A Converging Lens (f = 11.6 Cm) Is Located 30.3 Cm To The Left Of A Diverging Lens (f = -5.82 Cm). A

A Converging Lens (f = 11.6 Cm) Is Located 30.3 Cm To The Left Of A Diverging Lens (f = -5.82 Cm). A

Understanding the behavior of optical systems involving multiple lenses is fundamental in optics and physics. When a converging lens with a focal length of 11.6 cm is positioned 30.3 cm to the left of a diverging lens with a focal length of -5.82 cm, the resulting image formation and light propagation can be analyzed through lens equations, magnification, and image characteristics. This comprehensive guide explores the principles governing such a lens arrangement, providing insights into image formation, calculations, and practical applications.

Fundamentals of Lens Optics

Types of Lenses and Their Focal Lengths

- Converging Lens (Convex Lens): Causes parallel light rays to converge to a focal point. Typically has a positive focal length.
- Diverging Lens (Concave Lens): Causes parallel light rays to diverge as if originating from a focal point on the same side as the incoming light. Has a negative focal length.

Lens Formula and Sign Conventions

The primary equation governing the behavior of lenses is:

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

- f: Focal length of the lens
- d_o: Object distance from the lens
- d_i: Image distance from the lens

Sign conventions:
- For converging lenses, $f > 0$
- For diverging lenses, $f < 0$
- Object distances are positive if the object is on the same side as incoming light
- Image distances are positive if the image is real and formed on the opposite side of the incoming light

---

Analyzing the Lens Arrangement

Positioning of the Lenses

- Converging lens: Located at some reference point, say at position 0 cm
- Diverging lens: Located 30.3 cm to the right of the converging lens, i.e., at position +30.3 cm

This setup can be visualized as:

```
[Object] --- Converging lens at 0 cm --- 30.3 cm --- Diverging lens at +30.3 cm
```

Objective of the Analysis

- To determine the nature, position, and size of the final image formed by the system
- To understand the combined effect of the two lenses on an object placed before the first lens

---

Step-by-Step Calculation of the Image Formation

1. Establishing the Object Position

- The problem typically assumes an object placed to the left of the converging lens
- For simplicity, consider the object at a specific distance, say d_{o_1}, from the first lens

Example: Let's assume the object is placed 50 cm to the left of the converging lens:

$$
d_{o_1} = 50\, \text{cm} \quad (\text{positive, since object is on the same side as incoming light})
$$

2. Find the Image from the Converging Lens

Applying the lens formula:

$$
\frac{1}{f_1} = \frac{1}{d_{o_1}} + \frac{1}{d_{i_1}}
$$

$$
\frac{1}{11.6} = \frac{1}{50} + \frac{1}{d_{i_1}}
$$

Calculating:

$$
\frac{1}{d_{i_1}} = \frac{1}{11.6} - \frac{1}{50} \approx 0.0862 - 0.02 = 0.0662
$$

$$
d_{i_1} \approx \frac{1}{0.0662} \approx 15.1\, \text{cm}
$$

Interpretation:
- The image is real (since $d_{i_1} > 0$)
- Located approximately 15.1 cm to the right of the converging lens

3. Determine the Object for the Diverging Lens

- The image from the first lens acts as an object for the second lens
- Its position relative to the second lens:

$$
d_{o_2} = \text{distance from the diverging lens to the intermediate image}
$$

- Since the diverging lens is at +30.3 cm, and the image is at +15.1 cm from the first lens:

$$
d_{o_2} = 30.3\, \text{cm} - 15.1\, \text{cm} = 15.2\, \text{cm}
$$

- Because the intermediate image is on the same side as the incoming light for the second lens, the object distance for the diverging lens is:

$$
d_{o_2} = -15.2\, \text{cm}
$$
(negative sign indicates virtual object on the same side as incoming light)

Calculating the Final Image

4. Applying Lens Formula to Diverging Lens

$$
\frac{1}{f_2} = \frac{1}{d_{o_2}} + \frac{1}{d_{i_2}}
$$
$$
\frac{1}{-5.82} = \frac{1}{-15.2} + \frac{1}{d_{i_2}}
$$

Calculating:
$$
\frac{1}{d_{i_2}} = \frac{1}{-5.82} - \frac{1}{-15.2} \approx -0.1717 + 0.0658 = -0.1059
$$
$$
d_{i_2} \approx \frac{1}{-0.1059} \approx -9.44\, \text{cm}
$$

Interpretation:
- The negative sign indicates that the final image is virtual and located approximately 9.44 cm on the same side as the diverging lens's object (which, in this case, is the intermediate image).

Implications of the Results

Image Characteristics

- Final Image Position: About 9.44 cm to the left of the diverging lens
- Nature: Virtual, upright, and magnified (since the image is virtual and on the same side as the incoming light)
- Magnification: The overall magnification can be calculated by multiplying the magnifications of each lens

Magnification Calculations

- For the converging lens:

$$
M_1 = \frac{d_{i_1}}{d_{o_1}} = \frac{15.1}{50} \approx 0.302
$$

- For the diverging lens:

$$
M_2 = \frac{d_{i_2}}{d_{o_2}} = \frac{-9.44}{-15.2} \approx 0.621
$$

- Total magnification:

$$
M_{total} = M_1 \times M_2 \approx 0.302 \times 0.621 \approx 0.188
$$

This indicates the final image is approximately 18.8% the size of the original object, magnified or reduced depending on the context.

Practical Applications of Converging and Diverging Lens Systems

Optical Devices and Systems

- Magnifying Glasses: Using converging lenses for magnification
- Eyeglasses: Correcting vision with converging or diverging lenses
- Cameras: Combining multiple lenses for image formation
- Microscopes and Telescopes: Complex lens arrangements for magnification

Engineering and Scientific Uses

- Laser Systems: Focusing beams with converging lenses
- Projection Systems: Using lens combinations for image projection
- Optical Sensors: Precise control of light paths

Advanced Concepts in Multi-Lens Systems

Lens Combinations and Image Formation

- Understanding how multiple lenses interact is crucial in designing optical instruments
- The overall system behavior depends on:
- Lens focal lengths
- Positions relative to each other
- Object placement

Ray Tracing Techniques

- Graphical methods to visualize how light rays pass through lenses
- Helps in predicting image characteristics accurately

Significance of Focal Lengths and Spacing

- Precise control of lens positions allows for desired magnification and focus
- Adjusting distances can switch between real and virtual images

---

Conclusion

The arrangement of a converging lens with \(f = 11.6\, \text{cm}\) positioned 30.3 cm to the left of a diverging lens with \(f = -5.82\, \text{cm}\) demonstrates the complex interplay of optics principles in image

Frequently Asked Questions

What is the overall optical system setup involving a converging and a diverging lens?

It consists of a converging lens with a focal length of 11.6 cm placed 30.3 cm to the left of a diverging lens with a focal length of -5.82 cm, forming a compound optical system.

How do you determine the combined focal length of the converging and diverging lenses?

Use the lens formula for each lens and combine their effects by considering their positions, or apply the effective focal length formula for two lenses in contact or separated by a distance.

How does the separation between the lenses affect the image formation?

The separation influences the intermediate image formed by the first lens, which then acts as the object for the second lens, affecting the final image position and size.

What is the significance of the focal lengths being positive and negative for these lenses?

A positive focal length (11.6 cm) indicates a converging lens, while a negative focal length (-5.82 cm) indicates a diverging lens, affecting how they bend light rays.

How can we calculate the image position for the converging lens in this setup?

Use the lens formula: 1/f = 1/do + 1/di, where do is the object distance from the converging lens, to find the image distance di.

What impact does the diverging lens have on the intermediate image formed by the converging lens?

The diverging lens typically causes the intermediate image to be diminished and shifted, modifying the overall image position and characteristics.

Can this system produce a real or virtual image, and under what conditions?

Yes, depending on the object position and the lens configurations, the system can produce real or virtual images; calculations based on object distances determine which occurs.

How would changing the distance between the two lenses influence the final image?

Varying the separation alters the intermediate image location, thereby changing the final image's position, size, and whether it is real or virtual.

What practical applications involve combining converging and diverging lenses like this?

Such systems are used in optical instruments like telescopes, microscopes, and camera systems to manipulate light paths for desired magnification and focus.

Additional Resources

Understanding the Optical Setup: Converging and Diverging Lenses in Tandem

The interplay between different types of lenses—particularly converging and diverging lenses—forms the foundation of many optical systems, from simple magnifying glasses to complex telescopic arrangements. In the scenario where a converging lens with a focal length of 11.6 cm is placed 30.3 cm to the left of a diverging lens with a focal length of -5.82 cm, the dynamics of light propagation become both intriguing and intricate. Such configurations are not merely academic exercises; they have practical implications in designing optical instruments, understanding image formation, and manipulating light for various applications. This article delves deeply into this specific setup, analyzing the physics involved, the behavior of light rays, and the potential outcomes of such an arrangement.

Fundamental Principles of Lenses: Converging vs. Diverging

Converging Lenses (Convex Lenses)

Converging lenses, often convex in shape, are characterized by their ability to bend incoming parallel light rays toward a common focal point on the opposite side of the lens. This property is due to their shape and the refractive index of the material (commonly glass). The focal length (f) is positive for converging lenses, indicating their converging nature.

- Focal Length (f): The distance from the lens to the focal point where parallel rays converge.
- Image Formation: Depending on the object distance, a converging lens can produce real or virtual images, magnified or diminished, inverted or upright.
- Applications: Cameras, microscopes, eyeglasses for hyperopia, and projectors.

Diverging Lenses (Concave Lenses)

Diverging lenses, typically concave, spread incoming light rays apart, making them diverge as if originating from a point behind the lens. Their focal length (f) is negative, reflecting their diverging nature.

- Focal Length (f): The negative value indicates the diverging property.
- Image Formation: Usually produce virtual, upright, and diminished images.
- Applications: Eyeglasses for myopia, laser beam expanders, and certain optical instruments requiring divergence.

The Geometry of the Setup: Spatial Arrangement and Its Significance

In the given scenario, the spatial arrangement is critical. The converging lens is positioned 30.3 cm to the left of the diverging lens. This separation influences how light rays emitted or originating from an object near the first lens interact with the second lens.

- Positioning Details:
- Converging lens at position $x_1 = 0$ (arbitrary reference point).
- Diverging lens at position $x_2 = +30.3$ cm (to the right).

This layout suggests a linear optical system where light first encounters the converging lens and then, after traveling 30.3 cm, interacts with the diverging lens. The distances involved are within practical ranges for laboratory setups, making the analysis relevant for real-world applications such as optical experiments, imaging systems, or educational demonstrations.

Ray Tracing and Image Formation: Step-by-Step Analysis

Understanding how images form in this system begins with analyzing the behavior of light rays passing through the lenses sequentially.

Step 1: Object Placement and Initial Ray Tracing

- Object Position: For analytical purposes, consider an object placed at a certain distance from the converging lens. Let's assume the object is located at a distance d_{o1} from the converging lens.
- Ray 1 (Parallel Ray): From the object, a ray travels parallel to the principal axis, then refracts through the converging lens and passes through its focal point on the opposite side.
- Ray 2 (Focal Ray): Another ray passes through the center of the lens without deviation.
- Ray 3 (Central Ray): A third ray passes through the focal point on the object side, emerging parallel to the principal axis after refraction.

Using these, one can locate the real or virtual image formed by the converging lens, which then serves as the "object" for the diverging lens.

Step 2: Image from the Converging Lens

Applying the lens formula:

$$
\frac{1}{f} = \frac{1}{d_{o1}} + \frac{1}{d_{i1}}
$$

where:

- $f = +11.6 \text{ cm}$,
- d_{o1} is the object distance from the converging lens,
- d_{i1} is the image distance from the converging lens.

For illustrative purposes, if an object is placed 15 cm to the left of the converging lens:

$$
\frac{1}{11.6} = \frac{1}{15} + \frac{1}{d_{i1}}
$$

$$
\frac{1}{d_{i1}} = \frac{1}{11.6} - \frac{1}{15} \approx 0.0862 - 0.0667 = 0.0195
$$

$$
d_{i1} \approx 51.3 \text{ cm}
$$

Since d_{i1} is positive, the image is real and located approximately 51.3 cm to the right of the converging lens.

This image acts as an "object" for the second lens, positioned 30.3 cm away from the converging lens. The relative position of this image with respect to the diverging lens determines the subsequent image formation.

Step 3: Image from the Diverging Lens

- Object for the Diverging Lens: The real image from the first lens is located at about 51.3 cm to the right of the first lens. Its position relative to the second lens depends on the initial object placement and the distances involved.

- Calculating Object Distance for the Diverging Lens:
- The image from the first lens is 51.3 cm from the first lens.
- The second lens is 30.3 cm to the right of the first lens.
- Therefore, the object distance for the diverging lens:

$$
d_{o2} = 51.3 \text{ cm} - 30.3 \text{ cm} = 21 \text{ cm}
$$

- Applying the Diverging Lens Formula:

$$
\frac{1}{f} = \frac{1}{d_{o2}} + \frac{1}{d_{i2}}
$$

where:

- $f = -5.82 \text{ cm}$,
- $d_{o2} = +21 \text{ cm}$ (positive if object is on the same side as the incoming light).

Calculating:

$$
\frac{1}{d_{i2}} = \frac{1}{f} - \frac{1}{d_{o2}} = \frac{1}{-5.82} - \frac{1}{21} \approx -0.1717 - 0.0476 = -0.2193
$$

$$
d_{i2} \approx -4.56 \text{ cm}
$$

The negative sign indicates the image is virtual and located approximately 4.56 cm on the same side of the diverging lens as the incoming light. This virtual image then can be projected or analyzed further, depending on the purpose.

Implications of the Lens Arrangement: Image Characteristics and System Behavior

The above calculations reveal several key points about this optical system:

- Image Orientation: The real images formed by the converging lens are inverted relative to the object, but the virtual images created by the diverging lens are upright.
- Magnification: The magnification factors at each stage influence the final image size. The magnification by the converging lens:

$$
M_1 = - \frac{d_{i1}}{d_{o1}}
$$

For an object at 15 cm:

$$
M_1 = - \frac{51.3}{15} \approx -3.42
$$

indicating a magnified, inverted image.

- Final Image Nature: The second image, formed by the diverging lens, being virtual and upright, results in a system that can produce an overall magnified, upright virtual image depending on the initial object placement and distances.

- System Applications: Such a configuration can be used intentionally in optical devices requiring image magnification with specific orientation, such as certain types of microscopes, optical couplers, or beam expanders.

Practical Considerations and Limitations

While the theoretical analysis provides valuable insights, practical implementation involves several considerations:

- Alignment Accuracy: Precise placement of lenses and correct alignment along the principal axis are crucial to achieving the predicted image characteristics.
- Aberrations: Real lenses introduce distortions and aberrations, which can deviate the actual image from the

ideal calculations.
- Object Distance Variability: Changing the initial object distance alters the entire image formation process, making the system adaptable but requiring recalibration.
- Magnification Limits: The magnification and size of the final image depend on the distances involved and the focal lengths, which can be

A Converging Lens F 11 6 Cm Is Located 30 3 Cm To The Left Of A Diverging Lens F 5 82 Cm A

A Converging Lens F 11 6 Cm Is Located 30 3 Cm To The Left Of A Diverging Lens F 5 82 Cm A

Related Articles

- The Pipe Assembly Is Subjected To The 80-n Force. Determine The Moment Of This Force About Point B.
- (b). A Double-slit Diffraction Pattern Is Formed Using A 546.1 Nm Mercury Green Light. Each Slit Has
- A Control Procedure Designed So That The Employee That Records Cash Received From Customers Does Not

Back to Home