpreting the Sign of Magnification

Magnification Value	Implication	Image Nature
m is Positive (+)	Image is upright	Virtual and Erect
m is Negative (-)	Image is inverted	Real and Inverted
$m > 1$	$m > 1$	> 1
$m < 1$	$m < 1$	< 1
$m = 1$	$m = 1$	$= 1$

Would you like to move on to the next topic in your curriculum, which is likely the definition of the Power of a Lens?

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Power of Lens

The text clearly defines the **Power of a Lens** (P), its units, its relationship to focal length, and its application in corrective lenses and optical systems.

Here is a summary of the concept and its practical uses.

Power of a Lens (P)

The power of a lens is a measure of its ability to **converge** (bend inwards) or **diverge** (bend outwards) light rays. The shorter the focal length, the more powerful the lens is at bending light.

Definition and Formula

Power (P) is mathematically defined as the **reciprocal of the focal length** (f).

The formula is:

$$P = \frac{1}{f}$$

Crucial Rule: The focal length (f) **must** be expressed in **metres (m)** for the power (P) to be in the standard unit.

Unit of Power: The Dioptre

- The SI unit of the power of a lens is the **dioptre**, denoted by the letter **D**.
- Definition: One dioptre (1 D) is the power of a lens whose focal length is one metre (1 m).

$$1 \text{ D} = 1 \text{ m}^{-1}$$

Sign Convention for Power

Since power is the reciprocal of focal length (f), it follows the same sign convention:

Lens Type	Focal Length (f)	Power (P)	Action
Convex Lens (Converging)	Positive (+)	Positive (+)	Stronger convergence = Shorter positive focal length = Higher positive power.
Concave Lens (Diverging)	Negative (-)	Negative (-)	Stronger divergence = Shorter negative focal length = Higher negative power (larger absolute value).

Application in Prescribed Lenses

Opticians use power because it simplifies eye prescriptions.

- A prescription of **+2.0 D** means a **convex (converging) lens** is required.
 - Focal length $f = \frac{1}{2.0 \text{ D}} = +0.50 \text{ m}$ (or $+50 \text{ cm}$).
- A prescription of **-2.5 D** means a **concave (diverging) lens** is required.
 - Focal length $f = \frac{1}{-2.5 \text{ D}} = -0.40 \text{ m}$ (or -40 cm).

+Power of Lenses in Combination

When multiple thin lenses are placed in close contact (as in complex optical instruments or eye-testing equipment), the net power (P) of the system is the **algebraic sum** of the individual powers (P_1, P_2, P_3, \dots).

$$P_{\text{net}} = P_1 + P_2 + P_3 + \dots$$

- Convenience:** Opticians can quickly test combinations of lenses by simply adding their powers.
 - Example: A $+2.0 \text{ D}$ lens combined with a $+0.25 \text{ D}$ lens yields a total power of $+2.25 \text{ D}$.
- Advanced Optics:** This additive property allows for the design of sophisticated lens systems (for cameras, microscopes, telescopes) to achieve high magnification and correct for image defects.

Would you like to move on to the final main topic in this section, which often covers the human eye and its defects?