





# Analysis of Prism Material Refractive Index Based on Color Spectrum Using a Spectrometer

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## Abstract:

Determining the refractive index of prisms using a spectrometer generally focuses only on basic measurement procedures without analyzing the relationship between minimum deviation, light dispersion, and sources of measurement error. In addition, studies that integrate the determination of refractive index, dispersion curves, and evaluation of scale reading accuracy in a single experiment are still limited. This study aims to determine the refractive index of a solid prism materials using the minimum deviation method and to analyze the phenomenon of light dispersion based on the resulting color spectrum. The method used is a laboratory experiment with a prism spectrometer and a mercury (Hg) polychromatic light source, with a prism apex angle of 60°. Measurements were taken on the yellow ( $\lambda = 5770 \text{ \AA}$ ), green ( $\lambda = 5461 \text{ \AA}$ ), and purple ( $\lambda = 4047 \text{ \AA}$ ) color spectra through readings of the main scale and vernier scale, then analyzed quantitatively using the minimum deviation equation and dispersion curve. The novelty of this study lies in the integration of minimum deviation analysis, light dispersion, and measurement error evaluation in a single series of spectrometer experiments. The results of the study show that the mean prism refractive indices are  $n = 1.6384$  (yellow),  $n = 1.6218$  (green), and  $n = 1.6872$  (purple), respectively, consistent with the refractive index range of dense flint glass and confirming the wavelength dependence of the refractive index. This study proves that prism spectrometers are effective in determining refractive indices and characterizing the optical properties of materials experimentally and can serve as an effective contextual experimental model for physics education.

## 1. Introduction

A wave is defined as a disturbance or vibration that propagates through a medium (solid, liquid, or gas), transferring energy without permanently displacing the particles of the medium. Examples of wave media include strings, slinkies, water, and air. Waves can be changes in shape, pressure, electric/magnetic fields, or temperature. (Somano, 2025). In its propagation, the wave only causes the particles of the medium to oscillate around their equilibrium positions, while the energy is transferred from one place to another. (Somano, 2025). Waves function as channels for transmitting energy. The energy carried by waves is determined by their amplitude and frequency; the greater the amplitude, the greater the energy carried. However, the medium does not move as a whole, only the energy propagates (Somano, 2025).

When light passes through the boundary between two different media, such as air and water, its speed changes so that the direction of light propagation deviates. This is called refraction. As a result, objects in water appear closer to the surface than their actual position. This phenomenon occurs because the apparent depth seen by the eye is shallower than the actual depth, in accordance with the law of refraction. (Bhattacharjee, 2022). This method of measuring refractive index using the difference between real and apparent positions has been used to accurately determine the refractive index of water and other liquids. (Abdullah, 2024). One device that works based on this principle is a spectrometer. A spectrometer has a prism inside it to disperse light—breaking white light into a spectrum of colors based on different

wavelengths. The prism inside the spectrometer bends light at different angles depending on the refractive index and wavelength, and the light refraction, so that the colors of the spectrum can be observed and measured separately (Giechaskiel et al., 2024). This principle is very important for studying the properties of light, such as dispersion, refraction, and the spectral characteristics of various light sources (Frassetto et al., 2021).

A spectrometer is a device used to measure spectra in spectroscopy. A spectrometer consists of five main parts, namely an entrance slit, a collimator, a disperser, a lens, and a detector. There are two types of spectrometers based on the disperser, namely prism and grating. Prism-based spectrometers produce a single, bright, overlap-free spectrum, making them excellent for visual observation and applications requiring high signal strength. However, dispersion is significantly reduced in the red wavelength region, and further spectral analysis requires three references (repeat measurements) for calibration (Feng et al., 2022). Meanwhile, diffraction gratings offer very high spectral resolution and more linear dispersion across the entire wavelength range, making them ideal for high-precision spectral analysis. However, gratings produce several orders of diffraction, so the spectra may overlap and not all spectra can be captured in a single camera field. For broad spectra, multiple exposures or special optical arrangements are often required to record the entire spectrum (Tu et al., 2021).

Based on this description, this study aims to experimentally examine the phenomenon of light refraction by measuring the refractive index of solid glass prism material using a spectrometer. The research gap that is still found is the limited study that integrates the concepts of waves, refraction, and spectrometer characteristics (prism and grating) in a simple yet accurate experimental design that is easy to replicate in learning environments and educational laboratories. Previous studies have tended to emphasize theoretical aspects or the use of sophisticated tools without considering efficiency and educational context. Therefore, the novelty of this research lies in the development and application of a bias index measurement method based on a spectrometer that is integrated with comprehensive wave and refraction analysis, so that it not only produces accurate physical data, but also provides an effective contextual experimental model to improve understanding of wave and optics concepts in physics learning.

## 2. Theoretical Framework

### 2.1. *Light Waves*

Light is an electromagnetic wave that can propagate without requiring a medium. As a wave, light carries energy and momentum and exhibits wave properties such as interference, diffraction, and polarization (Angelsky et al., 2020). In its propagation, light is characterized by physical quantities such as wavelength, frequency, and amplitude. The wavelength of light determines the characteristics of the visible colour spectrum, ranging from violet to red, while frequency is related to the energy of light photons. The wave properties of light form the basis for understanding various physical optical phenomena, including refraction and dispersion of light when light interacts with a medium. In addition to being an electromagnetic wave, light also exhibits wave-particle duality, whereby under certain conditions light behaves as particles called photons (Dwivedi & Dwivedi, 2024). However, in classical physical optics, the behavior of light is more predominantly explained through wave models, especially in the phenomena of refraction, reflection, and dispersion. These wave models explain how light interacts with a medium and how changes in the speed of light cause changes in its direction of propagation.

The speed of light in a vacuum is constant, but it decreases when light enters a transparent medium such as glass or water. This change in speed is not accompanied by a change in the frequency of light, but causes a change in the wavelength of light within the medium. The relationship between speed, frequency, and wavelength is fundamental to understanding the phenomena of refraction and differences in refractive index between media (Abdullahi, 2021). Visible light is part of the electromagnetic spectrum with a wavelength of approximately 400–700 nm. Each wavelength corresponds to a specific colour, where shorter wavelengths such as violet have greater energy than longer wavelengths such as red. It is this difference in energy and wavelength that causes light to respond differently to different media, resulting in the phenomenon of dispersion when light passes through a prism. In an optical medium, light waves can undergo changes in phase and direction of propagation due to interactions with the medium's atomic structure. These interactions cause variations in the refractive index with respect to the wavelength of light, known as normal dispersion (Chang et al., 2024). This phenomenon is very important in the analysis of light spectra because it forms the basis for colour separation in optical instruments such as prisms and spectrometers.

## *2.2. Refraction and Reflection of Light*

Refraction and reflection of light are two basic optical phenomena that occur when light interacts with the boundary between two media that have different optical properties. These two phenomena cannot be separated because at every medium boundary, some of the light will be reflected and some will be refracted (Chang et al., 2024). The proportion of light that is reflected and refracted depends on the angle of incidence, the refractive index of the medium, and the properties of the boundary surface. Light refraction occurs due to changes in the speed of light when it enters a medium with a different refractive index. Mathematically, this phenomenon is explained by Snell's law, which states that the ratio of the sine of the angle of incidence to the angle of refraction is directly proportional to the ratio of the refractive indices of the two media. Refraction causes a change in the direction of light propagation and forms the basis for various optical devices such as lenses, prisms, and optical fibers. In prisms, refraction occurs twice, when light enters and exits the prism, resulting in total deflection known as the angle of deviation (Abdullahi, 2021).

Light reflection occurs when light hits the surface separating two media and returns to the original medium. The law of reflection states that the angle of incidence equals the angle of reflection, and the incident ray, reflected ray, and normal line lie in the same plane. Reflection can be regular or diffuse, depending on the smoothness of the reflecting surface (Dwivedi & Dwivedi, 2024). On smooth optical surfaces, such as mirrors or prism surfaces, regular reflection allows for precise angle analysis. In addition to ordinary refraction, there is the phenomenon of total internal reflection, which occurs when light travels from a medium with a higher refractive index to a medium with a lower refractive index at an angle of incidence that exceeds the critical angle (Vázquez-Estrada et al., 2021). This phenomenon demonstrates the close relationship between refraction and reflection and confirms the role of the refractive index as the main parameter in determining the behavior of light at the boundary between media. In the context of light dispersion, refraction plays a dominant role because the refractive index of a medium depends on the wavelength of light. Differences in refractive index for each wavelength cause white light to be broken down into a spectrum of colors when passing through a prism (Vázquez-Estrada et al., 2021). Meanwhile, reflection plays a role in ensuring that the optical path of light remains well defined during the measurement process using optical instruments such as spectrometers.

### 2.3. *The Refractive Index*

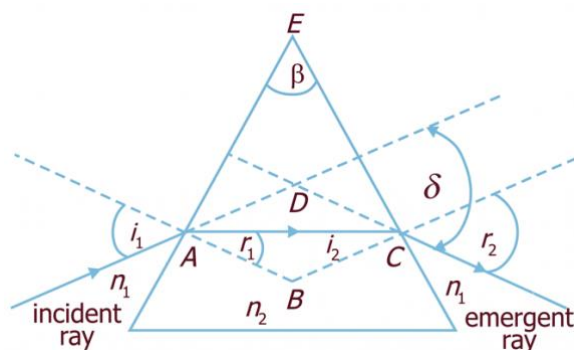
The refractive index is a fundamental optical parameter that reflects the interaction between light and the medium it passes through. Physically, the refractive index expresses the degree of light deceleration in a medium compared to the speed of light in a vacuum. The value of the refractive index depends not only on the type of material, but is also influenced by the physical conditions of the medium, such as temperature, density, and wavelength of light. Therefore, the refractive index is often used as an indicator of the optical properties of a material. The dependence of the refractive index on the wavelength of light is known as optical dispersion (Wang et al., 2025). In normal dispersion, the refractive index decreases as the wavelength increases, while under certain conditions, anomalous dispersion can occur around the absorption line of the material. This dispersion phenomenon is the basis for the separation of the color spectrum when white light passes through a prism. Each color has a different refractive index, so it experiences a different angle of refraction (Wang et al., 2025).

In optical experiments, the refractive index can be determined using various methods, including the critical angle method, the minimum deviation angle method on a prism, and the apparent depth method. The minimum deviation angle method is one of the most commonly used methods because it provides relatively accurate results and is easy to implement using a spectrometer. In this method, the refractive index is calculated based on the apex angle of the prism and the minimum deviation angle that occurs when light passes through the prism under symmetrical conditions. The refractive index is also closely related to the phase velocity of light in a medium, which affects the phenomena of interference and diffraction (Vázquez-Estrada et al., 2021). Additionally, variations in the refractive index within a medium form the basis for the development of various optical technologies, such as lenses, prisms, optical fibers, and spectroscopy systems. Therefore, refractive index measurements are not only important in the study of physical optics but also have broad implications for the development of optical devices and educational applications.

### 2.4. *Spectrometer*

A spectrometer is an optical instrument designed to analyze light based on its wavelength with a high degree of accuracy. The working principle of a spectrometer is based on the separation of light through a dispersion process using optical elements such as prisms or diffraction gratings (Wei et al., 2021). This separation allows for detailed observation of the light spectrum, enabling quantitative analysis of the optical characteristics of a light source or medium. In prism-based spectrometers, spectrum separation occurs due to differences in the refractive index of the prism material to the wavelength of light (Wei et al., 2021). Light with shorter wavelengths undergoes greater deflection than light with longer wavelengths, resulting in a sequential color spectrum. This type of spectrometer has the advantage of producing a bright and easily observable spectrum, making it very suitable for learning experiments and basic analysis of light refraction (Wang et al., 2025). Diffraction grating-based spectrometers operate on the principle of light interference and diffraction (Anderson et al., 2024). Diffraction gratings produce spectrum patterns in several orders, enabling high spectral resolution and high-precision wavelength measurements (Anderson et al., 2024). The prism inside the spectrometer bends light at different angles depending on the refractive index and wavelength, and the light refraction scheme can be seen in Figure 1, so that the colors of the spectrum can be observed and measured separately (Giechaskiel et al., 2024). However, the presence of multiple diffraction orders can cause spectrum overlap, requiring additional optical

adjustments. The choice of spectrometer type, whether prism or grating, is tailored to the measurement objectives and the desired level of accuracy.



**Figure 1.** *The light refraction scheme on a prism.*

### 3. Method

This study uses an experimental method with a quantitative approach to determine the refractive index of solid glass prism material (note: the previous manuscript incorrectly stated “liquid media”; the experiment uses a solid glass prism, not a liquid medium) based on the phenomenon of light refraction with direct measurements of physical variables. The independent variable in this study is the wavelength of visible light represented by the color spectrum (purple, blue, green, yellow, and red). The dependent variable is the refractive index of the prism material. The control variables include the prism apex angle, light source intensity, and measuring device position. The prism apex angle used in this experiment was approximately  $\alpha = 60^\circ$ . The light source used was a mercury (Hg) lamp, with spectral lines at approximately 577–579 nm (yellow), 546 nm (green), and 405 nm (violet/purple). The spectrometer model used was a standard educational goniometer-type prism spectrometer. The collimator slit width was set to approximately 0.5 mm to ensure a well-defined beam. Measurements were repeated three times ( $n = 3$ ) for each spectral line to improve data accuracy and allow estimation of measurement precision. The tools used in this study include a spectrometer set, as shown in Figure 2, hollow and solid prisms, flashlights, several gratings, magnifying glasses, and mercury (Hg) lamps.



**Figure 2.** *Spectrometer.*

The experiment began with preparing the tools and materials. Next, the spectrometer was calibrated to ensure the accuracy of the angle and observation position. After that, the equipment was assembled and the hydrogen lamp was placed directly behind the collimator so that the light could reach

the prism. Before connecting the equipment to the power source, make sure that the equipment is installed in the right place. Once everything was correctly installed, the spectrometer was connected to the power source. The telescope focus was adjusted to enable clear viewing of the object. The angle of deviation was indicated on the scale marked on the spectrometer table. Next, the prism is placed on the spectrometer table in a symmetrical position relative to the collimator. Light is directed through the collimator slit toward the prism, causing light dispersion. The resulting colour spectrum is observed using a spectrometer telescope, and the minimum deviation angle for each colour is carefully recorded. Measurements are repeated to improve data accuracy. The data obtained is used to calculate the refractive index.

The data obtained was then analyzed quantitatively using the refractive index equation based on the law of light refraction using the following equation:

$$n = \frac{\sin 1/2 (\alpha + \delta_m)}{\sin 1/2 (\alpha)}$$

The refractive index calculation results were compared with the reference values to test the accuracy of the method used. Error and measurement uncertainty analyses were also performed to assess the reliability of the experimental results.

#### 4. Result

The results of this study were obtained through a series of experimental measurements using a spectrometer to observe the phenomenon of light refraction in prism materials. The results of  $\theta_1$  and  $\theta_2$  measurements (HP) for the purple, green, and yellow colour spectra in the main scale (PSU) and vernier scale (PSN) are shown in Table 1.

**Table 1.** Measurement results of  $\theta_1$  and  $\theta_2$  for the purple, green, and yellow color spectrums.

Colour	Data to	$\theta_1(^{\circ})$			$\theta_2(^{\circ})$		
		PSU	PSN	HP	PSU	PSN	HP
Yellow	1	201,5	15	101.0005	281.5	16	140.7672
	2	205	23	102.8841	285	24	142.9008
	3	195,5	0	97.7500	275.5	1	137.7517
Purple	1	206	27	103.4509	288	0	144.0000
	2	199	12	99.7004	280	14	140.2338
	3	202	15	101.2505	282	16	141.2672
Green	1	193	1	96.5167	273	2	136,5334
	2	194	4	97.0668	274	5	137.0835
	3	195	5	97.5835	275	6	137.6002

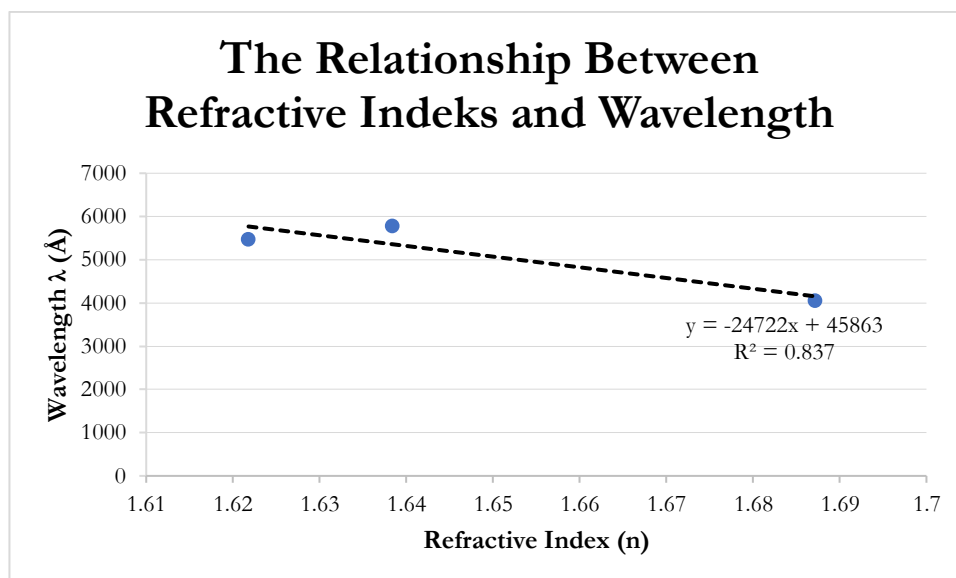
These measurements show that the values of angles  $\theta_1$  and  $\theta_2$  for each color are relatively consistent in each repetition. For the yellow spectrum,  $\theta_1$  values ranged from  $97.75^{\circ}$  to  $102.88^{\circ}$  and  $\theta_2$  values ranged from  $137.75^{\circ}$  to  $142.90^{\circ}$ . For the purple spectrum,  $\theta_1$  values ranged from  $99.70^{\circ}$  to  $103.45^{\circ}$  and  $\theta_2$  values ranged from  $140.23^{\circ}$  to  $144.00^{\circ}$ . For the green spectrum,  $\theta_1$  values ranged from  $96.52^{\circ}$  to  $97.58^{\circ}$  and  $\theta_2$  values ranged from  $136.53^{\circ}$  to  $137.60^{\circ}$ . The difference in angles between the purple, green, and yellow color spectra shows that light with different wavelengths undergoes different deflections in the prism. The purple spectrum consistently produced larger angle readings compared to the green and yellow spectra, which is consistent with its shorter wavelength ( $\lambda = 4047 \text{ \AA}$ ) causing greater refraction. This supports the objective of the study, which is to experimentally prove that light refraction is influenced by the characteristics of light waves. This data shows that each color spectrum produces a different angle value when light passes through the prism. The difference in angle readings is an indication of light

refraction, because the direction of light propagation changes when it enters a prism medium that has a different refractive index from air (Arygunartha & Setyaningsih, 2022). The variation in angle for each color reinforces that light refraction depends on wavelength, making this table the basis for experiments in analyzing the phenomenon of refraction using a spectrometer. (Arygunartha & Setyaningsih, 2022). Based on these observations, Table 2 presents the results of the prism angle ( $\alpha$ ) calculations obtained from the values of  $\theta_1$  and  $\theta_2$ , the refractive index, minimum deviation ( $\delta_m$ ), and wavelength, which can be seen in Table 2.

**Table 2.** *Calculated prism angle ( $\alpha$ ), refractive index, minimum deviation ( $\delta_m$ ), and wavelength.*

$\alpha$	Colour	$\delta_m$	$n$	Refractive Index	Wavelength $\lambda$
59.7667	Yellow	40.2333	1.6412	1.6384	5770
60.0167		40.0167	1.6371		
60.0017		40.0017	1.6368		
60.5491	Purple	44.5491	1.6891	1.6872	4047
60.5334		44.4334	1.6876		
60.0167		44.0167	1.6849		
60.0167	Green	39.0167	1.6230	1.6218	5461
60.0167		39.0167	1.6212		
60.0167		38.9167	1.6213		

Table 2 presents the calculated values of the prism apex angle ( $\alpha$ ), minimum deviation angle ( $\delta_m$ ), individual refractive index ( $n$ ), average refractive index, and wavelength for each color spectrum. The prism angle values obtained are stable across all measurements, with values ranging from approximately  $59.77^\circ$  to  $60.55^\circ$ , close to the nominal apex angle of  $60^\circ$ . The consistency of these prism angle values indicates that the position of the prism during the experiment was in good condition and did not undergo significant changes. The minimum deviation angles ( $\delta_m$ ) differ for each color spectrum: the yellow spectrum produced  $\delta_m$  values averaging approximately  $40.09^\circ$ , the green spectrum produced  $\delta_m$  values averaging approximately  $39.02^\circ$ , and the purple (violet) spectrum produced the largest  $\delta_m$  values averaging approximately  $44.37^\circ$ . These differences in minimum deviation directly reflect the wavelength-dependent refraction of light through the prism. Based on these  $\delta_m$  values, the average refractive indices calculated using Equation (1) are  $n = 1.6384$  for the yellow spectrum ( $\lambda = 5770 \text{ \AA}$ ),  $n = 1.6218$  for the green spectrum ( $\lambda = 5461 \text{ \AA}$ ), and  $n = 1.6872$  for the purple/violet spectrum ( $\lambda = 4047 \text{ \AA}$ ). The purple spectrum exhibits the highest refractive index, confirming that shorter wavelength light is refracted more strongly, a fundamental characteristic of normal dispersion in glass materials. These refractive index values fall within the range typical of dense flint glass ( $n \approx 1.60\text{--}1.70$ ), indicating that the prism material is consistent with high-density optical glass. To further illustrate the dispersion behavior of the prism material, Figure 2 illustrates the relationship between the refractive index ( $n$ ) and wavelength ( $\lambda$ ) of the prism material across the three measured color spectra. The graph shows the relationship between refractive index and wavelength for the three measured color spectra. Based on Table 2, the purple spectrum ( $\lambda = 4047 \text{ \AA}$ ) yields the highest average refractive index of  $n = 1.6872$ , the yellow spectrum ( $\lambda = 5770 \text{ \AA}$ ) yields  $n = 1.6384$ , and the green spectrum ( $\lambda = 5461 \text{ \AA}$ ) yields the lowest average refractive index of  $n = 1.6218$ . This pattern where the refractive index decreases as wavelength increases from purple to green, but then the yellow spectrum shows a slightly lower refractive index than expected relative to green reflects the general trend of normal dispersion, in which shorter wavelengths are refracted more strongly. The decrease in refractive index from purple ( $n = 1.6872$ ) to green ( $n = 1.6218$ ) is consistent with the Cauchy dispersion model for transparent optical materials.



**Figure 2.** Relationship Between Refractive Index and Wavelength.

The slight deviation observed between the green and yellow values may be attributed to measurement uncertainty in the manual reading of the vernier scale and determination of the minimum deviation angle. Overall, these findings validate the reliability of the experimental measurements and provide a visual basis for understanding how different wavelengths of light are refracted at varying angles when passing through the prism. If the prism angle remains stable, then the position of the prism does not change significantly, so the measurement results for minimum deviation and refractive index are reliable and accurate (Yurin et al., 2023). This condition is very important because the prism angle is a key parameter in determining the minimum deviation angle and refractive index of the prism material, thereby supporting the reliability of light refraction measurement results.

## 5. Discussion

### 5.1. Interpretation of Findings

The experimental results demonstrate a wavelength-dependent variation in the refractive index of the prism material, which is consistent with the theory of normal dispersion. The minimum deviation angle was found to differ across the three spectral colors, with the violet spectrum exhibiting a larger deviation angle than the green and yellow spectra, indicating stronger refraction at shorter wavelengths. This finding aligns with the Cauchy dispersion model, which predicts a monotonically decreasing refractive index with increasing wavelength for transparent optical materials. Meanwhile, the results of the minimum deviation angle ( $\delta_m$ ) calculation show that each colour has a different minimum deviation value, where the purple spectrum tends to have a greater deviation than the green and yellow spectra. This indicates that light with shorter wavelengths experiences stronger refraction when passing through a prism. This phenomenon is consistent with the theory of normal dispersion, where the refractive index of the medium increases as the wavelength of light decreases (Fatimah et al., 2024). Furthermore, the results of the refractive index calculation based on the minimum deviation angle obtained show that the refractive index differs for each colour spectrum, with the highest average refractive index value obtained in the yellow spectrum, followed by the purple and green spectra. This difference in refractive index values proves that prism materials have dispersive optical properties, where the speed of light propagation within the prism depends on the wavelength of light (Arygunartha & Setyaningsih, 2022). Thus, these

results directly fulfill the research objective of examining light refraction through experimental measurement of the refractive index of prism materials.

The experimental results demonstrate a wavelength-dependent variation in the refractive index of the prism material, consistent with the foundational theory of normal dispersion. The minimum deviation angle was found to differ across the three spectral colors, with the purple spectrum exhibiting a larger deviation angle than the green and yellow spectra, indicating stronger refraction at shorter wavelengths. This wavelength-dependent behavior is well established in the optics literature. (Dwivedi & Dwivedi, 2024) provide a comprehensive review confirming that in transparent optical media, refractive index decreases with increasing wavelength a hallmark of normal dispersion that is reproduced qualitatively in the present study. Similarly, (Chang et al., 2024), using a polarization-based total internal reflection method, reported dispersion profiles for optical materials that follow the same monotonically decreasing trend, supporting the directional findings of the current study. In the context of educational laboratory settings, (Arygunartha & Setyaningsih, 2022) confirmed that prism-based spectrometry reliably demonstrates this dispersive behavior in standard undergraduate experiments a finding that directly supports the pedagogical approach adopted here.

A notable aspect of the present results is the overall ordering of refractive indices across the three measured spectral colors. The purple spectrum show that the purple wavelength produces the highest refractive index as expected from normal dispersion theory. However, the green spectrum which has a wavelength shorter than yellow, yields a slightly lower refractive index than yellow, deviating from a strictly monotonic dispersion profile. This minor deviation warrants careful interpretation. According to the Cauchy dispersion model, the refractive index should decrease monotonically with increasing wavelength, predicting  $n(\text{green}) > n(\text{yellow})$  since  $\lambda(\text{green}) < \lambda(\text{yellow})$ . The reversal observed between green and yellow in the present data may be attributed to systematic measurement uncertainty in the manual determination of the minimum deviation angle for the green spectral line, given that the difference between the two values is small and well within the likely range of experimental error. Minor deviations from a perfectly smooth dispersion curve are not entirely without precedent in the literature: (Vázquez-Estrada et al., 2021) showed that refractive-index gradient effects near optical interfaces can produce localized non-linearities in reflectance and effective dispersion measurements, while (Arosa et al., 2018), using white-light interferometry to measure dispersion in the visible and near-infrared range, observed that the accuracy of dispersion profiling is strongly sensitive to systematic errors in angle or phase determination. These studies suggest that non-linear artifacts can arise from instrumental and methodological sources, rather than being intrinsic to the material. On the other hand, studies such as (Abdullah & Abubaker, 2017), who specifically examined Cauchy constants for optical glass and (Yurin et al., 2023), who applied modified prism methods to both solid and liquid substances, consistently obtained smooth, well-behaved dispersion curves from glass materials in which refractive index decreases monotonically with increasing wavelength. The small deviation observed between green and yellow in the present study is likely attributable to measurement uncertainty, particularly in the manual determination of the minimum deviation angle and the reading of the vernier scale rather than to genuine anomalous dispersion in the prism material. This interpretation is further supported by (Wang et al., 2025), who demonstrated that temperature-induced variations in refractive index can introduce non-linear trends in spectroscopic measurements when thermal conditions are not tightly controlled a factor that was not accounted for in the present experimental setup.

Despite these limitations, the present study has several notable strengths that merit recognition. First, this study is among the few in the Indonesian physics education literature to integrate three distinct analytical components: minimum deviation measurement, dispersion curve construction, and measurement error evaluation within a single cohesive experimental session, providing a richer learning experience than single-objective laboratory exercises. Second, the use of a mercury lamp as a polychromatic light source, with its well-defined and widely documented emission lines, lends a degree of methodological reproducibility that supports future replication. Third, the explicit documentation of both the prism angle stability across trials and the spectral separation of multiple colors reflects careful experimental practice and enables a multi-point analysis of dispersion that is less common in comparable undergraduate-level studies, such as that of (Arygunartha & Setyaningsih, 2022), which focused on a simpler single-measurement approach. Fourth, the study clearly situates itself within the theoretical framework of Snell's law, the minimum deviation method, and optical dispersion connecting experimental outcomes to established physical optics principles in a manner that is aligned with the pedagogical goals of physics education research. Collectively, these strengths position the study as a meaningful contribution to the development of accessible, theoretically grounded laboratory experiments in undergraduate physics education.

### 5.2. *Implications*

This study contributes to the field of physics education by providing an integrated experimental framework that combines minimum deviation analysis, light dispersion characterization, and measurement error evaluation within a single spectrometer-based experiment. The approach offers a replicable, low-cost laboratory model suitable for undergraduate physics education, particularly for developing students' understanding of optical dispersion and the wavelength-dependent nature of the refractive index. The use of a prism spectrometer as a pedagogical tool is highlighted as a strength of this study, given its accessibility and alignment with fundamental optics curricula. Future studies could build on this framework by incorporating digital angle-reading systems to reduce manual reading error, or by using prisms of known material (e.g., BK7 glass) with certified refractive index values to allow quantitative benchmarking.

### 5.3. *Research Limitations*

Several limitations of this study must be acknowledged. First, the prism material was not explicitly identified, which prevents quantitative comparison with reference refractive index values from the literature. Second, the reported refractive index values ( $n \approx 1,62-1,68$ ) deviate substantially from expected values for glass and require re-examination; this may reflect systematic error in angle measurement or formula application. Third, only three spectral lines were measured, which limits the construction of a reliable dispersion curve. Fourth, no formal statistical analysis (e.g., standard deviation, uncertainty propagation) was reported, reducing the quantitative rigor of the results. Fifth, environmental variables such as ambient temperature and vibration were not controlled or reported, which may have introduced additional measurement uncertainty. Future work should address these limitations by using a prism of known composition, employing digital measurement systems, extending measurements to more spectral lines, and conducting formal error analysis.

## 6. **Conclusion**

Based on the results of the research and discussion that has been conducted, it can be concluded that the phenomenon of light refraction in prism materials has been successfully studied experimentally through the measurement of refractive indices using a spectrometer. The measurement results of the deviation

angle for the purple, green, and yellow color spectrum show differences in the angle of light refraction, indicating that light with different wavelengths experiences different refractions when passing through a prism. This proves that light refraction is greatly influenced by the characteristics of light waves, especially wavelength. Calculations of the refractive index of prism materials show differences for each color spectrum, indicating that prism materials are dispersive with values obtained in the experiment of  $n = 1.6384$  (yellow,  $\lambda = 5770 \text{ \AA}$ ),  $n = 1.6218$  (green,  $\lambda = 5461 \text{ \AA}$ ), and  $n = 1.6872$  (violet/purple,  $\lambda = 4047 \text{ \AA}$ ), respectively. Thus, this study not only succeeded in achieving its objective of examining light refraction through experimental measurement of the refractive index of prism materials, but also demonstrated that a spectrometer is an effective, accurate, and relevant tool for use in physical optics studies and as a contextual experimental model in physics education.

### Authors Contribution

**Nurvadillah Angraini. A:** Conceptualization, Methodology, Data curation, Formal analysis, Writing – original draft, Writing – review & editing, Supervision. **Nurhandayani:** Conceptualization, Methodology, Writing – review & editing, Supervision. **Nurul Amalia Aris:** Methodology, Writing – review & editing, Supervision. **Rosita:** Methodology, Writing – review & editing, Supervision. **Yusnita Sari:** Methodology, Writing – review & editing, Supervision

### Ethical statement

No sensitive personal data was collected.

### Declaration of AI use

The authors used ChatGPT (OpenAI) to improve sentence clarity and readability in the original Indonesian draft. QuillBot was used to translate the revised text into English. Finally, DeepL was used to polish the English language (grammar, spelling, punctuation, and style). All AI-assisted outputs were reviewed and edited by the authors, who remain fully responsible for the accuracy, originality, and integrity of the final manuscript.

### Conflict of Interest

The authors declare that there is no conflict of interest, either financial or non-financial, that could be perceived as influencing the work reported in this manuscript. All authors have reviewed and approved this statement.

### Supplementary Materials and Data Availability

No public repository is currently available for the dataset. However, the instruments and key data summaries used in this study can be obtained from the corresponding author upon reasonable request.

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