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A COMPARISON OF THE EFFECTIVENESS OF HOLLOW PRISM AND PARALLEL PLANS THE MEASUREMENT OF FLUDIA'S REFRESH INDEX: CASE STUDY ON AQUADES AND ALCOHOL

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***Abstract**. A refractometer is a tool used to measure the refractive index of fluids. However, there are several issues, including the considerable cost involved and the fact that not all school laboratories have this tool. Therefore, we conducted a study to compare the accuracy of refractive index values using a hollow prism and a plan parallel prism. Among the various methods available today, refraction is a relatively simple and cost-effective method for determining the refractive index of fluids. In measuring the refractive index of fluids, the use of containers or vessels is essential. Following a review of existing studies, two commonly used types of vessels were identified: the cube-shaped vessel (plan parallel) and the hollow prism. This research aims to compare the refractive index results obtained using a hollow prism and a plan parallel prism, using two samples-namely, distilled water (aquades) and alcohol-which have predetermined values in the refractive index table. The results indicate that the refractive index value for aquades using a plan parallel prism is 0.97, while with a hollow prism, it is 1.33, where the true refractive index value is 1.33. For alcohol, the results using a plan parallel prism are 0.91, and with a hollow prism, it is 1.35, where the true refractive index value is 1.36.*

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The conclusion drawn is that using a hollow prism yields refractive index values for both aquades and alcohol that closely approximate the true refractive index, compared to the use of a plan parallel prism.

Keywords*: hollow prism, plans parallel, refractive index*

Abstrak. Sebuah refraktometer adalah alat yang digunakan untuk mengukur indeks bias dari cairan. Namun, terdapat beberapa isu, termasuk biaya yang cukup besar dan kenyataan bahwa tidak semua laboratorium sekolah memiliki alat ini. Oleh karena itu, kami melakukan sebuah penelitian untuk membandingkan akurasi nilai indeks bias menggunakan prisma berongga dan prisma paralel datar. Di antara berbagai metode yang tersedia saat ini, refraksi adalah metode yang relatif sederhana dan cost-effective untuk menentukan indeks bias dari cairan. Dalam mengukur indeks bias dari cairan, penggunaan wadah atau bejana sangat penting. Setelah meninjau studi-studi yang ada, dua jenis wadah yang umum digunakan diidentifikasi: wadah berbentuk kubus (prisma paralel datar) dan prisma berongga. Penelitian ini bertujuan untuk membandingkan hasil nilai indeks bias yang diperoleh menggunakan prisma berongga dan prisma paralel datar, dengan menggunakan dua sampel yaitu air destilasi (aquades) dan alkohol yang memiliki nilai-nilai terdahulu dalam tabel indeks bias. Hasil menunjukkan bahwa nilai indeks bias untuk aquades menggunakan prisma paralel datar adalah 0,97, sedangkan dengan prisma berongga adalah 1,33, di mana nilai indeks bias sebenarnya adalah 1,33. Untuk alkohol, hasil menggunakan prisma paralel datar adalah 0,91, dan dengan prisma berongga adalah 1,35, di mana nilai indeks bias sebenarnya adalah 1,36. Kesimpulan yang diambil adalah bahwa penggunaan prisma berongga menghasilkan nilai-nilai indeks bias baik untuk aquades maupun alkohol yang mendekati nilai indeks bias sebenarnya, dibandingkan dengan penggunaan prisma paralel datar.
Kata kunci: bidang sejajar, indeks bias, prisma berongga

INTRODUCTION

Measurement of the refractive index of fluids is a crucial aspect in the refraction laboratory at schools. Highly accurate methods for measuring the refractive index are interferometric methods, including Mach-Zehnder interferometry, Fabry-Perot interferometry, and Michelson interferometry (Pedrotti et al., 2017).

However, these methods tend to be complex and time-consuming. The commonly used method involves a specialized tool, namely a refractometer, to accurately measure the refractive index. However, the high cost of this tool often poses a barrier, especially in the availability of the equipment in school laboratories. Therefore, we found an effective and efficient alternative solution by conducting experiments using two media, namely, plan parallel and hollow prism, to determine a more accurate refractive index.

In general, each medium has its own refractive index value, where the refractive index can be defined as the ratio of the speed of light between two media (Elisa, 2015). The refractive index holds significance in various fields such as fiber optics and thin films (Parmitasari, 2013). According to Muhammad Nasir (2020), the measurement of refractive index can determine the quality of oil. The results of his research indicate that the smaller the refractive index value, the better the quality of the oil (Nasir, 2020).

The refractive index can also be utilized to identify the composition and quality of a solution. For instance, research conducted by Yunus et al. (2009) indicates that the refractive index can be employed to ascertain the purity and expiration of oil (Mahmood Mat Yunus et al., 2009). In fluids, the refractive index values of light vary, and a higher density produces a larger refractive index (Mukhlis et al., 2021). In the field of spectroscopy, the refractive index can be utilized to interpret spectroscopic data. Meanwhile, the refractive index coefficient can be employed in the design of solid-state lasers (Singh, 2002).

Measurement of refractive index in the industry can be utilized to determine physical parameters such as concentration, temperature, pressure, and others (Govindan et al., 2009). According to Suhadi & Wiranda (2019), the simplest method for refractive index measurement is by using the refraction method. The research results show that when light passes through media of different types, the rays will be refracted, and the larger the angle of refraction, the larger the angle of incidence. The use of a plan parallel container with a thickness of 1 mm produces a refractive index that approaches the true value (Suhadi, 2019).

Another study uses a different container, a hollow prism. According to Idris, et al. (2016), the hollow prism is a container that produces refractive index values close to the actual table (Nasrullah Idris et al., 2017). The hollow prism undergoes two refractions like a regular prism, and the resulting deviation angle comes from the continuation of the incident ray and the second refraction of light (Saputra E R & Sucahyo Imam, 2015). Kasli & Royani (2016) state that the relationship between the refractive index value and the angle of refraction is inversely proportional when using a plan parallel container (Kasli & Royani, 2016).

In the development of science and technology, there is progress in the field of physics through research. In previous research, only a comparison of the refractive index with different types of fluids was conducted. In this research, the parameter used is comparing two previous studies, namely the research of Zamroni and the research of Idris, et al., by comparing the refractive index of fluids using a hollow prism and plan parallel. Zamroni (2013) used a plan parallel with a thickness of 1 mm and produced a refractive index value close to the actual value (Zamroni, 2013). According to Murniati (2023), the factors influencing the refractive index are the viscosity of the liquid, the speed of light propagation, temperature, and wavelength. If the solution becomes more viscous, the refractive index value increases. However, if the solution becomes more dilute, the refractive index value decreases (Evi Murniati & Miranda, 2023).

The principle used in this research is refraction, where light passes through two different media with different refractive indices. The refractive index is the ratio of the speed of light in the air to the speed of light in the substance itself. In alcohol and distilled water, there are differences in the refractive index values, and the aim of this research is to compare the results of the refractive index using a hollow prism and plan parallel with two samples, namely, distilled water and alcohol, which already have fixed values in the refractive index table.

Table 1. Table of Refractive Indices for Various Substances

Medium	Index
Alcohol	1,36
Water	1,33
Hydrogen	1,000132
Ice	1,31
Helium	1,000036
Ethyl	1,48

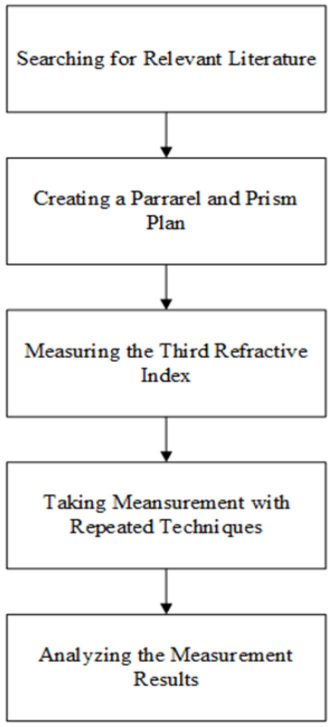
Glycerol	1,50
Benzene	1,46
Empety Air	1,000
Air at STP	1,0003
Glass	1,52
Carbon Dioxida	1,000132

Source : (Zamroni, 2013)

Our research aims to provide an alternative solution for accurately measuring the refractive index without the need for specialized equipment, such as a refractometer. Often, the high cost of this equipment poses a barrier to its availability in schools. In this study, we compare the findings of previous research conducted by Zamroni (2013) on the effectiveness of measuring the refractive index of fluids using a Plan Parallel with the research conducted by Nasrulloh (2017) on the effectiveness of hollow prisms in measuring the refractive index of fluids. Applying the principles of refraction, we compare the effectiveness of hollow prisms and plan parallel, as demonstrated through experimental results measuring the refractive index of alcohol and distilled water. The outcomes of this research are expected to provide a practical solution that can be implemented in schools.

RESEARCH METHOD

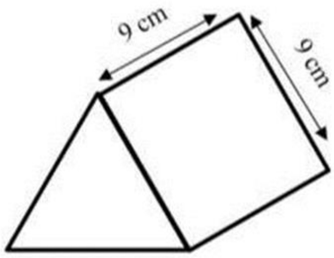
This research is an experimental study conducted at the Optics Laboratory, Physics Education Program, Faculty of Educational Sciences, Syarif Hidayatullah State Islamic University Jakarta. The research lasted for one month, starting from the title discovery to the article writing.



(Personal Document)

The tools used in this research include plan parallel and hollow prism as fluid containers, HVS paper for drawing relevant objects, colored ballpoint pens for illustrating lines resulting from refraction, a ruler to measure the formed distances, a protractor to measure the angles of incident and refracted rays, and finally, a laser as the light source. The materials used in this research are alcohol and distilled water (aquadest).

The plan parallel is made of acrylic material with a length of 10 cm, width of 5 cm, and height of 5 cm. Meanwhile, the hollow prism is made of acrylic with a length of 9 cm, width of 9 cm, and the side parts of the prism triangle have a length of 9 cm. The thickness of the acrylic used in both tools is 5 mm. Both plan parallel and hollow prism have open tops to facilitate the placement of fluids.



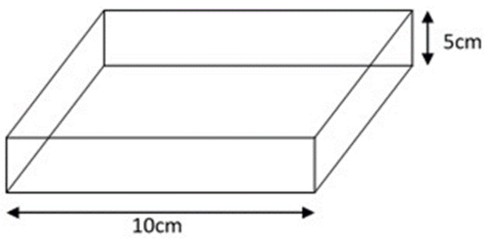


Figure 1. Hollow prism **Figure 2.** Parallel plan

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This research was conducted in two stages. The first stage involved the creation of a plan parallel and a hollow prism, while the subsequent stage focused on measuring the refractive index of fluids to compare the accuracy of the plan parallel and the hollow prism by seeking refractive index values close to those listed in the refractive index table. The second stage included data collection using a repetitive technique, carried out to enhance the accuracy and precision of the obtained data.

In the first phase of the study, a hollow prism was utilized. The initial step involved forming the hollow prism on HVS paper by drawing its normal line. Subsequently, the hollow prism was filled with alcohol, and a laser was shot with a single beam corresponding to the predetermined angle of incidence. The resulting refracted beam was marked with a pen, and the angle was measured. This process was repeated three times, and the average was calculated from the repetitions. Afterward, alcohol was replaced with distilled water (aquades), and the steps for collecting data with aquades were the same as those for collecting data with alcohol.

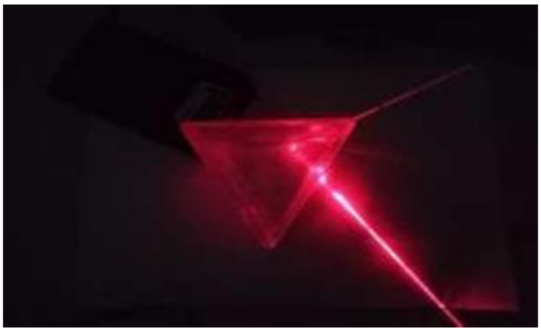

Figure 3. Hollow prism measurements

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In the second study, a plan parallel was utilized. The steps taken were similar to those in the study using a hollow prism, with a fluid change after repeating the process three times. Upon completion, the obtained refractive index results were averaged and compared with the specified values in the refractive index table. To obtain the refractive index value for the hollow prism, a formula was used.

$$n = \frac{\frac{1}{2}(dm+A)}{sin\frac{1}{2}A} \quad \textbf{(Equation.1)}$$

Information:

dm = angle of deviation

A = prism angle (60°)

However, when employing a parallel plan, the formula used involves Snell's law, where $n_1 sin\theta_1 = n_2 sin\theta_2$. If considering the incident angle and the refracted angle, the equation is as follows:

$$n = \frac{sin\theta_1}{sin\theta_2} n_1 \quad \textbf{(Equation.2)}$$

Information:

θ_1 = angle of incidence

θ_2 = angle of refraction

n_1 = refractive index of the first medium

According to Sahodo et al. (2013) research, the refractive index value for acrylic is 1.49 (Sahodo et al., 2013).

RESULT AND DISCUSSION

From the research conducted using both the hollow prism and the parallel plan, the results obtained are as follows :

Table 1. The hollow prism utilizes Aquades

Repetition	Angel of Refraction	Refractive Index
1	16˚	1,32
2	15˚	1,3
3	20˚	1,39
Mean		1,33

Table 2. The hollow prism utilizes Alcohol

Repetition	Angel of Refraction	Refractive Index
1	19˚	1,37
2	18˚	1,36
3	16˚	1,32
Mean		1,35

Table 3. The parallel plan utilizes Aquades

Repetition	Angel of Refraction	Angel of Incidence
1	53˚	32˚
2	58˚	35˚
3	39˚	23˚
Mean	50˚	30˚

Table 4. The parallel plan utilizes Alcohol

Repetition	Angel of Refraction	Angel of Incidence
1	41˚	19˚
2	47˚	28˚
3	57˚	35˚
Mean	48˚	27˚

Table 5. The refractive index values are determined using a hollow prism

Num	Sample	Refractive Index Value
1	Distilled Water	1,33
2	Alcohol	1,35

Table 6. The refractive index values are determined using a parallel plan

Num	Sample	Refractive Index Value
1	Distilled Water	0,97
2	Alcohol	0.91

With this method, the refractive index results obtained using a hollow prism are closer to the values in Table 1 compared to using a parallel plate. The refractive index of distilled water measured with a hollow prism yields a value of 1.33, while using a parallel plate gives a value of 0.97. Meanwhile, the refractive index of alcohol measured with a hollow prism produces a value of 1.35, whereas with a parallel plate, the value obtained is 0.91.

This study demonstrates that the use of a hollow prism provides more accurate and precise results compared to using a parallel plate. This tool can be utilized to determine the refractive index values of various fluids, such as alcohol and distilled water. The refractive index values measured with a parallel plate tend to deviate from the table values due to the difficulty in finding the angle of refraction caused by the thickness of the acrylic. Previous research by Achmad Zamroni resulted in refractive index values close to the table values because the parallel plate used had an acrylic thickness of 1 mm.

In the application of light, the ability to propagate through two different media is influenced by the density, and the speed of light depends on the medium itself. The use of acrylic material aims to minimize the influence of the container's refractive index on the refractive index of the fluid to be measured.

Our research findings indicate that a hollow prism is more effective in determining the refractive indices of distilled water and alcohol compared to using a parallel plane. Therefore, this study can serve as a foundation for further research in developing more efficient practical materials for schools. We hope that these findings will assist students in better understanding the concept of refractive indices and provide them with opportunities to conduct direct experiments using more efficient and effective equipment.

CONCLUSION

Based on the results of the conducted research, it can be concluded that the hollow prism is more accurate compared to the parallel plan in measuring the refractive index of water and alcohol. The hollow prism is not influenced by the thickness of the material, as the materials used in both cases are the same and have a thickness of 5 mm. We have conducted a study that shows in the case of comparing the refractive index between distilled water and alcohol, the use of a hollow prism is more effective than a parallel plane. These findings reinforce previous research on other case studies, which demonstrated a higher effectiveness of the hollow prism. Therefore, this study makes a significant contribution to the scientific literature in this field

When using the parallel plan box to measure the refractive index, it must have a very thin thickness. This is because, in the previous study, although the results were accurate, it used a material with a thickness of 1 mm.

To the researchers who will be continuing this study, please accept warm regards from our team that initiated this significant endeavor. We recommend our research as a strong foundation, albeit with certain limitations that require further attention. We sincerely hope that you can refine and expand upon this research with innovative ideas, making it more comprehensive and relevant in the future. Our recomendations aims for this research to contribute to future scientific knowledge by creating simpler and more user-friendly tools. With the same enthusiasm, we believe you can advance the understanding and application of the findings we have obtained. This collaboration will enrich scientific development and have a positive impact on society.

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