A Lens With F=15.0 Cm Is Held 29.0 Cm From An Object. Where Does The Image Form

A Lens With F=15.0 Cm Is Held 29.0 Cm From An Object. Where Does The Image Form?

Understanding where an image forms when using a lens involves applying fundamental principles of geometric optics, particularly the lens formula and magnification concepts. Given a converging (convex) lens with a focal length of 15.0 cm, and an object placed 29.0 cm from the lens, our goal is to determine the position of the resulting image. This problem provides an excellent opportunity to explore how lenses form images, how to apply the lens formula, and how to interpret the results in practical terms.

Fundamental Concepts in Lens Optics

Before delving into calculations, it is essential to understand some core concepts:

1. Types of Lenses

- **Convex (Converging) Lens:** Thick in the middle and thinner at the edges, causes parallel rays to converge at a focal point.
- **Concave (Diverging) Lens:** Causes parallel rays to diverge as if originating from a focal point behind the lens.

In this scenario, since the focal length is positive, we are dealing with a convex lens.

2. Focal Length (f)

- The distance from the lens to its focal point where parallel rays converge.
- For this lens, \(f = +15.0\, \text{cm}\).

3. Object Distance (u)

- The distance from the object to the lens.
- Given as $u = -29.0\, \text{cm}$, following the sign convention where object distances are negative if the object is on the same side as the incoming light (real object).

4. Image Distance (v)

- The distance from the lens to the image.
- To be determined.

5. Sign Convention

- For real objects and real images:
- Object distance (u) is negative if the object is on the same side as the incoming light.
- Image distance (v) is positive if the image is real and on the opposite side of the lens.
- Focal length (f) is positive for convex lenses, negative for concave lenses.

Applying the Lens Formula

The key formula to find the image position is the lens equation:

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

Where:
- f = focal length
- v = image distance
- u = object distance

Given:
- $f = +15.0\, \text{cm}$
- $u = -29.0\, \text{cm}$

Rearranged to solve for v:

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

Plugging in the known values:

$$
\frac{1}{v} = \frac{1}{15.0\, \text{cm}} - \frac{1}{-29.0\, \text{cm}}
$$

Simplify:

$$
\frac{1}{v} = \frac{1}{15.0} + \frac{1}{29.0}
$$

Calculate each term:

$$
\frac{1}{15.0} \approx 0.0667\, \text{cm}^{-1}
$$
$$
\frac{1}{29.0} \approx 0.0345\, \text{cm}^{-1}
$$

Adding:

$$
\frac{1}{v} \approx 0.0667 + 0.0345 = 0.1012\, \text{cm}^{-1}
$$

Now, find v:

$$
v = \frac{1}{0.1012} \approx 9.89\, \text{cm}
$$

Since the result for v is positive, the image forms on the opposite side of the lens from the object, indicating a real image.

Interpreting the Result

The calculation shows that:

- Image Distance (v) ≈ 9.89 cm from the lens.
- The positive value indicates a real, inverted image on the opposite side of the lens.
- The image is located approximately 9.89 cm from the lens, closer than the object distance.

Image Characteristics

Using the magnification formula:

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

Calculate the magnification:

$$
m = \frac{9.89}{-29.0} \approx -0.341
$$

The negative sign indicates that the image is inverted relative to the object. The magnitude tells us the size ratio:

- The image is approximately 34.1% the size of the object, indicating it’s smaller.

Summary of Image Properties

- Position: approximately 9.89 cm from the lens on the side opposite the object.

- Type: Real and inverted.

- Size: Smaller than the object (about 34% of the object size).

Practical Implications and Additional Considerations

Understanding where an image forms has applications in various optical devices such as cameras, microscopes, and eyeglasses. In this case, knowing the image position helps determine image clarity, magnification, and whether additional lenses are needed for desired focus.

1. Effect of Changing Object Distance

- Moving the object closer or further from the lens alters the image position.
- For objects beyond twice the focal length, images tend to be smaller and closer to the focal point.

2. Magnification and Image Size

- The magnitude of magnification indicates how large or small the image appears.
- Critical for designing optical systems where size matters.

3. Image Orientation and Nature

- Inverted images are characteristic of real images formed by convex lenses when the object is outside the focal length.
- If the object were within the focal length, the lens would produce a virtual, upright, and magnified image.

Conclusion

In this specific scenario, a convex lens with a focal length of 15.0 cm held 29.0 cm from an object produces a real, inverted image approximately 9.89 cm from the lens on the side opposite the object. The image is smaller than the object, and its position can be precisely calculated using the lens formula. This understanding not only demonstrates fundamental optical principles but also illustrates their practical applications across various optical devices and systems.

By mastering these calculations and concepts, one can predict image formation in a wide range of optical setups, enhancing the design and analysis of optical instruments and improving clarity in visual representations and imaging technologies.

Frequently Asked Questions

How do you determine the image position for a lens with a focal length of 15.0 cm when an object is placed 29.0 cm from it?

Use the lens formula: 1/f = 1/do + 1/di. Substituting f = 15.0 cm and do = 29.0 cm, solve for di to find the image position.

What is the image distance when an object is 29.0 cm from a lens with a focal length of 15.0 cm?

Applying the lens formula: 1/15 = 1/29 + 1/di, solving for di gives approximately 9.34 cm, meaning the image forms about 9.34 cm from the lens on the same side as the image.

Is the image formed real or virtual for this lens-object setup?

Since the calculated image distance is positive and real, the image is real and formed on the opposite side of the lens from the object.

How does the focal length affect the position of the image in this scenario?

A shorter focal length (15.0 cm) results in a closer image position compared to the object, indicating a converging lens forming a real, inverted image closer to the lens.

What happens to the image size relative to the object in this setup?

Using the magnification formula (m = -di/do), the image is approximately 0.32 times the size of the object, indicating a reduced, inverted image.

Can this lens produce a magnified image given the object distance and focal length?

No, since the magnification is less than 1 (approximately 0.32), the image is diminished in size rather than magnified.

How would the image position change if the object were moved closer to the lens?

Moving the object closer to the lens (reducing do) would increase the image distance (di), resulting in a larger, still real image, according to the lens formula.

Additional Resources

A Lens With F=15.0 Cm Is Held 29.0 Cm From An Object. Where Does The Image Form?

Understanding how images are formed by lenses is fundamental in optics, with applications spanning from everyday devices like cameras and eyeglasses to advanced scientific instrumentation. When dealing with a converging lens—such as a convex lens—the position and nature of the resulting image depend on the object's distance from the lens and the lens's focal length. This article offers a detailed exploration of the problem: a lens with a focal length of 15.0 cm is held 29.0 cm from an object, and we seek to determine where the image forms.

Fundamentals of Lens Optics

The Nature of Convex Lenses

Convex lenses are transparent, curved optical devices that converge light rays passing through them. They are commonly used in magnifying glasses, cameras, and corrective eyewear. The focal length (F) of a convex lens is a measure of its converging power, indicating the distance from the lens to the focal point where parallel rays converge.

- Focal Length (F): The distance from the lens to the focal point.
- Object Distance (do): The distance from the object to the lens.
- Image Distance (di): The distance from the lens to the formed image.

The relationship among these variables is governed by the lens formula:

> 1/f = 1/do + 1/di

Where f is the focal length (positive for convex lenses), do is the object distance, and di is the image distance.

Given Data and Initial Analysis

The problem provides:

- Focal length of the lens, f = +15.0 cm (positive indicating a convex lens).
- Object distance from the lens, do = 29.0 cm.

Objective: Find the position of the image, i.e., di.

Before delving into calculations, it’s essential to understand that the object is placed at a distance greater than the focal length, which typically results in a real, inverted image formed on the opposite side of the lens. The position of this image can then be precisely determined using the lens formula.

Applying the Lens Formula

The lens formula is a cornerstone in geometric optics:

> 1/f = 1/do + 1/di

Plugging in the known values:

> 1/15.0 = 1/29.0 + 1/di

Rearranging for 1/di:

> 1/di = 1/15.0 - 1/29.0

Calculating each term:

> 1/15.0 ≈ 0.06667

> 1/29.0 ≈ 0.03448

Subtracting:

> 1/di ≈ 0.06667 - 0.03448 ≈ 0.03219

Finding di:

> di ≈ 1 / 0.03219 ≈ 31.07 cm

This positive value indicates that the image forms on the same side as the outgoing light, i.e., on the opposite side of the object, confirming a real image.

Interpretation and Characteristics of the Image

Location of the Image

The image forms approximately 31.07 cm from the lens, on the side opposite the object. Since the object is at 29.0 cm, and the image is at about 31.07 cm, the image is located slightly farther from the lens than the object.

Magnification and Image Properties

Magnification (M) describes the size of the image relative to the object and is given by:

> $M = - di / do$

Calculating:

> $M = -31.07 / 29.0 \approx -1.07$

The negative sign indicates the image is inverted relative to the object. The magnitude (~1.07) suggests the image is slightly larger than the object, approximately 7% magnification.

Summary of image characteristics:

- Type: Real, inverted image
- Size: Slightly larger than the object
- Position: About 31.07 cm from the lens, on the opposite side

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Implications and Practical Context

Understanding where the image forms provides insights into lens applications:

- Magnification in optical devices: Slight enlargement with an inverted image is typical in microscopes and telescopes.
- Image positioning: Knowing the image distance helps in designing optical systems, such as aligning screens or sensors.

The scenario exemplifies basic principles used in designing optical instruments, emphasizing the importance of precise measurements and calculations to achieve the desired imaging outcomes.

Extended Considerations: Lens Formula in Practice

While straightforward here, real-world applications often involve additional complexities:

- Aberrations: Imperfections in lenses can distort images.
- Paraxial approximation: Most calculations assume rays are close to the principal axis.
- Object and image distances: Constraints such as physical space or lens

mounting can influence placements.

Understanding these factors ensures that the theoretical calculations align with practical results, essential for engineers, scientists, and hobbyists.

Conclusion: Where Does the Image Form?

By applying the fundamental lens formula, the image in this scenario forms approximately 31.07 centimeters from the convex lens, on the opposite side of the object. It is a real, inverted image, slightly larger than the object itself. Such calculations not only deepen our understanding of optical principles but also serve as foundational knowledge for the design and optimization of various optical devices. Whether in scientific research, medical imaging, or everyday technology, the precise determination of image formation remains a central aspect of optical science and engineering.

Final Thoughts

The interplay between object distance, focal length, and image position encapsulates the elegance of geometric optics. As demonstrated, small changes in object placement can significantly influence image properties, underscoring the importance of accurate measurements and calculations. In the broader context, mastering these concepts equips professionals and enthusiasts alike with the tools to harness light effectively, pushing forward innovations in imaging, communication, and beyond.

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