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A Simple Experimental Set for Refractive Index Measurements of Liquids

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Abstract

The objectives of this work were to reconstruct the simple refractive index experimental set using Snell's law and refracted light through different media and to study the efficiency of them. It was apparently comfortable and easy to use. It is consisted of: 1) an acrylic box and LASER source, 2) the acrylic box that connected with a scale meter ruler and 3) the plate mirror which could be varied horizontal angel for using. In finding the efficiency by using the simple experimental set, send the light from LASER source trough the desired liquid in box after that had refracted in the air. The refractive index was calculated from the data of the horizontal distance between the refract light position on the plate mirror to the scale ruler , the height distance from the refracted light position on mirror to refracted light position on the scale ruler and the horizontal angel of the plate mirror. The excellent of the simple experimental set was the horizontal angel can be varied. The using of the simple refractive index experimental set found the refractive indices of 4 types of liquids; water, glycerin, 50% of syrup and palm oil. The results revealed that the refractive indices of water, glycerin, 50% of syrup and palm oil were 1.244-1.286, 1.346-1.558, 1.286-1.328 and 1.323-1.584, respectively. The error percentage of this simple refractive index experimental set was less than 10 %

Keywords: simple experimental set, refractive index, water, glycerin, 50%of syrup, palm oil

I. Introduction

Physics is an important basic discipline; it is the natural science foundation. Physics itself is an experimental basis in natural science, physical definition, theorem and laws. It is built on a large number of experiments and practical activities. It is based on developing an understanding of the world around us by experiments and measurements, and also using those understandings to predict results. The experiments have so called central role in physics education that hardly any textbook fails to mention that physics is an "experimental science" and that in physics "knowledge is based on experiment". Based on Feynmen's study [1], Ismo T.Koponen and Terhi Mantylia [2] referred that "The test of all knowledge is experiment. Experiment is the sole judge of scientific truth". According to these studies, physics teaching is experimentally an integral component in providing the starting point of knowledge information and conceptualization. At Rangsit University, learning processes in physics are divided into two steps which are descriptive theory and laboratory. The main purposes of laboratory experiments are to augment and supplement the learning. Moreover, the understanding of basic physical principles can learn through laboratory procedures, techniques, and equipment. It is not surprising that equipment or tools are the most important things in studying Physics laboratory. Accordingly, it is essential that physics classes are provided with high efficient equipment. However, the experimental sets developed by private companies do not respond of

demand of teachers. Some contents absent from the experimental set. For example, optics is a branch of physics which deals with the study of light. We had learned about the properties of light which are reflection, refraction, interference and diffraction. Therefore, the refractive indexes of liquid were interested. It is often required in physics to knowledge base for optics and electromagnetics and chemistry to determine the concentration of solution. The teachers usually teach by solving equations. Light is very important because it is knowledge base for optics and electromagnetics. If the students learn by suiting experiment, they will deeply understand about refractive index of liquid. It is interesting to a researcher to develop a simple refractive index experimental set by reconstruction from Phewphong tammanon and Nirun Witit-anun's study; titled "Measurement of Refractive Index of Liquid by Refracted Light Technique" [3].They designed and invented apparatus for refractive index measurement by using the Snell's law. However, it is difficult to move due to a large size. Consequently, the objectives of this research were to reconstruct the apparatus for refractive index which is easy to move and use called the simple refractive index experimental set.

II. Materials and Experiment

A. Objectives

1. Reconstruct the simple refractive index experimental set by changing the different angle of incidence for more comfortable and easier to use

2. Study students' satisfactions on the simple refractive index experimental set.

B. Population and sample group

25 engineering students who registered in physics subject in summer of academic year 2014 were the target group.

C. Instrument for collecting data

The instrument in this study was a questionnaire of students' satisfaction on the simple refractive index experimental set. It is a 5-point Likert scale. The scale consists of three domains and one open-ended question. The first domain is a 6-item on learning management. The second one is a 4-item on students' behavior, and the last part is a 3-item.

D. Data analysis

Descriptive statistics were analyzed in the study to indicate means scores and standard deviations.

E .Research methodology

E1. Reviews of Snell's law and refractive index of liquid

The research which related to the measurement of refractive index for liquid and then summarized the good and the weakness points of another method for refractive index measurements were studied.

According to a study of S.K.Mohnlal titled "A simple method for refractive index measurements for liquids" [4], author manipulated a simple method for the measurement of refractive index in transparent plates using the principle of total internal refraction. The study found that the measurements of refractive index of water, paraffin oil, carbon tetrachloride, glycerol, carbon disulphide, kerosene and benzene were 1.311, 1.511, 1.443, 1.434, 1.624, 1.555 and 1.550, respectively.

The study of Phewphong Tammanon and Nirun Witit-anun, "Measurement of Refractive Index of Liquid by Refracted Light Technique" [3] designed and invented apparatus for refractive index measurement using the Snell's law. The study revealed that the measurements of refractive index of water, glycerin and ethyl alcohol were 1.30-1.33, 1.43-1.49 and 1.26-1.27, respectively.

In the article, "Refractive Index of Liquids by measuring Displacement of Refracted LASER Beam"[5] by K.Satheesh Kumer, it had found that a simple method for measuring the refractive index of liquid was described with the help of detailed theory. A laser beam suffers a lateral displacement due to refraction while passing through a liquid. This displacement of laser beam from its incident direction is measured for difference angles of incidence to find the refractive indices of oils that are commonly used in the laboratory. The measurements of refractive index of water, coconut oil, palm oil and kerosene were 1.303-1.337, 1.402-1.447, 1.448-1.458 and 1.430-1.449, respectively.

In the article, "A Novel Method of Using Refractive index as a Tool for Finding the Adultration of Oils" [6] by Ariponnammal S. Author had studied the refractive index of liquids by spectrometer using hollow prism and Abbe's

refractometer that can also use for finding the refractive index with very good accuracy[7] . The refractive index of palm oil determined by spectrometer and Abbe's refractometer were 1.463 and 1.4583, respectively.

In the article, "The use of a conical lens to find the refractive index of liquids" by Marcelino Anguiano-Morales et al. [8]. They have discussed a technique for the measurement of refractive index of various solutions using a conical lens. This can be done by coupled the conical surface in a cylindrical container with the unknown refractive index liquids. The measured values of refractive indices at 25°C for water, acetone and glycerin were 1.323, 1.355 and 1.473, respectively.

E2. Design and Construction

Three aims of design and construction of the simple refractive index experimental set were 1) changing the different angle of incidence, 2) comfortable with easy to use and 3) low cost and self-sufficient. The simple refractive index experimental set shown in Fig. 1.

Fig.1 The simple refractive index experimental set

In Fig.1, the simple refractive index experimental set were consisted of: 1) rectangle base which used for setting an acrylic box and LASER source, 2) the acrylic box that connected with a scale meter ruler and 3) the plate mirror that the horizontal angel could be varied for using.
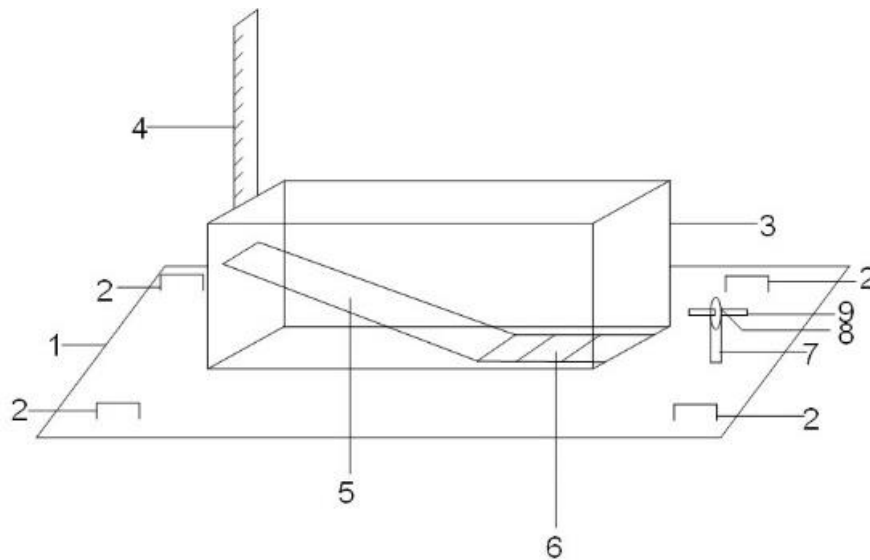
Fig. 2 The details of the simple refractive index experimental set

In Fig. 2, the details of the simple refractive index experimental set were (1) rectangle base, (2) four handle, (3) rectangle acrylic box ,(4) ruler scale,(5) rectangle mirror, (6) rectangle acrylic with three steps of thickness for different angle of incidence, (7)(8)(9) LASER pointer set

E3.Testing

There were 3 phases to test the simple refractive index experimental set. Phase I was tested by the researcher and team works. Phase II was tested by the expert physics teachers. Phase III was tested by the students in science teaching, master degree program.(Fig. 3-5)

Fig. 3 Testing of phase I

Fig. 4 Testing of phase II

Fig. 5 Testing of phase III

The refractive index of liquid was calculated by using the Snell's law.
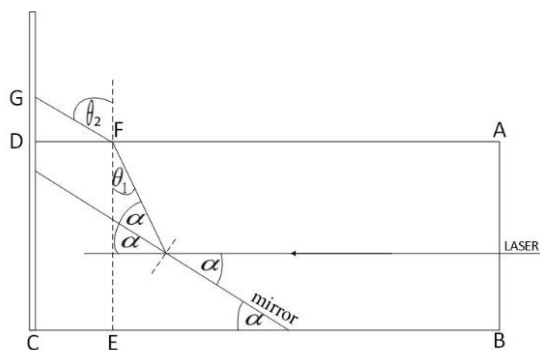

Fig. 6 Model of refractive ray

Form Fig. 6 could be explained by equations:

$$\frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2} \qquad (1)$$

$$n_1 = n_2\left(\frac{\sin\theta_2}{\sin\theta_1}\right) \qquad (2)$$

$$n_1 = n_2\left(\frac{\sin\left(\tan^{-1}\dfrac{DF}{DG}\right)}{\sin(90° - 2\alpha)}\right) \qquad (3)$$

F is the position of the refracted light on the plate mirror and through the water surface

D is the position on the scale ruler at the same F level

G is the position of the refracted light on the plate mirror and through the water surface after incidencing on the scale ruler

DF is the horizontal distance between D position to F position

DG is the vertical distance between D position to G position

α is the horizontal angel of the plate mirror

θ_1 is incident angle

θ_2 is refractive angle

n_1 is refractive index of liquid

n_2 is refractive index of air

III. Results and Discussions

1. Results

This study found that:

1) The reconstruction instrument called the simple refractive index experimental set consisted of: 1) the rectangle base that was used for setting an acrylic box and LASER source, 2) the acrylic box that connected with a scale meter ruler and 3) the plate mirror that the horizontal angel could be varied for using. It was comfortable, easy to use, low cost and self-sufficient.

2) The measurement of the refractive indices of 4 types of liquids, water, glycerin, 50%of syrup and palm oil. The results revealed that the refractive indices of water, glycerin and 50%of syrup were 1.244-1.286, 1.346-1.558, and 1.286-1.328 and 1.323- 1.584, respectively. The error percentage of this simple refractive index experimental set was less than 10 % (Table 1).

Table 1 the measured values refractive indices of 4 types of liquids

Types of liquid	Angles of incidence	n_{exp}	S.D.	n_{std}	%error
water	25°	1.244	0.001	1.333	6.7
	30°	1.437	0.001	1.333	7.8
	35°	1.286	0.002	1.333	3.5
glycerin	25°	1.558	0.001	1.473	5.8
	30°	1.346	0.001	1.473	8.6
	35°	1.407	0.001	1.473	4.4
50% of syrup	25°	1.328	0.001	1.420	6.5
	30°	1.286	0.001	1.420	9.4
	35°	1.316	0.001	1.420	7.3
Palm oil	25°	1.323	0.002	1.455*	9.1
	30°	1.517	0.001	1.455*	4.3
	35°	1.584	0.003	1.455*	8.7

*From FN Ngassapa and OC Othman's study at 25° C [9]

3) Table 2 shown the descriptive data of the students' satisfaction on the simple refractive index experimental set. Learning management mean score was 4.46, students' behavior mean score was 4.43, and usefulness mean score was 4.15.

Table 2 The students' satisfaction on the simple refractive index experimental set

Details	means*	SD.
1) learning management	4.46	0.40
1.1 Supporting content	4.52	0.58
1.2 Participate on learning.	4.70	0.46
1.3 According theory	4.52	0.64
1.4 Enhance skills and learning process	4.52	0.51
1.5 Uncomplicated learning	4.19	0.56
1.6 Suitable time for experiment	4.30	0.67
2. Students' behavior	4.31	0.61
2.1 Interesting to self-learning about refractive index	4.37	0.67
2.2 Enjoy on learning	4.33	0.78
2.3 Making creative	4.11	0.75
2.4 Team works	4.41	0.80
3. Usefulness	4.15	0.65
3.1 Solving problem in physics subject	4.19	0.74
3.2 Apply to the another subject	4.04	0.76
3.3 Explain about event in daily life	4.22	0.80

*The level of means could be explained;

4.50-5.00 were extremely satisfied level

3.50-4.49 were satisfied level

2.50-3.49 were somewhat satisfied level

1.50-2.49 were unsatisfied level

1.00-1.49 were extremely unsatisfied level

4) Example of the students' comments from the open-ended question;

"I'd like to know relationship between color of water and refractive index"

"Laser refractive point on water surface wasn't clear and I want to measure refractive index for more types of liquid"

B. Discussion

B1. The refractive index of liquid

From Table 1, the results are similar to the study of S.K. Mohanlal. [4] He found that the measured values of the refractive indices of water at different angles of incidence (5, 10, 15, 20, 25, 30, 35 and 40) were 1.332, 1.335, 1.331, 1.334, 1.337, 1.334, 1.336 and 1.303, respectively. The finding clearly support Satheesh Kumer's study [5] for the measured values of the refractive indices of liquids varied with concentration.

B2. The students' satisfaction

Table 2 is shown that total mean scores for all of the students' satisfactions were at satisfied level. It was evident that using the simple refractive index experimental set in laboratory supported students' cognitive process of forming knowledge. The results are in line with many studies which were done by Sokoloff & Thornton [10],Redish[11][12],Van Heuvelen[13], McDemott et al. [14] and Hammer [15]

IV. Conclusions

Form this study, we are confident that the simple refractive index experimental set will help

the students study in title "Snell's law and refracted light". It had been useful to develop conceptual understanding for the students. In future, the researcher will measure values of the refractive indices of many types of liquids, decrease the size of the simple refractive index experimental set or change the material to construct which more comfortable and easier to use than this experimental set.

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