Law of Reflection

Laboratory Experiment #2

By:

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Submitted to:

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ETS 1210C- Introduction to Photonics

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Objective:

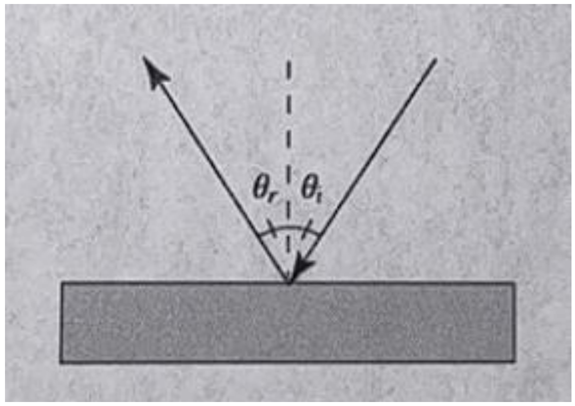
The experiment is being conducted to empirically verify the Law of Reflection, which states that the angle of incidence (θ_i) is equal to the angle of reflection (θ_r) when light rays strike a reflective surface. Through this experiment, by systematically adjusting the angle of incidence and measuring the corresponding angle of reflection, we aim to demonstrate this fundamental principle of optics. The objective is to reinforce the theoretical understanding of reflective properties of surfaces with practical, measured observations, thereby bridging the gap between theory and practice in photonics.

Materials:

- Optical Table (SG-22-2)
- IF-HN15M HeNe Laser (IFO)
- Rotation Stage (RSP-2)
- Two Post Holders (VPH-2)
- One Inch Diameter Adjustable Mirror Mounts (E55-532)
- Mirror Al 25mm (NT32-945)
- Screw Kit, ¼ x 20 (SK-25A)
- Aluminum Square Rule
- Protractor & Ruler

Background:

The background of the Law of Reflection experiment in photonics encompasses the fundamental principles of light behavior upon striking a reflective surface. The Law of Reflection is a core concept in both classical and modern optics, stating that when a light ray reflects off a surface, the angle of incidence (θ_i) is equal to the angle of reflection (θ_r). This law is succinctly expressed by the equation θ_i=θ_r.



(Figure 1) Angle of Reflection (θ_r) is equal with the angle of incidence (θ_i).

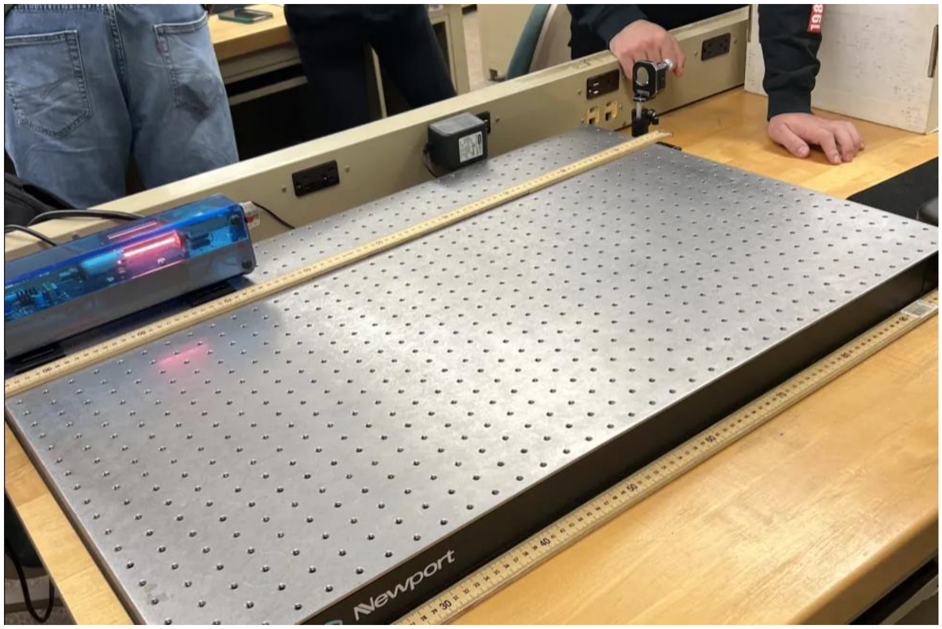
This experiment also touches upon the concept of the speed of light in different media. In a vacuum, light travels at its maximum speed, denoted by the letter 'c'. When light passes through any other medium, such as air, water, or glass, its speed decreases due to the medium's refractive index (n), which is the ratio of c to the speed of light in the medium. The refractive index is responsible for the bending of light, or refraction, when it passes from one medium to another with a different refractive index.

Reflection and refraction are governed by Snell's Law in optically denser or rarer media. However, in this experiment focused on reflection, we primarily consider the behavior of light as it interacts with a reflective surface under the same medium, typically air in a laboratory setting.

The experimental setup is designed to measure and confirm the equality of the angles of incidence and reflection, thereby providing practical confirmation of the theoretical law. This understanding is crucial for applications in designing optical devices, understanding the behavior of light in various environments, and serves as a fundamental principle in the field of photonics.

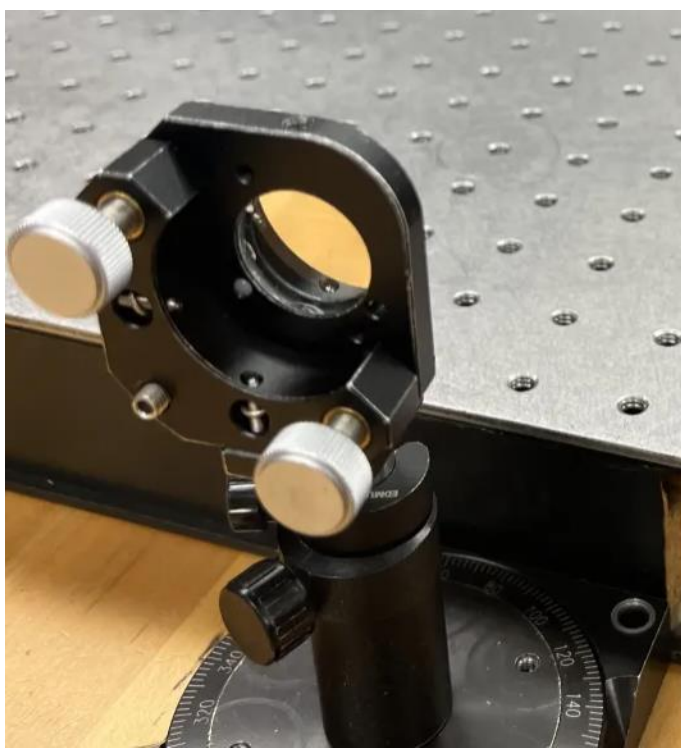
<u>Procedure:</u>

1. Set up the optical table near a wall, ensuring it is level and stable. Arrange the HeNe laser on the table so that it points horizontally toward the wall. The edge of the laser box should align with the holes pattern on the optical table for stability.



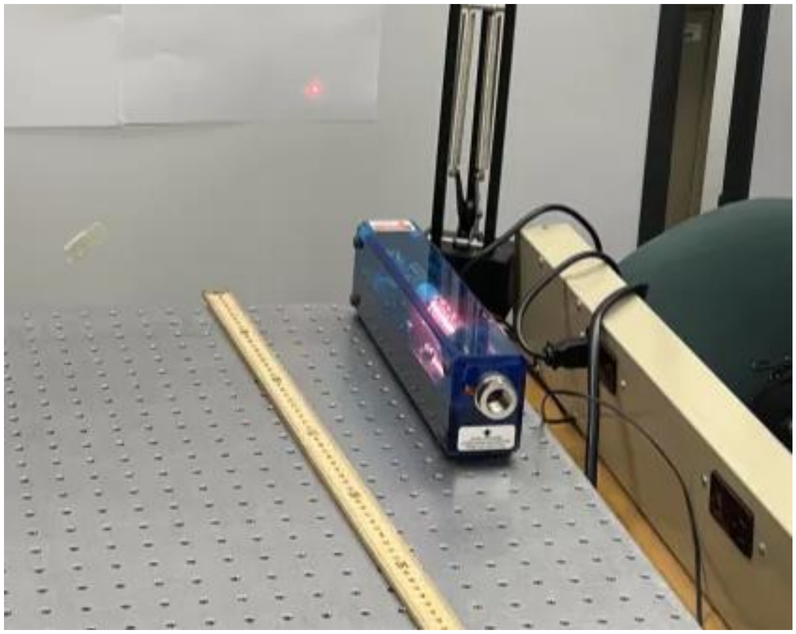
(Figure 2) Setting up optical table near the wall.

2. Securely mount a 25mm mirror in the adjustable mirror holder. Place the mirror holder on the opposite end of the table, on top of the rotation stage, which allows for precise angular adjustment. The rotation stage itself should be firmly placed on the bench to avoid any movement during the experiment.



(Figure 3) Mirror securely mounted on the holder.

3. Turn on the HeNe laser. The beam should strike the mirror directly at its center. Adjust the position of the mirror if necessary.



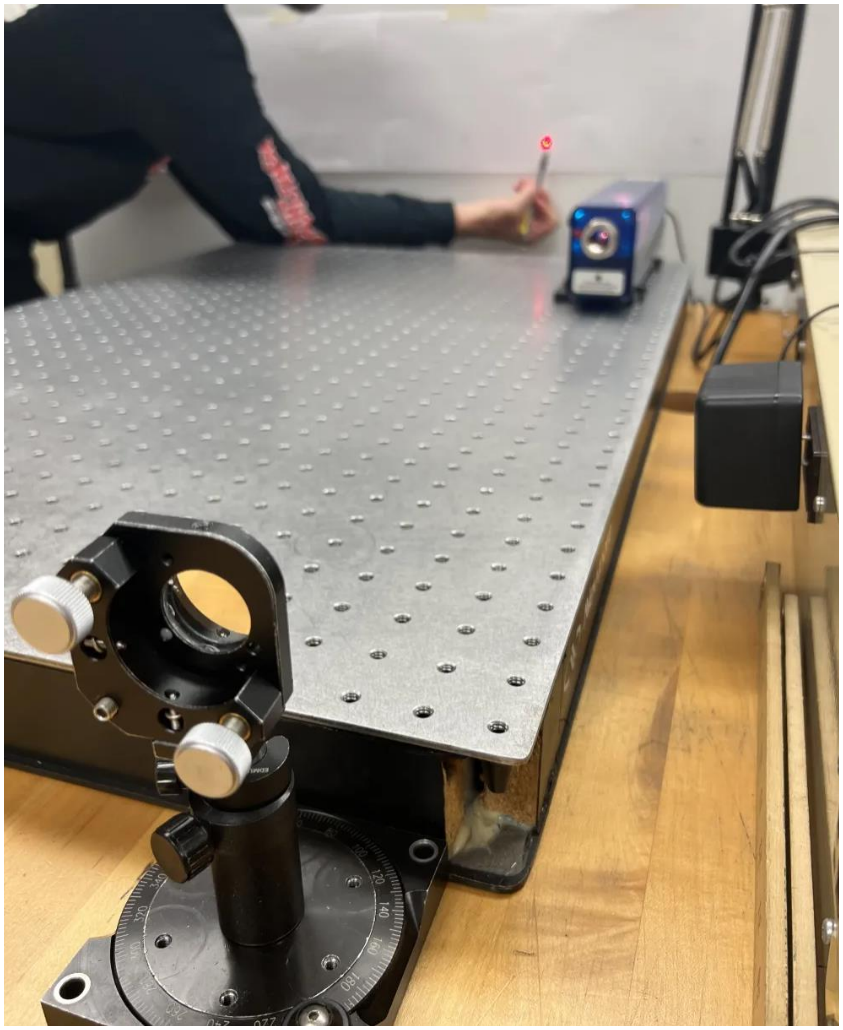
(Figure 4) Laser reflecting right above itself.

4. Place a whiteboard or a large sheet of paper on the wall where the reflected laser beam will hit. This will be your screen to observe the reflected beam.

(Figure 5) Placing paper on white board.

5. Mark the initial position of the laser beam on the screen before it hits the mirror. This mark represents the incident beam.

6. Rotate the mirror in 4-degree increments using the rotation stage, each time marking the new position of the reflected beam on the screen. This demonstrates the movement of the reflected beam as the angle of incidence changes.



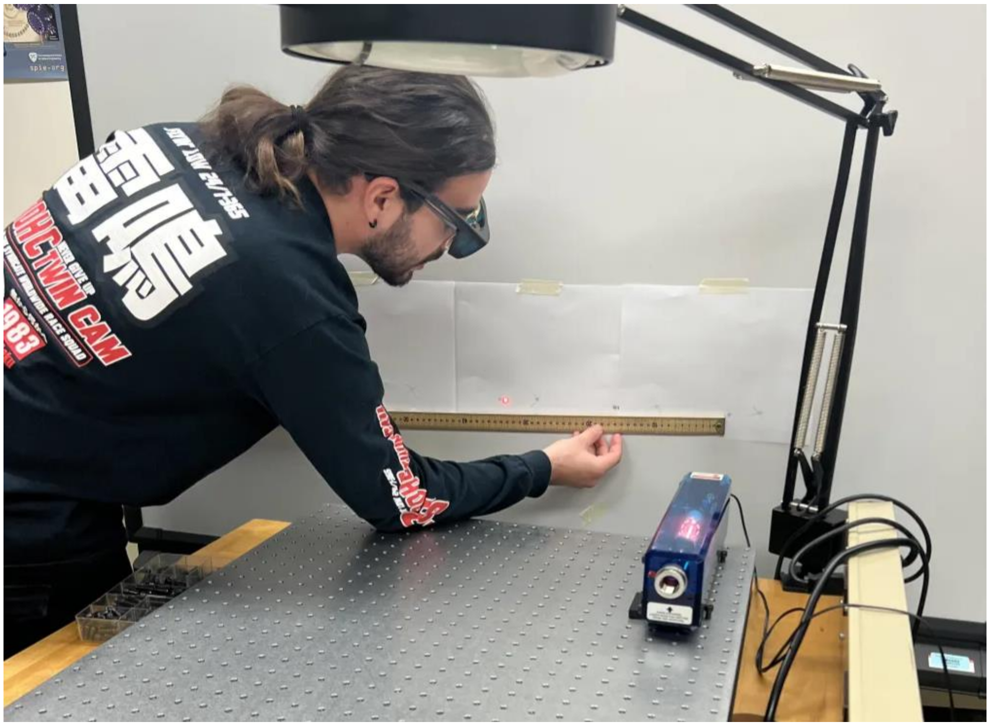
(Figure 6) Rotating the mirror and marking the next position.

7. After each adjustment, measure the distance from the laser to the mirror (d) and the distance from the initial position to the reflected spot on the screen (x). Record these measurements in Table 1 provided in the lab report.

8. Using the measurements, calculate the angle of incidence (θ_i) using the formula:

$$\theta_n = \tan^{-1}\left(\frac{x}{d}\right)$$

Then, calculate the angle of reflection (θ_r) for each rotation of the mirror.



(Figure 7) Measuring (x).

9. Observe and note any discrepancies between θ_i and θ_r, which may arise due to measurement or setup errors.

10. Finally, compile your observations to discuss the verification of the Law of Reflection and reflect on any factors that could have affected the accuracy of your measurements.

Data and Observations:

Table 1

d [cm]	x[cm]	θ_i *[Degrees]*	θ_n *[Degrees]*	θ_r *[Degrees]*
120	15.8	4	7.5	3.5
	33.5	8	15.6	7.6
	52.5	12	23.63	11.63
	74.1	16	31.7	15.7
	98.5	20	39.38	19.38

Calculations example:

$$\theta_n = \tan^{-1}\left(\frac{x}{d}\right)$$

$$\theta_n = \ tan^{-1}\left(\frac{15.5}{120}\right) = 7.5^o$$

$$\theta_r = \theta_n - \theta_i$$

$$\theta_r = 7.5^o - 4^o = 3.5^o$$

The discrepancies observed in the measured data can be attributed to a variety of experimental factors. Precision in aligning the laser, the mirror, and the rotation stage is critical; even slight deviations can lead to significant differences in the measured angles. The surface quality of the mirror may also play a role; imperfections can cause scattering or diffraction of the laser beam, resulting in less precise reflections. Additionally, human error in reading the ruler and in marking the laser spot can contribute to inaccuracies.

Answers to Lab Questions:

13. What relation should be between θ_i and θ_r according to Reflection Law?

According to the Law of Reflection, the relation between the angle of incidence (θ_i) and the angle of reflection (θ_r) should be such that they are equal. This means:

$$\theta_i = \ \theta_r$$

This law holds for a perfect, ideal reflective surface where the incident light and reflected light are in the same plane, and the surface of reflection is smooth. In the context of the lab, despite practical discrepancies due to measurement or setup errors, this relation should still approximately hold true, and any deviations should be minimal.

Conclusion:

The Law of Reflection experiment aimed to demonstrate the fundamental principle that the angle of incidence (θ_i) is equal to the angle of reflection (θ_r). The results, while generally following the trend predicted by the Law of Reflection, exhibited some discrepancies between the measured angles of incidence and reflection.

The experiment did yield results that align broadly with the theoretical expectations, confirming the proportional relationship between θ_i and θ_r. However, the exact one-to-one correspondence as dictated by the law was not perfectly observed. This slight divergence from the expected outcome suggests the presence of systematic or random errors in the experiment.

The interpretation of these results points to the intricacies of practical experimentation, where ideal conditions are approximated rather than perfectly met. The observed discrepancies could be due to factors such as measurement precision, alignment of the optical components, or environmental disturbances, rather than a failure of the law itself.

From this experiment, it has been learned that meticulous attention to detail is crucial in optical experiments, and even small misalignments or measurement errors can significantly impact the results. For future work or improvements, it is recommended to conduct multiple trials to average out any random errors and to utilize more precise measuring tools if available. Additionally, ensuring the experimental setup is isolated from vibrations and air currents can improve the accuracy of the results. This experiment serves as a valuable lesson in the challenges of translating theoretical physics into practice and the importance of experimental technique.