# An Object Is Placed 49.5 Cm In Front Of A Convex Mirror. If The Focal Length Of The Mirror Is 12.0 Cm,

**An Object Is Placed 49.5 Cm In Front Of A Convex Mirror. If The Focal Length Of The Mirror Is 12.0 Cm,** this scenario is a classic example used in geometric optics to understand how convex mirrors form images. Such problems are fundamental in physics, especially in the study of optics, and are relevant for students, engineers, and anyone interested in the behavior of light and image formation. In this article, we will explore the principles involved, the formulas used, and the step-by-step process to determine the characteristics of the image formed by the convex mirror under the given conditions.

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## Understanding Convex Mirrors

### What Is a Convex Mirror?

A convex mirror, also known as a diverging mirror, is a mirror with a surface that curves outward. Unlike concave mirrors that focus light inward, convex mirrors cause parallel rays of light to diverge upon reflection. These mirrors are commonly used in vehicles as side-view mirrors, security mirrors in stores, and in various optical devices due to their wide field of view.

### Key Properties of Convex Mirrors

- Diverging Rays: Parallel rays incident on a convex mirror diverge after reflection.
- Virtual Images: The images formed are virtual, erect, and diminished in size.
- Focal Length: The focal length of a convex mirror is positive, typically small compared to the object distance.

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## Fundamental Concepts and Formulas in Mirror Optics

### Mirror Equation

The relationship between the object distance (u), the image distance (v), and the focal length (f) of a mirror is given by the mirror equation:

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

Where:
- $f$ = focal length of the mirror
- $v$ = image distance from the mirror
- $u$ = object distance from the mirror

Note: For convex mirrors, $f$ and $v$ are taken as positive in the sign convention used here.

## Magnification Formula

The magnification (M) of the mirror, which indicates the size change between the object and the image, is given by:

$$
M = \frac{h'}{h} = -\frac{v}{u}
$$

Where:
- $h'$ = height of the image
- $h$ = height of the object

The negative sign indicates the nature of the image (erect or inverted).

## Sign Convention

In the Cartesian sign convention for mirrors:
- Object distances ($u$) are negative if the object is in front of the mirror (real object).
- Image distances ($v$) are positive if the image is virtual and on the same side as the reflected rays.
- Focal length ($f$) is positive for convex mirrors.

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# Applying the Concepts to the Given Problem

## Given Data

- Object distance, $u = -49.5\, \text{cm}$ (since object is in front of the mirror)
- Focal length, $f = +12.0\, \text{cm}$ (positive for convex mirror)

## Objective

Determine:
- The image distance, $v$
- The nature and size of the image
- The magnification

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# Step-by-Step Solution

## 1. Write Down the Mirror Equation

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

## 2. Substitute Known Values

$$
\frac{1}{12.0} = \frac{1}{v} + \frac{1}{-49.5}
$$
$$
\Rightarrow \frac{1}{v} = \frac{1}{12.0} - \frac{1}{49.5}
$$

## 3. Calculate the Right Side

$$
\frac{1}{12.0} \approx 0.08333
$$
$$
\frac{1}{49.5} \approx 0.02020
$$
$$
\Rightarrow \frac{1}{v} = 0.08333 - 0.02020 = 0.06313
$$

## 4. Find $v$

$$
v = \frac{1}{0.06313} \approx 15.84\, \text{cm}
$$

Since $v$ is positive, the image is virtual and formed behind the mirror.

### 5. Calculate Magnification $M$

$$
M = -\frac{v}{u} = -\frac{15.84}{-49.5} \approx 0.32
$$

The positive magnification indicates the image is erect, and the size of the image is approximately 32% of the object height.

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## Interpreting the Results

### Nature of the Image

- Type: Virtual
- Orientation: Erect
- Size: Reduced (about 32% of the object size)
- Position: Behind the convex mirror, at approximately 15.84 cm from the mirror

### Implications of the Image Properties

Convex mirrors always produce virtual, erect, and diminished images regardless of the object distance, which is essential for their role in providing wide-angle views. The calculations confirm that, even when an object is placed relatively close to a convex mirror, the image remains virtual and smaller than the actual object.

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## Practical Applications and Significance

### Use of Convex Mirrors in Daily Life

- Vehicle Side Mirrors: Provide a wide field of view, reducing blind spots.
- Security Mirrors: Used in stores and corridors to monitor large areas.
- Architectural Applications: For aesthetic and safety purposes.

### Importance of Understanding Mirror Behavior

Knowing how convex mirrors form images aids in designing safer vehicles, effective surveillance systems, and optical devices.

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# Additional Considerations in Mirror Optics

## Effects of Changing Object Distance

- As the object moves closer to the convex mirror, the image remains virtual and erect but slightly larger.
- When the object is very close, the image size increases but remains smaller than the object.

## Limitations of the Model

- Assumes ideal mirror with no aberrations.
- Does not account for real-world factors like surface imperfections or light scattering.

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# Summary

In this scenario, placing an object 49.5 cm in front of a convex mirror with a focal length of 12.0 cm results in the formation of a virtual, erect, and diminished image approximately 15.84 cm behind the mirror. Using the mirror equation and magnification formula, we can accurately determine the image's position and size, which is crucial for understanding and applying optical principles in everyday devices and safety systems.

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# Conclusion

Understanding the behavior of convex mirrors through the application of fundamental optics principles not only enhances conceptual knowledge but also has practical implications. Whether in vehicle safety, surveillance, or optical device design, the ability to analyze and predict image formation is a vital skill. The detailed steps outlined above serve as a comprehensive guide for solving similar problems involving convex mirrors and object-image relationships.

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For further learning, consider exploring how changing the object distance affects the image properties or how convex mirrors compare with concave mirrors in different optical scenarios.

# Frequently Asked Questions

## What is the image distance when an object is placed 49.5 cm in front of a convex mirror with a focal length of 12.0 cm?

Using the mirror formula: 1/f = 1/do + 1/di, where do = 49.5 cm and f = 12.0 cm, the image distance di is approximately 4.0 cm behind the mirror (positive value indicating a virtual image).

## Is the image formed by the convex mirror real or virtual in this scenario?

The image is virtual, erect, and diminished, which is characteristic of images formed by convex mirrors when the object is in front of the mirror.

## What is the magnification of the image formed by the convex mirror in this case?

Magnification (m) = -di / do. Substituting di ≈ 4.0 cm and do = 49.5 cm, m ≈ -0.081, indicating the image is upright and significantly smaller than the object.

## How does the focal length of the convex mirror affect the size of the image produced?

A shorter focal length (more convex) produces a smaller and more upright virtual image, whereas a longer focal length results in a larger image closer to the object size.

## What is the nature of the image formed by a convex mirror with the given parameters?

The image is virtual, erect, diminished, and located behind the mirror at approximately 4.0 cm.

## How can the mirror formula be used to determine the image position in this scenario?

By applying 1/f = 1/do + 1/di with do = 49.5 cm and f = 12.0 cm, solving for di gives the image distance, which helps locate the virtual image behind the mirror.

# Additional Resources

An Object Is Placed 49.5 Cm In Front Of A Convex Mirror. If The Focal Length Of The Mirror Is 12.0 Cm, what are the characteristics of the resulting image? This question delves into the fundamental principles of optics, specifically the behavior of convex mirrors and the formation of images. Understanding this scenario not only provides insight into the physics behind everyday reflective surfaces but also highlights practical applications such as vehicle mirrors, security installations, and optical devices. In this article, we explore the detailed process of calculating the image position, size, and nature using the mirror equation and magnification concepts, offering a comprehensive guide for students, educators, and optics enthusiasts alike.

# Understanding the Basics: Convex Mirrors and Their Properties

Before diving into calculations, it is essential to comprehend what convex mirrors are and their fundamental properties.

## What Is a Convex Mirror?

A convex mirror is a reflective surface that curves outward, resembling the exterior of a sphere. Unlike concave mirrors, which curve inward, convex mirrors diverge light rays. This divergence causes the reflected rays to spread apart, resulting in specific image characteristics that are consistent regardless of the object position in front of the mirror.

## Key Characteristics of Convex Mirrors

- Image Nature: Always virtual, erect, and diminished (smaller than the object).
- Image Position: Located behind the mirror.
- Field of View: Wider, making convex mirrors ideal for surveillance and vehicle side mirrors.
- Focal Length: Negative value, indicating the diverging nature of the mirror's focal point.

# Fundamental Concepts and Equations in Mirror Optics

To analyze the image formation, several core concepts and mathematical relationships are employed.

## The Mirror Equation

The mirror equation relates the object distance (u), the image distance (v), and the focal length (f):

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

Where:

- $f$ is the focal length of the mirror.
- $v$ is the distance from the mirror to the image.
- $u$ is the distance from the mirror to the object.

Sign conventions:
- For convex mirrors, the focal length $f$ is negative.
- Object distance $u$ is positive when the object is in front of the mirror.
- Image distance $v$ is positive if the image is real and on the same side as the object; negative if virtual and on the same side behind the mirror.

## Magnification (m)

Magnification indicates the size ratio between the image and the object:

$$
m = \frac{h'}{h} = -\frac{v}{u}
$$

Where:
- $h'$ is the height of the image.
- $h$ is the height of the object.
- The negative sign indicates the orientation (erect or inverted).

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## Applying the Concepts: Calculating Image Position

Given data:
- Object distance, $u = 49.5\, \text{cm}$
- Focal length, $f = -12.0\, \text{cm}$ (negative for convex mirror)

Using the mirror equation:

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

Substituting the known values:

$$
\frac{1}{-12.0} = \frac{1}{v} + \frac{1}{49.5}
$$

Rearranged to solve for $1/v$:

\[

$$
\frac{1}{v} = \frac{1}{-12.0} - \frac{1}{49.5}
$$

Calculating each term:

$$
\frac{1}{-12.0} \approx -0.08333
$$
$$
\frac{1}{49.5} \approx 0.02020
$$

Thus:

$$
\frac{1}{v} = -0.08333 - 0.02020 = -0.10353
$$

Finally, find $v$:

$$
v = \frac{1}{-0.10353} \approx -9.66\, \text{cm}
$$

Interpretation:
- The negative value of $v$ indicates the image is virtual and located behind the mirror.
- The image forms approximately 9.66 cm behind the convex mirror.

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# Analyzing the Image: Size, Orientation, and Nature

With the image position determined, further properties can be deduced.

## Magnification Calculation

Using the magnification formula:

$$
m = -\frac{v}{u} = -\frac{-9.66}{49.5} \approx 0.195
$$

Implications:
- The positive magnification (~0.195) indicates the image is erect.
- The magnitude less than 1 confirms the image is diminished (smaller than the object).

## Image Characteristics Summary

| Property | Description |
|---|---|
| Type | Virtual |
| Orientation | Erect |
| Size | Reduced (~19.5% of the object size) |
| Position | Approximately 9.66 cm behind the mirror |

This analysis aligns with the typical behavior of convex mirrors: they produce smaller, upright, virtual images that appear behind the mirror surface.

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# Practical Applications and Significance

Understanding the physics of convex mirrors is crucial for multiple real-world applications.

## Vehicle Side Mirrors

- Designed as convex mirrors to provide a wider field of view.
- The diminished, upright images help drivers see more area, but at the expense of some size reduction.

## Security and Surveillance

- Used in stores and public spaces to monitor larger areas owing to their wide-angle view.
- The virtual, erect images enable effective observation without distortion.

## Optical Devices and Engineering

- In optical systems, convex mirrors are used for beam control and in telescopic arrangements.
- Understanding image formation aids in designing better optical instruments.

# Conclusion: The Significance of Optics Calculations in Everyday Life

The scenario of an object placed 49.5 cm in front of a convex mirror with a focal length of 12.0 cm exemplifies the fundamental principles of mirror optics. By applying the mirror equation and magnification formulas, we discover that the virtual image forms approximately 9.66 cm behind the mirror, smaller and upright relative to the object. Such analyses are not only academic exercises but also underpin the design and understanding of devices and systems integral to daily life.

In an era where visual perception and safety are paramount, mastering the principles behind convex mirrors enhances our ability to interpret and utilize these reflective surfaces effectively. Whether in vehicle safety, security surveillance, or scientific instrumentation, the physics of mirrors remains a vital aspect of optical engineering, blending scientific rigor with practical utility.

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