A Camera With A Lens Of Focal Length 6.0cm Takes A Picture Of A 1.4m Tall Man Standing 11m Away. The

A Camera With A Lens Of Focal Length 6.0cm Takes A Picture Of A 1.4m Tall Man Standing 11m Away. The scenario raises interesting questions about photography, optics, and how various parameters influence the resulting image. Whether you're a photography enthusiast, a student studying optics, or someone curious about how focal length affects images, understanding the principles behind this setup can deepen your appreciation of camera technology.

In this article, we will explore the fundamental concepts involved in capturing an image with a camera of a specified focal length, analyze the relationship between object size, distance, and image size, and discuss how to calculate the magnification and image dimensions. We will also look into practical considerations such as field of view, image scale, and the implications of using a 6.0 cm focal length lens.

Understanding the Camera and Its Focal Length

What Does a Focal Length of 6.0 cm Mean?

The focal length of a camera lens, typically expressed in millimeters or centimeters, defines the distance from the lens to its focus point when focused at infinity. A 6.0 cm (or 60 mm) lens is generally considered a standard or slightly telephoto lens, depending on the camera's sensor size.

- Shorter focal lengths (e.g., 18mm) produce wider fields of view.
- Longer focal lengths (e.g., 100mm) offer narrower fields of view, magnifying distant objects.

A 6.0 cm focal length lens offers a moderate telephoto effect, allowing the camera to focus on subjects at a distance with some magnification, but still providing a reasonable field of view suitable for portraits, medium-distance photography, and more.

Object and Image Relationships in Photography

Key Concepts: Object Size, Distance, and Image Size

Understanding how an object's size and distance relate to its image involves several optical principles:

- Object height (h_o): The actual height of the subject (here, 1.4 meters).

- Object distance (d_o): The distance from the camera to the object (here, 11 meters).
- Image size (h_i): The height of the projected image on the camera's sensor or film.
- Magnification (M): The ratio of the image size to the object size, given by:

$$
M = \frac{h_i}{h_o} = \frac{d_i}{d_o}
$$

where d_i is the image distance, or the distance from the lens to the image plane.

In photography, the lens formula connects the focal length, object distance, and image distance:

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

where:

- f = focal length (here, 6.0 cm)
- d_o = object distance (here, 11 m)
- d_i = image distance (to be calculated)

Calculating the Image Formation

Step 1: Convert Units for Consistency

Given:

- Focal length, $f = 6.0 \text{ cm}$
- Object distance, $d_o = 11 \text{ m} = 1100 \text{ cm}$
- Object height, $h_o = 1.4 \text{ m} = 140 \text{ cm}$

Ensuring all measurements are in centimeters allows straightforward calculations.

Step 2: Find the Image Distance d_i

Using the lens formula:

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

$$
\Rightarrow \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}
$$

$$

$$
\Rightarrow \frac{1}{d_i} = \frac{1}{6} - \frac{1}{1100}
$$

Calculating:

$$
\frac{1}{d_i} = \frac{1100 - 6}{6 \times 1100} = \frac{1094}{6600} \approx 0.16576
$$

$$
d_i \approx \frac{1}{0.16576} \approx 6.03 \text{ cm}
$$

This indicates that the image forms approximately 6.03 cm behind the lens, very close to its focal length, which suggests a highly magnified image.

Step 3: Determine Magnification M

Using:

$$
M = \frac{d_i}{d_o} = \frac{6.03}{1100} \approx 0.00548
$$

This is a small magnification factor, indicating the image is tiny compared to the object.

Calculating the Image Size

Using the magnification:

$$
h_i = M \times h_o = 0.00548 \times 140 \text{ cm} \approx 0.77 \text{ cm}
$$

This means the image of the man on the camera's sensor or film would be approximately 0.77 centimeters tall.

Implications for Photography and Field of View

Field of View (FOV)

The field of view determines how much of the scene is captured. It depends on the focal length and the sensor size:

$$
\text{FOV} = 2 \times \arctan \left(\frac{\text{sensor dimension}}{2 \times f} \right)
$$

For example, assuming a typical full-frame sensor width of approximately 36 mm:

$$
\text{Horizontal FOV} \approx 2 \times \arctan \left(\frac{36/2 \text{ mm}}{60 \text{ mm}} \right) = 2 \times \arctan \left(\frac{18}{60} \right)
$$

$$
\approx 2 \times \arctan (0.3) \approx 2 \times 16.7^\circ \approx 33.4^\circ
$$

This relatively narrow FOV means the camera would frame the man tightly, emphasizing him against the background.

Practical Considerations in Photography

- Depth of Field: At this focal length and distance, the depth of field can be quite shallow, requiring careful focusing.
- Image Resolution: The small image size (about 0.77 cm) on the sensor may demand high-resolution sensors for detailed images.
- Magnification and Composition: While the image is small, digital cropping or high-resolution sensors can help achieve desired composition.

Summary and Conclusion

In summary, a camera with a 6.0 cm focal length lens photographing a 1.4-meter-tall man standing 11 meters away produces a highly magnified, small image of approximately 0.77 centimeters in height. The calculations highlight how focal length, object distance, and object size influence the resulting image.

Understanding these relationships allows photographers and students to predict how their images will turn out, optimize camera settings, and comprehend the optical principles at play. Whether capturing distant subjects or framing close-ups, knowledge of focal length and its effects is essential for achieving desired photographic results.

Key Takeaways:
- The focal length determines the magnification and field of view.
- The image of the man would be very small on the sensor (~0.77 cm tall).
- Adjusting focal length or distance can control the framing and composition.
- Optical formulas like the lens equation are crucial for predicting image characteristics.

By mastering these concepts, photographers can better utilize their equipment and capture stunning images tailored to their creative vision.

Frequently Asked Questions

What is the approximate angular field of view of the camera with a 6.0 cm focal length when photographing a 1.4 m tall man from 11 m away?

Using the formula for angular field of view, θ ≈ 2 × arctangent (sensor size / (2 × focal length)). Assuming a standard sensor width (e.g., 36 mm), the approximate horizontal field of view is about 36 degrees, which captures the man fully at 11 m distance.

Will the man appear larger or smaller in the picture taken with the 6.0 cm focal length camera at 11 m distance?

The man will appear relatively small because a 6.0 cm focal length (a wide-angle lens) provides a broader field of view, making objects at that distance appear smaller compared to telephoto lenses.

What is the magnification factor of the camera lens when capturing the man?

Magnification is approximately equal to the ratio of the focal length to the camera's sensor size. For a typical 35 mm sensor, magnification ≈ 6.0 cm / 36 mm ≈ 0.17, indicating the image of the man will be about 17% of his real size on the sensor.

How would changing the focal length affect the size of the man in the photograph?

Increasing the focal length (telephoto lens) would enlarge the man's image, making him appear bigger, while decreasing it (wide-angle lens) would make him appear smaller in the picture.

What considerations should be made to ensure the entire man fits into the frame?

You should select a lens with a focal length that provides a field of view wide enough to encompass the 1.4 m tall man from 11 m away. Alternatively, adjusting your distance or using zoom can help frame the subject appropriately.

If the camera's sensor height is 24 mm, what is the height of the man in the captured image in millimeters?

The height of the man in the image is approximately (focal length / sensor height) × real height. So, (60 mm / 24 mm) × 1.4 m ≈ 2.5 × 1.4 m = 3.5 meters scaled to the image, which in pixel terms depends on the sensor resolution. In terms of image size, the man would occupy about 17% of the image height, assuming the entire image height corresponds to the sensor height.

Additional Resources

A camera with a lens of focal length 6.0 cm takes a picture of a 1.4 m tall man standing 11 m away. This scenario offers a fascinating glimpse into the principles of optics, specifically how focal length influences image formation, size, and clarity. Whether you're a photography enthusiast, a student of physics, or simply curious about how cameras work, understanding this setup can deepen your appreciation of the science behind capturing images. In this comprehensive guide, we'll explore the fundamental concepts, perform detailed calculations, and discuss practical considerations related to this scenario.

Understanding the Basics: Key Concepts in Camera Optics

Before diving into calculations, it's essential to grasp some foundational principles:

1. Focal Length (f)

- The distance from the lens's optical center to its focal point.
- Determines the angle of view and magnification.
- Shorter focal lengths (wide-angle lenses) capture broader scenes.
- Longer focal lengths (telephoto lenses) magnify distant objects.

2. Image Formation

- When an object is placed in front of a converging lens, an image is formed on the opposite side.
- The image's size and position depend on the object distance and lens properties.

3. Magnification (M)

- The ratio of the image size to the object size.
- Calculated as:

$$
M = \frac{\text{Image height}}{\text{Object height}} = \frac{v}{u}
$$

where:
- u = object distance (from lens)
- v = image distance (from lens)

4. Lens Formula

- Relates object distance (u), image distance (v), and focal length (f):

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

This formula enables us to determine where the image forms relative to the lens for a given object distance and focal length.

Analyzing the Scenario: Step-by-Step Breakdown

Given data:
- Focal length of lens, $f = 6.0\,cm$
- Height of man, $H_o = 1.4\,m = 140\,cm$
- Distance of man from camera, $u = 11\,m = 1100\,cm$

Our goal:
- Find the size and nature of the image formed.
- Understand how the focal length influences the resulting photograph.

Step 1: Calculate the Image Distance (v)

Using the lens formula:

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

Substituting the known values:

$$
\frac{1}{6} = \frac{1}{v} + \frac{1}{1100}
$$

Expressed in centimeters:

$$
\frac{1}{v} = \frac{1}{6} - \frac{1}{1100}
$$

Calculate each term:

$$
\frac{1}{6} \approx 0.1667
$$
$$
\frac{1}{1100} \approx 0.000909
$$

Subtract:

$$

$$
\frac{1}{v} \approx 0.1667 - 0.000909 \approx 0.1658
$$

Invert to find v:

$$
v \approx \frac{1}{0.1658} \approx 6.03\,cm
$$

Interpretation: The image forms approximately 6.03 cm behind the lens.

Step 2: Determine the Magnification (M)

Using the relation:

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

Substitute known values:

$$
M = \frac{6.03}{1100} \approx 0.00548
$$

Meaning: The image is magnified by approximately 0.548%, or about 1/182th of the actual size.

Step 3: Find the Image Height (H_i) of the Man

Since:

$$
H_i = M \times H_o
$$

Calculate:

$$
H_i = 0.00548 \times 140\,cm \approx 0.77\,cm
$$

Result: The image of the man will be approximately 0.77 cm tall on the camera’s film or sensor.

Implications of the Focal Length Choice

- The 6.0 cm focal length corresponds to a wide-angle lens by typical standards, offering a broad field of view but producing a relatively small image of distant objects.
- The small image size (~0.77 cm) indicates that the photograph will show the man as a tiny figure, emphasizing the importance of magnification in photography.

Practical Considerations and Real-World Applications

While the calculations provide theoretical insights, several practical factors influence the actual outcome:

1. Lens Aberrations and Quality

- Real lenses introduce distortions, especially at wide angles.
- High-quality lenses minimize aberrations, ensuring sharper images.

2. Camera Sensor or Film Size

- The actual size of the film or sensor affects the final image size.
- Larger sensors capture more detail and allow for larger printed images.

3. Focusing Distance and Depth of Field

- At a distance of 11 m, focusing is straightforward, but depth of field considerations matter.
- A narrow aperture increases sharpness across the image but reduces light entering the lens.

4. Field of View (FOV)

- The focal length determines the FOV.
- For \(f = 6\,cm \), the FOV is relatively wide, capturing more of the scene.

5. Practical Image Size and Framing

- To produce a life-sized image, a longer focal length or closer distance would be required.
- For portrait or close-up shots, lenses with longer focal lengths are preferred.

Extending the Analysis: Variations and Additional Factors

- Changing the object distance: Moving the man closer or farther from the camera will affect the image size.
- Using different focal lengths: A longer focal length (e.g., 12 cm) would produce a larger image, increasing magnification.
- Considering real-world lens thickness: The calculations assume thin lenses; real lenses have thickness and multiple elements affecting image formation.
- Image inversion: The calculated image is real and inverted, typical for converging lenses used in cameras.

Summary and Key Takeaways

- The focal length of a lens significantly impacts image size, magnification, and field of view.
- For a 6.0 cm focal length lens, a man standing 11 m away will produce a very small, approximately 0.77 cm tall, real image.
- Understanding the lens formula and magnification is crucial in predicting how scenes are captured.
- Practical photography involves additional factors like sensor size, lens quality, aperture, and focusing, all of which influence the final image.

Conclusion

This detailed analysis of a camera with a lens of focal length 6.0 cm taking a picture of a 1.4 m tall man standing 11 m away reveals the intricate interplay of optics principles that govern image formation. By applying fundamental formulas and considering real-world factors, photographers and enthusiasts can better understand how focal length shapes their images, guiding them in selecting the right equipment and settings for their desired outcomes. Whether for artistic effect or scientific understanding, the principles discussed here form the backbone of optical imaging and photography.

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