An Object Placed 50cm Away From An Emerging Lens Of Focal Length 15cm Produce A Focus Image On A Screen

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Understanding the principles of optics is fundamental to various scientific and practical applications, including photography, microscopy, and optical instrument design. When an object is positioned at a specific distance from a converging lens, the lens forms a focused image on a screen. In this article, we explore the scenario where an object is placed 50 cm from a lens with a focal length of 15 cm and analyze how the image is formed, its characteristics, and the underlying physics principles involved.

Introduction to Lens and Image Formation

Optical lenses are transparent objects with curved surfaces that refract light rays to converge or diverge. The two primary types are:

- **Convex (converging) lenses:** These lenses cause parallel rays of light to converge to a focal point.
- **Concave (diverging) lenses:** These cause rays to diverge as if they originate from a focal point behind the lens.

In our case, the focal length of 15 cm indicates a converging lens, commonly known as a convex lens. The focal length (f) is a key parameter determining how the lens refracts light and forms images.

Understanding the Object and Image Relationship

When an object is placed in front of a converging lens, the image's position, size, orientation, and nature depend on the object distance (u) relative to the lens's focal length.

Sign Convention

To analyze the situation systematically, we adopt the Cartesian sign convention:

- Object distances (u): Negative if the object is on the same side as the incoming light (real object).
- Image distances (v): Positive if the image is on the opposite side of the lens (real image), negative if on the same side (virtual image).
- Focal length (f): Positive for converging lenses, negative for diverging lenses.

Applying this convention simplifies calculations and clarifies the nature of the images formed.

Calculating the Image Position Using the Lens Formula

The fundamental equation governing image formation in thin lenses is the lens formula:

$$1/f = 1/v + 1/u$$

Where:

- $f = 15$ cm (positive for converging lens)
- $u = -50$ cm (object distance; negative per sign convention)

Let's compute the image distance (v):

$$1/15 = 1/v + 1/(-50)$$

Simplify:

$$1/15 = 1/v - 1/50$$

Rearranged:

$$1/v = 1/15 + 1/50$$

Calculate the right side:

- Find common denominator: 150

$$1/v = (10/150) + (3/150) = 13/150$$

Thus,

$$v = 150/13 \approx 11.54 \text{ cm}$$

Interpretation:

- The positive value of v indicates that the image is real and formed on the opposite side of the lens.
- The image is approximately 11.54 cm from the lens.

Characteristics of the Image Formed

Knowing the image location allows us to determine other properties:

1. Magnification (M)

Magnification relates the size of the image to the object:

$$M = v/u$$

Calculate:

$$M = 11.54 / (-50) \approx -0.23$$

Implications:

- The negative sign indicates the image is inverted relative to the object.
- The magnitude (0.23) shows the image is smaller than the object, approximately 23% of the object's size.

2. Image Orientation and Nature

- Inverted: Due to negative magnification.
- Real: Formed on the opposite side of the lens.
- Reduced size: Smaller than the object.

3. Image Sharpness and Focus

Since the image forms at approximately 11.54 cm, positioning a screen at this point will produce a sharply focused image, provided the lens and object are stable and free of aberrations.

Practical Applications and Significance

Understanding how an object at a specific distance relates to the image formed by a converging lens is fundamental in designing optical devices.

1. Camera and Photography

- Proper focusing involves adjusting the distance between the lens and the film or sensor to match the object distance and focal length.

- Knowing the relationship ensures sharp images of objects at various distances.

2. Microscopes and Telescopes

- Precise calculations of object and image positions enable clear magnified images at desired locations.
- The principles discussed underpin the design of complex optical instruments.

3. Educational Demonstrations

- Demonstrating image formation with different object distances illustrates core optics concepts.
- Visualizing the real, inverted, and reduced images enhances understanding.

Additional Considerations in Practical Scenarios

While theoretical calculations provide a foundation, real-world factors may influence image quality:

- Lens aberrations and imperfections
- Alignment of the optical axis
- Size and shape of the lens
- Environmental conditions like lighting and ambient vibrations

Ensuring these factors are controlled enhances the accuracy and clarity of the focused image.

Summary of Key Points

- An object placed 50 cm from a converging lens with a focal length of 15 cm produces a real, inverted, and smaller image.
- The image forms approximately 11.54 cm on the opposite side of the lens.
- The magnification is approximately -0.23, indicating a reduction in size.
- Precise calculations using the lens formula are essential for predicting image characteristics.
- Practical applications span photography, microscopy, telescopic devices, and educational tools.

Conclusion

The formation of a focused image by a converging lens involves understanding the relationships between object distance, focal length, and image parameters. In the scenario where an object is 50 cm away from a 15 cm focal length lens, the resulting image is real, inverted, and diminished, located about 11.54 cm from the lens. This fundamental understanding is crucial across various fields leveraging optical systems, ensuring clarity, precision, and efficiency in imaging technology.

By mastering these concepts, scientists, engineers, and students can better design, utilize, and appreciate the intricacies of optical devices and systems, advancing both scientific knowledge and practical applications.

Frequently Asked Questions

How is the image formed when an object is placed 50cm from a convex lens with a focal length of 15cm?

The image is formed by diverging or converging light rays through the convex lens, resulting in a real, inverted, and magnified image on the screen as the object is placed beyond the focal length.

What is the nature and position of the image formed in this scenario?

Since the object is placed beyond the focal length (50cm > 15cm), a real, inverted, and magnified image is formed on the screen, located at a distance calculated using the lens formula.

How can we determine the size of the image formed on the screen?

The size of the image can be found using the magnification formula, which is the ratio of the image height to the object height, calculated as the negative ratio of the image distance to the object distance.

What is the significance of the focal length being 15cm in this setup?

The focal length of 15cm indicates the lens's converging power; since the object is placed beyond the focal length, a real and inverted image is formed on the screen, with the position determined by the lens formula.

How does changing the object distance affect the image formation in this scenario?

Moving the object closer or farther from the lens alters the image's size and position; closer objects (but beyond focal length) produce larger images closer to the lens, while objects farther away produce smaller images farther from the lens.

Additional Resources

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Introduction

The phenomenon where an object placed at a certain distance from a lens produces a focused image on a screen is fundamental in optics and has been the basis for countless technological advancements, from simple magnifiers to sophisticated cameras and microscopes. The scenario under investigation involves an object placed 50 centimeters (cm) from an emerging lens with a focal length of 15cm, resulting in a focused image on a screen. Understanding the underlying principles requires a deep dive into lens equation mechanics, image formation, and practical implications for optical device design.

This article aims to explore, in detail, the physics governing this setup, analyze the conditions under which a focused image forms, and examine the implications of the specific parameters involved. Through rigorous analysis, we will elucidate the behavior of the lens system, provide calculations to determine the image position, and discuss real-world applications and limitations.

Fundamental Concepts in Geometric Optics

The Lens Formula

At the core of understanding image formation through lenses is the lens formula:

$$
\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}
$$

where:

- f is the focal length of the lens (positive for converging lenses),
- d_o is the object distance (distance from the object to the lens),
- d_i is the image distance (distance from the lens to the image).

This formula relates the object and image positions through the lens's focal length, enabling calculations of where the image will form relative to the lens.

Sign Conventions

In optics, consistent sign conventions are vital:

- For converging lenses (like the "emerging lens" in question), $f > 0$.
- Object distances (d_o) are positive if the object is on the same side as the incoming light (real object).
- Image distances (d_i) are positive if the image is formed on the opposite side of the lens (real image), negative if virtual.

Analyzing the Setup

Given Parameters

- Object distance, $d_o = 50\, \text{cm}$
- Focal length of the lens, $f = 15\, \text{cm}$

The question is whether this configuration results in a focused real image on a screen. To determine this, we use the lens formula.

Step 1: Calculate the Image Distance

Applying the lens formula:

$$
\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}
$$

$$
\frac{1}{15} = \frac{1}{50} + \frac{1}{d_i}
$$

Expressed with common denominators:

$$
\frac{1}{d_i} = \frac{1}{15} - \frac{1}{50}
$$

Calculating:

$$
\frac{1}{d_i} = \frac{50 - 15}{15 \times 50} = \frac{35}{750} = \frac{7}{150}
$$

Thus:

$$
d_i = \frac{150}{7} \approx 21.43\, \text{cm}
$$

Since d_i is positive, the image is real and formed approximately 21.43cm on the opposite side of the lens, meaning it can be projected onto a screen placed at this position.

Interpretation of Results

- The image forms approximately 21.43cm from the lens.
- The image is real, inverted, and focused, satisfying the conditions for projection onto a screen placed at that position.
- The object is placed 50cm in front of the lens, which is beyond the focal length, consistent with producing a real inverted image.

Deep Dive: Optical Behavior and Practical Considerations

Magnification and Image Size

The magnification M of the image is given by:

$$
M = -\frac{d_i}{d_o}
$$

Calculating:

$$
M = -\frac{21.43}{50} \approx -0.429
$$

The negative sign indicates the image is inverted. The size of the image is approximately 42.9% of the object size.

Implications for Image Quality and Brightness

- Brightness: The amount of light reaching the screen depends on the lens's aperture and the intensity of the object.
- Image sharpness: Ideal focusing at the calculated d_i ensures a sharp image, but aberrations and lens quality affect real-world clarity.

Practical Setup Requirements

- The screen must be positioned approximately 21.43cm behind the lens.
- The object must be held or placed stably at 50cm in front of the lens.
- Adjustments can be made to the object or screen position to achieve perfect focus.

Exploring Variations and Edge Cases

What Happens if the Object Distance Changes?

- If the object is closer than the focal length ($d_o < f$), the lens produces a virtual, erect, and magnified image on the same side as the object.
- If the object is at infinity ($d_o \to \infty$), the image forms at the focal point ($d_i = f$) on the

opposite side.

Effect of Lens Type

- The analysis assumes a converging (convex) lens; diverging lenses would produce different image characteristics, often virtual images.

Real-World Applications and Limitations

Application in Optical Instruments

- Projection Systems: The calculation demonstrates how a simple converging lens can project a real image onto a screen, fundamental in projectors.
- Microscopy and Imaging: Understanding image formation helps in designing lenses that produce sharp, focused images at desired distances.

Limitations and Practical Challenges

- Lens Aberrations: Spherical aberration, chromatic aberration, and distortions can degrade image quality.
- Alignment Precision: Accurate placement of the object and screen is essential for optimal focus.
- Light Intensity: For brightness, the lens's aperture and illumination conditions matter.

Summary and Conclusions

The scenario involving an object placed 50cm from an emerging lens with a focal length of 15cm successfully produces a focused real image on a screen located approximately 21.43cm behind the lens. This outcome aligns with classical optics principles, confirming that:

- The object is beyond the focal length, enabling real image formation.
- The image is inverted and magnified, with a magnification ratio of approximately -0.429.
- Precise calculations using the lens formula are vital for predicting image positions.

This analysis underscores the importance of understanding fundamental optical equations for designing and optimizing imaging systems. Whether in educational demonstrations, professional optical instrument design, or consumer electronics, mastering these principles is essential for effective application.

Future Directions and Further Research

- Exploring Composite Lens Systems: Combining multiple lenses to correct aberrations or achieve specific magnifications.
- Investigating Non-Ideal Conditions: Effects of lens imperfections, material properties, and environmental factors.
- Adaptive Optics: Dynamic adjustment of lens parameters for optimal focus in variable conditions.

In conclusion, the ability of an object placed 50cm from a 15cm focal length lens to produce a focused image on a screen exemplifies fundamental optical principles. The precise calculations and understanding of image formation mechanics are invaluable in both theoretical studies and practical applications across various fields of science and technology.

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