SECTION 6.1 – Reflection and the Law of Reflection

Explore Notes

Opening

How does a mirror determine where light travels after striking its surface? Every reflection follows a precise geometric rule. Understanding that rule allows us to predict exactly how light behaves.

Objectives

- I can identify and define the components of a reflection diagram (incident ray, reflected ray, normal, angles).
- I can measure angles of incidence and reflection from the normal using a ray diagram.
- I can apply the Law of Reflection ($\theta_i = \theta_r$) to calculate unknown angles.
- I can construct and analyze ray diagrams to predict how light reflects from flat mirrors.

Introduction

Light is electromagnetic energy that travels in straight lines called rays. When a ray strikes a smooth surface, it reflects in a predictable way. Angles are measured relative to a line drawn perpendicular to the surface called the normal.

The Law of Reflection states that the angle of incidence equals the angle of reflection: $\theta_i = \theta_r$.

Here, θ_i is measured between the incident ray and the normal, and θ_r is measured between the reflected ray and the normal.

Real-World Connection

Reflection is used in periscopes, rear-view mirrors, telescopes, laser alignment systems, and many optical instruments. Engineers rely on predictable reflection angles when designing devices that guide light.

Historical Context

The Law of Reflection was described in ancient Greek geometry. Later, Ibn al-Haytham used experimentation to study light behavior, helping establish optics as a scientific field.

Vocabulary

Light: Electromagnetic energy that allows us to see objects.

Ray: A straight line with an arrow that shows the direction light travels.

Reflection: The bouncing of light off a surface.

Incident Ray: The incoming ray that strikes a surface.

Reflected Ray: The outgoing ray that leaves a surface after bouncing.

Normal: A line drawn perpendicular to a surface at the point of contact.

Angle of Incidence: The angle between the incident ray and the normal.

Angle of Reflection: The angle between the reflected ray and the normal.

Specular Reflection: Reflection from a smooth surface where rays remain orderly.

Diffuse Reflection: Reflection from a rough surface where rays scatter.

Core Strategies

1. Measure From the Normal

Angles of incidence and reflection are always measured from the normal. If an angle is given from the mirror surface, convert it using $90^\circ - (\text{angle from surface})$.

2. Apply the Law of Reflection

The Law of Reflection states that $\theta_i = \theta_r$. Once the angle of incidence is known, the reflected angle must match it.

3. Use Symmetry

The incident and reflected rays are symmetric across the normal. The total angle between them equals $2\theta_i$.

4. Analyze Each Reflection Separately

For multiple mirrors, apply the Law of Reflection at each surface independently. Parallel mirrors preserve the angle relative to the normal.

Example 1

A light ray strikes a mirror at 38° from the normal. Determine the angle of reflection and sketch the ray diagram.

Example 2

A ray makes a 25° angle with the mirror surface. Determine the angle of incidence from the normal and sketch the reflection.

Example 3

The total angle between an incident and reflected ray is 140°. Determine the angle of incidence.

Example 4

A light ray enters a system of two parallel mirrors at an angle from the surface. Analyze how the angle changes at each reflection. Draw and label the full ray path.

Summary of Key Concepts

- Angles of incidence and reflection are always measured from the normal.
- The Law of Reflection states that $\theta_i = \theta_r$.
- Angles given from the mirror surface must be converted using $90^\circ - (\text{angle from surface})$.
- The total angle between incident and reflected rays equals $2\theta_i$.
- Each reflection in a multi-mirror system follows the same law independently.

Common Mistakes

- Measuring angles from the mirror surface instead of from the normal.
- Forgetting to convert surface angles to normal angles.
- Assuming the reflected angle changes magnitude.
- Failing to draw the normal before analyzing a diagram.
- Trying to combine multiple reflections instead of analyzing them step by step.

Practice

Vocabulary Review

1. Define the term *normal* and explain why it is important in reflection problems.

2. Describe the difference between an incident ray and a reflected ray.

3. Define specular reflection and give a real-world example.

4. Define diffuse reflection and explain how it differs from specular reflection.

5. What is the angle of incidence?

6. State the Law of Reflection using words and symbols.

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Conceptual Understanding

7. A ray strikes a mirror at 30° from the surface. Explain why the angle of incidence is not 30°.

8. Why must angles in reflection be measured from the normal instead of from the surface?

9. A ray strikes a mirror at 0° from the normal. Describe the path of the reflected ray.

10. Explain why the total angle between the incident and reflected rays equals $2\theta_i$.

11. Two parallel mirrors face each other. Explain why a ray reflecting between them maintains the same angle from the normal.

12. A student measures an angle from the mirror surface and uses it directly as the angle of incidence. Explain the mistake.

Single-Step Calculations

13. A light ray strikes a mirror at 62° from the normal. Find the angle of reflection.

14. A ray makes an 18° angle with the mirror surface. Determine the angle of incidence.

15. The angle of reflection is 73°. Determine the angle of incidence.

16. A ray strikes a mirror at 27° from the normal. What is the total angle between the incident and reflected rays?

17. The total angle between an incident ray and its reflected ray is 120°. Determine the angle of reflection.

Multi-Step Problems

18. A light ray strikes a mirror at 32° from the mirror surface. Determine the angle of incidence, the angle of reflection, and the total angle between the rays.

19. The total angle between an incident and reflected ray is 150°. Determine the angle of incidence, the angle of reflection, and the angle the ray makes with the mirror surface.

20. A ray enters a periscope system using two parallel mirrors. The ray strikes the first mirror at 35° from the surface. Trace the ray through both reflections and determine the final angle relative to the normal at the second mirror.

Solutions

1–6 Vocabulary

1. The normal is an imaginary line drawn perpendicular (90°) to the surface at the point where the ray strikes. It is important because all reflection angles are measured from this line.

2. The incident ray is the incoming light ray that strikes the surface. The reflected ray is the outgoing ray that leaves the surface after bouncing.

3. Specular reflection occurs when light reflects from a smooth surface and the reflected rays remain orderly and parallel. Example: a flat mirror.

4. Diffuse reflection occurs when light reflects from a rough surface and scatters in many directions. Unlike specular reflection, the reflected rays are not parallel.

5. The angle of incidence is the angle between the incident ray and the normal to the surface at the point of contact.

6. The Law of Reflection states that the angle of incidence equals the angle of reflection: $\theta_i = \theta_r$.

7–12 Conceptual

7. If the ray is 30° from the surface, the angle from the normal must be found by subtracting from 90°. $90^\circ - 30^\circ = 60^\circ$. The angle of incidence is 60°, not 30°, because reflection angles are measured from the normal.

8. The Law of Reflection compares angles measured relative to a perpendicular reference line (the normal). Measuring from the surface would not preserve the equality required by the law.

9. At 0° from the normal, the ray strikes straight on. Since $\theta_i = \theta_r$, the reflected ray travels straight back along the same path.

10. The incident and reflected rays are symmetric about the normal. Each makes an angle θ_i with the normal, so the total angle between them is $\theta_i + \theta_i = 2\theta_i$.

11. Parallel mirrors have parallel normal lines. Since $\theta_i = \theta_r$ at each reflection, the angle relative to the normal remains the same after each bounce.

12. The student measured from the surface instead of from the normal. The correct angle of incidence must be calculated as $90^\circ - (\text{angle from surface})$.

13–17 Single-Step Calculations

13. Given $\theta_i = 62^\circ$. By the Law of Reflection, $\theta_r = 62^\circ$.

14. Given 18° from the surface. Angle from normal: $90^\circ - 18^\circ = 72^\circ$. Angle of incidence = 72°.

15. Given $\theta_r = 73^\circ$. Since $\theta_i = \theta_r$, $\theta_i = 73^\circ$.

16. Given $\theta_i = 27^\circ$. Total angle between rays = $2\theta_i = 2(27^\circ) = 54^\circ$.

17. Total angle = 120°. $2\theta_i = 120^\circ$ $\theta_i = 60^\circ$ Angle of reflection = 60°.

18–20 Multi-Step Problems

18. Given 32° from the surface. Angle from normal: $90^\circ - 32^\circ = 58^\circ$. Angle of incidence = 58°. Angle of reflection = 58°. Total angle between rays = $2(58^\circ) = 116^\circ$.

19. Total angle = 150°. $2\theta_i = 150^\circ$ $\theta_i = 75^\circ$ Angle of reflection = 75°. Angle from surface = $90^\circ - 75^\circ = 15^\circ$.

20. First convert from surface: $90^\circ - 35^\circ = 55^\circ$. Angle of incidence at first mirror = 55°. Angle of reflection = 55°. Because the mirrors are parallel, the ray strikes the second mirror at 55° from the normal. Final angle relative to the normal = 55°.