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Determining the Viscosity Coefficient of Fluids Using a Simple Viscosity Practical Tool Aided by Arduino Uno and a Magnetic Sensor

Aris Doyan[1,2*], Bung Ashabul Qahfi[1], Susilawati[1,2]

[1] Master of Science Education Study Program, Postgraduate University of Mataram, Mataram, West Nusatenggara, Indonesia.
[2] Physics Education Study Program, FKIP, University of Mataram, Mataram, West Nusatenggara, Indonesia.

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Corresponding Author:
Aris Doyan
aris_doyan@unram.ac.id

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Abstract: This study aims to design and create fluid viscosity test equipment in the form of used oil, sunlight, soklin, liquid rinso, and harpick. The working principle of the viscometer uses a free-falling ball system according to Stokes' law principles. The stages in making a viscometer are designing a tool model, designing hardware and software, designing a mechanical system and testing. Designing hardware includes hall effect magnet sensor, arduino uno, lCD, and power supply. The software uses the Arduino IDE-assisted programming language. The design of the tool includes supports, boxes, magnets, and glass tubes. the test was carried out by measuring the viscosity coefficient of used oil, sunlight, so klin, rinso, and harpick. The viscosity coefficients of used oil, sunlight, floor soklin, liquid Rinso, and harpick from the test results have been able to be measured with a viscometer that has been made.

Keywords: Viscosity; Ardunino Uno; Hall Effect

Introduction

Physics in learning activities cannot be transformed solely through information (Carlone, 2004; Rahardja et al., 2019). Skills training and experience are also important factors in gaining a deeper understanding. Learning physics cannot only use the lecture method in the classroom (Dewi & Primayana, 2019). However, scientific action is also needed in learning activities. The scientific action in question is an activity of students and teachers in the laboratory room or in the wild (Firdaus et al., 2020).

This activity aims to provide proof of theories, concepts, principles, and laws that students already know about physics. Assumptions related to difficult physics learning will be reduced if this practicum activity can be carried out in the classroom (Habiburrohman & Fauzi, 2020; Rahmani et al., 2022). Based on the importance of scientific or practical activities, it is necessary to provide complete and adequate facilities and infrastructure as well as practical tools in schools. But in reality, sometimes schools are lacking in providing tools and materials for practical needs. Indeed, teaching aids can be used as one of the learning media to help visualize theories, laws, and physics concepts as well as a measuring tool in practical activities (Boimau et al., 2020).

Learning by utilizing interactive simulations has a positive effect on students' beliefs about physics (Akhlis et al., 2020; Maison et al., 2019). Learning outcomes and students' abstract reasoning abilities can be improved through simulation-based learning. Learning media in the form of teaching aids is very important to use so that it can help students to analyze problems and help construct a thought into real life (Eli Yuliansih & Wahidy, 2021). Teaching aids or practicums for fluid material are needed because to master the material perfectly, students need expertise directly, namely with the help of these tools (Sunardi et al., 2022; Trisnawati et al., 2022). Based on the situation above, the researcher

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aims to make a "viscometer" practicum tool that can be used to determine the viscosity of the liquid used. With this tool, it is hoped that it can become a practical tool that makes it easier for students to know the relationship between concepts in determining the viscosities of different liquids and is expected to attract students' attention in studying fluid material.

Basic theory

Viscosity is a parameter that describes the density of a liquid or fluid in SI units is N.s/m² (Sajjan et al., 2022). The property of a liquid that is closely related to the resistance of the liquid to flow is called density. Of the several kinds of fluids, some can flow slowly and some can flow quickly. Honey, oil, and oil are examples of liquids that have a greater density value, while water, alcohol, and gasoline are examples of liquids that have a small density value. So, viscosity is a determination of the flow rate of a liquid.

An object will experience friction if the object is moved on a solid with a rough surface. In this regard, the greater density of the liquid will cause an object to experience friction. From this situation, through the magnitude of the velocity of an object, it can be seen the frictional force on an object moving in a liquid with a greater density. The frictional force experienced by a ball moving in a liquid with a greater density according to Stokes' law is shown in Figure 1.

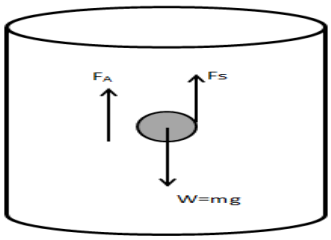

Figure 1. Stokes' Law Viscosity

$$F_s = 6\pi r\eta v \quad (1)$$

Describe
F = frictional force experienced by the ball (N)
r = radius of a ball (m)
η = Coefficient of viscosity (N·s/m²)
v = Speed of a ball (m/s)

Object review

$$\sum F = 0$$
$$W + F_a + F_s = 0$$
$$W = F_a + F_s \quad (2)$$
$$6\pi r\eta v = \rho_b gV - \rho_f gV$$
$$6\pi r\eta v = gV(\rho_b - \rho_f)$$
$$6\pi r\eta v = g(\frac{4}{3}\pi r^3)(\rho_b - \rho_f)$$
$$v = \frac{2r^2 g(\rho_b - \rho_f)}{9\eta} \quad (3)$$

The speed of the ball in uniform straight motion.

$$v = \frac{y}{t}$$
$$t = \frac{y}{v}$$
$$t = \frac{9\eta y}{2\pi r^2(\rho_b - \rho_f)} \quad (4)$$

The coefficient of viscosity is defined as the resistance that appears in a flowing liquid. The Poiseuille equation can be used in determining the viscosity coefficient.

$$\eta = \frac{2\,r^2 g}{9\,V}(\rho_b - \rho_f) \quad (5)$$

Method

The manufacture of this viscosity practicum tool was carried out at the Physics Education Laboratory of FKIP, University of Mataram from April to May 2022. To determine the quality of the tool, a trial of the tool was carried out using five different types of liquids, namely used oil, sunlight, floor soklin, liquid rinso, and harpicks. Making a viscosity practicum tool using tools and materials in the form of Arduino Uno, 12C LCD, Hall Effect Magnetic Sensor, USB Cable, Jumper Cable, and PCB Board.

Before the program is ready to be uploaded and compiled, it is initialized to initiate the software system. After the initiation is complete, proceed with uploading and compiling the program so that it is ready to be tested. The liquid sample that has been filled into the tube is then dropped by an iron ball. The iron ball moving in the liquid will be detected by sensor 1 as the trigger for the start time and sensor 2 as the finish time. The ball travel time from sensor 1 to sensor 2 will be displayed on the LCD.

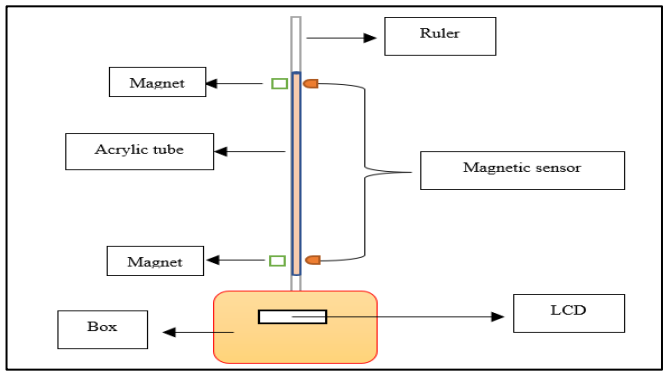

Figure 2. Viscosity practicum tool design

The working stages of the viscosity practicum tool are as shown in the system flow diagram in Figure 3. The initial stage is to initialize the software. Then, the microcontroller reads the time it takes the ball to pass through the two UGN3503 Hall effect sensors. The time data is processed and displayed on the LCD.

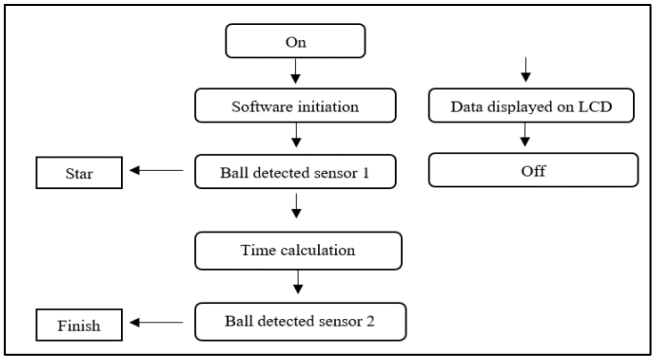

Figure 3. System flowchart

Result and Discussion

After finishing making the viscosity practicum tool using Stokes' law. The next stage is testing the tools that have been made. This test aims to determine whether it meets expectations and is ready to use. The Hall effect sensor is the effect of the output voltage that arises on the sensor due to the influence of the magnetic field (Figure 4).

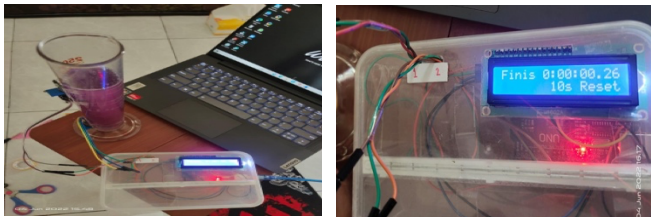

Figure 4. Viscosity test tool

The ball used in this experiment is a magnetic ball. The pole of the magnetic ball will produce a magnetic field value that affects the sensor inversely with the output voltage value. This viscosity coefficient measurement uses a digital system where the motion of the ball in the liquid paint is detected using the Hall effect sensor UGN3503.

To activate the Arduino Uno microcontroller, the input voltage is 5 volts. Furthermore, the pins used in the microcontroller are 6 pins, namely the SCL and SDA pins as LCD outputs, 7 pins as the start button and sensor 1 output, and pin 8 as the finish button and sensor 2 output. seen in Table 1.

Tabel 1. Ball size

Ball diameter (cm)	Ball mass (gr)	Ball volume (cm^3)	Ball ρ ($\frac{gr}{cm^3}$)
1.40	7.35	1.44	5.10

Furthermore, in this experiment, the liquids used were used oil, sunlight, floor soklin, liquid rinso, and harpick, each of which was 250 ml. Furthermore, the average distance and time in the liquid viscosity experiment is shown in Table 2.

Table 2. Distance and time

No	Time					Distance (cm)
	Oil	*Sunlight*	*Soklin*	*Rinso*	*Harpick*	
1	0.55	2.21	0.48	1.21	0.69	21.5
2	0.67	2.70	0.48	1.30	0.48	21.5
3	0.54	2.92	0.47	1.23	0.60	21.5
4	0.58	2.40	0.48	1.66	0.48	21.5
5	0.79	2.70	0.50	1.60	0.53	21.5
$t_{average}$	0.63	2.59	0.48	1.40	0.56	

After the ball travel time data is obtained from sensor 1 to sensor 2, calculations are carried out to determine the coefficient of viscosity (η). In determining the viscosity coefficient, equation (5) is used. The data in Table 3 is the viscosity coefficient obtained from the calculation.

Table 3. Liquid Viscosity Coefficient

Liquid	Coefficient of Viscosity η $\left(\frac{Kg}{m \cdot s}\right).(10^{-2})$
Oil	1.34
Sunlight	5.40
Soklin	1.00
Liquid Rinso	2.70
Harpick	1.14

Based on the test results, the travel time of the ball at a distance of 21.5 cm in used oil is 0.63 s, sunlight 2.59 s, floor soklin 0.48 s, liquid Rinso 1.40 s, and harpick 0.56 s which means that the time required for the ball to pass sunlight is longer. compared to other liquids. It can also be seen from the liquid which has a higher viscosity coefficient value.

Conclusion

In determining the travel time of an object in a liquid, a tool is needed to determine it precisely. this can be done using sensors, one of which is the Hall effect magnet sensor UGN3503. The viscosity coefficient value obtained from the results of the experiments carried out is used oil of 1.34×10^{-2} Kg/(m·s), sunlight 5.40×10^{-2}

Kg/m·s, floor soklin 1.00× 10^{-2} Kg/m·s, rinso 2.70×10^{-2} Kg/m·s, and harpick 1.14×10^{-2} Kg/m·s. Based on the viscosity value, it can be concluded that the greater the viscosity coefficient value, the longer it takes the ball to arrive at the starting point to the end point.

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