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Cite as: AIP Conference Proceedings **2468**, 020009 (2022); https://doi.org/10.1063/5.0103033
Published Online: 29 December 2022

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Development of a Practicum Tool to Analyze The Angular Speed and Direction of The Wheel's Movement

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Abstract. This research aims to develop a practicum tool to analyze the angular velocity and direction of rotation produced by the wheel's movement. The study method used is research and development which is the most reliable in scientific knowledge and is concerned with changes that lead to improvements. The research and development stage begins with a discussion stage for collecting ideas, submitting designs, and making tools. The working principle of the tool was to connect the tool to the electric current. So that the wheels can rotate and observe the direction of rotation. The rotation of the wheels that touch each other is connected by a rope. The data that will be obtained from this experiment is the number of turns on the wheel, the length of time the wheel rotates, and the diameter of each wheel. Data analysis was carried out by determining the frequency, angular velocity, and direction of rotation of each wheel. The result showed the intersecting wheels had different rotational directions and angular velocities. The wheel connected to the rope has a rotating direction in the same direction at different angular velocities. Thus, the practicum tool developed can analyze the angular velocity and direction of the wheel's movement rotation.

INTRODUCTION

Physics explains all macroscopic and microscopic phenomena that occur in the universe [1]. Various experiences are gained by conducting experiments and from these various experiments, knowledge will be gained [2]. Physics is very close to everyday life [3]. Life always experiences developments in every field, including education. Education is always developing, therefore learning must also adjust. The interaction between teachers and students in learning requires media. One example of learning media is a practicum tool [4]. Experiment tools make it easier to carry out learning activities [5]. With experimentation, students can gain the ability to improve their understanding of science and prepare themselves as scientists [6]. In addition, other benefits of experiments are to reduce the occurrence of verbalism, increase interest and attention to learning, provide real experiences, foster self-employed activities, and develop regular and continuous thinking. [7]. The use of real learning media makes it easier for students to accept and understand concepts [8]. Contextual-oriented learning is implemented to cultivate and develop students' attitudes, knowledge, and skills [9].

The experiment is a method in learning that uses tools in the learning process [10]. The experimental method emphasizes a way of teaching and learning that involves students to experience and prove the process to the

International Conference on Mathematics and Science Education (ICMScE 2021)
AIP Conf. Proc. 2468, 020009-1–020009-5; https://doi.org/10.1063/5.0103033
Published by AIP Publishing. 978-0-7354-4288-7/$30.00

experimental results by themselves [11] [12]. The laboratory requires the provision of tools and materials as well as good management so that the implementation of learning is optimal [13]. Students can find firsthand the formulation of the material being taught and more meaningful for students by experimenting in the laboratory [14]. The characteristics of learning activities in the knowledge domain and skills have similarities and differences [15]. Experimental in the laboratory integrate the learning activities of students' knowledge and skills domains.

One of the activities in the laboratory is carrying out a circular motion experiment. Students learn circular motion as one of the physics concepts learned in senior high school. Regular circular motion is a motion whose trajectory forms a circle. The speed of regular circular motion is constant [16]. The results of learning circular motion are often limited to knowledge, circular motion is a motion with a circular path. Teachers rarely engage students for further investigation by carrying out experiments [17]. The teacher only explains the mathematical formulation related to various variables in a circular motion. Students do not understand the relationship between each variable in a circular motion As a result, students often have difficulty understanding the concept of this circular motion [18].

Based on these problems, students to more easily understand the concept of circular motion a practicum tool is needed. The making of experimental tools on the concept of regular circular motion will be developed. Previous research related to circular motion practicum tools only as props. The resulting experimental tool is designed with tools that are difficult to obtain and require high cost [19]. The novelty of this research is to develop a circular motion experimental tool by utilizing existing equipment in everyday life. Tools that are made require a lower cost. Students can calculate the rotation produced by the wheel when it rotates. Purpose of the research to develop a practicum tool to analyze the angular velocity and direction of rotation produced by the wheel's movement. Thus, students can better understand the relationship between variables in the concept of circular motion.

METHOD

The study method used is research and development. The research and development method is the most reliable in their scientific knowledge and is concerned with changes that lead to improvements [20]-[22]. The research and development stage begins with a discussion stage for collecting ideas, submitting designs, and making tools. The steps taken during the research consisted of: analyzing core competencies and basic competencies; analyzing teaching materials, formulating competency achievement indicators, making tool designs, validating tools; revising tools; conducting tool trials, implementing tools on a large scale, and analyzing the results of the implementation of the tools.

The tools needed in making this tool are small wheels, medium wheels, bear wheels with dynamo, adapters, measuring the number of turns, ropes, and boards. The use of an electric motor as a driving force to turn the wheels in a circle. The circular motion of a wheel is a source of renewable and potential energy. The an electric motor attached to the tool serves as a tool to rotate the wheel and increase the efficiency of operating the experimental device [23] [24]. The experimental tools produced in this study are shown in Fig. 1.

FIGURE 1. Practicum tool to analyze the angular speed and direction of the wheel's movement

The way to use this tool is that the main wheel (the wheel connected to the dynamo is located in the middle) is connected using a rope to the second wheel (the left wheel). Then the travois is connected to a voltage source of 22

V. Bring the turn count counter closer to each wheel that has been connected to the rope. Set the stopwatch for the required time. This experiment took 30 seconds. Count the number of revolutions experienced by both wheels. The calculation of the number of rotations of the main wheel associated with the third wheel follows the same steps when performing the previous experiment.

The data that will be obtained from this experiment is the number of turns on the wheel, the length of time the wheel rotates, and the diameter of each wheel. Data analysis was carried out by determining the frequency, angular velocity, and direction of rotation of each wheel. The data obtained will be processed using the following equation (1) and (2).

$$f = \frac{n}{t} \tag{1}$$

Equation (1) is used to determine the frequency of each wheel. After knowing the frequency of each wheel, equation (2) is used to determine the angular velocity value of each wheel.

$$\omega = \frac{\theta}{t} = \frac{2\pi}{T} = 2\pi f \tag{2}$$

RESULT AND DISCUSSION

Observations are made to measure the number of turns of each wheel. Each experiment took the same 30 seconds. The first observation is made on the two intersecting wheels. The first wheel has a diameter of 12.6 cm and the second wheel is 10.2 cm. The results of the observations of the two wheels that intersect are shown in Table 1.

TABLE 1. Data on the number of wheel rotations 1 and 2

No.	Wheel 1 (n_1)	Wheel 2 (n_2)
1	160	197
2	161	195
3	159	195
4	160	193
5	160	196
6	158	192
7	157	194
8	162	198
9	159	195
10	160	195

From this experiment, it can be seen that the two wheels rotate in opposite directions and with different angular velocities. Where wheel 1 is a wheel that has a larger diameter than wheel 2. The results of calculating the angular speed are shown in Table 2.

TABLE 2. Data on the frequency and angular speed of wheel 1 and wheel 2

No.	f_1(Hz)	ω_1(rad/s)	f_2(Hz)	ω_2(rad/s)
1	5.33	33.49	6.57	41.24
2	5.37	33.28	6.50	40.82
3	5.30	33.70	6.50	40.82
4	5.33	32.86	6.43	40.40
5	5.33	33.93	6.53	40.03
6	5.27	33.28	6.40	40.19
7	5.23	33.49	6.47	40.61
8	5.40	33.07	6.60	41.45
9	5.30	33.49	6.50	40.82
10	5.33	33.49	6.50	40.82
Average	5.32	33.41	6.50	40.72

Based on the calculation data that has been done, the greatest frequency and angular velocity are wheel 2. Because wheel 2 has a smaller diameter so that the rotation is faster. The friction on the wheel is in contact with it produces tangential forces. Which is, in turn, will lead to the opposite direction to the rotational speed [24].

The second observation was on the two wheels connected by a rope, with a diameter of wheel 1 of 12.6 cm and wheel 3 of 8.6 cm. The time needed for 30 seconds. The observed data are shown in Table 3.

TABLE 3. Data on the number of wheel rotations 1 and 3

No.	Wheel 1 (n_1)	Wheel 3 (n_3)
1	133	197
2	135	196
3	138	197
4	135	199
5	133	194
6	137	199
7	132	192
8	139	198
9	134	197
10	133	199

Based on the observation that wheel 1 and 3 have the same rotation direction. The two wheels have different angular speeds. Wheel 1 has a larger diameter than wheel 3. Based on the calculation of the angular velocity, wheel 3 is the largest. Because wheel 3 has a smaller diameter so that the rotation is faster. The results of calculating the angular velocity of each wheel are shown in Table 4.

TABLE 4. Data on the frequency and angular speed of wheel 1 and wheel 3

No.	f_1(Hz)	ω_1(rad/s)	f_3(Hz)	ω_3(rad/s)
1	4.43	27.84	6.57	41.24
2	4.50	28.26	6.53	41.03
3	4.60	28.89	6.57	41.24
4	4.50	28.26	6.63	41.66
5	4.43	27.84	6.47	40.61
6	4.57	28.68	6.63	41.66
7	4.40	27.63	6.40	40.19
8	4.63	29.10	6.60	41.45
9	4.47	28.05	6.57	41.24
10	4.43	27.84	6.63	41.66
Average	4.50	28.24	6.56	41.20

Based on the calculation that of the frequency and angular velocity, the largest is wheel 3. Because the wheel has a smaller diameter than wheel 1 so that the rotation is faster. When compared between wheels touching and wheels connected by a rope, they have different angular velocities. Wheel 1 tends to have less angular velocity when it is attached than when tangled. Finding this angular velocity also helps students to feel more conceptually challenged [25].

Basically, circular motion is a phenomenon that is closely related to everyday life [26]. As we know that for wheel connections that are touching at the same time, then the length of the track traveled by both wheels is the same. But the direction of rotation of the two wheels is opposite. The movement of the wheel connected by a rope has the same direction of rotation [27]. Thus, the developed experimental tool provides results by the theory it should be.

Improvement and enhancement of the learning process must be continuously implemented. Physics learning should be varied using various learning media. Learning media can be developed from a variety of low-cost and easy-to-find equipment in everyday life. Learning physics is not only explaining mathematical formulation, providing examples of questions and exercises. Thus, the quality of learning becomes optimum [28]. Therefore, this experimental tool of being developed to obtain the optimum quality of learning. Studying circular motion will be easier to understand if using a medium [8]. Future research is expected to improve the quality of the experimental tools being developed. This equipment has limitations in the rope used is not flexible. Besides, measuring the number of rotations is sometimes difficult to show the results measurement.

CONCLUSION

This research has succeeded in developing a circular motion experimental tool. This equipment is used to explain the concept of the wheel-wheel relationship. The experimental results show conformity with the relevant theory. The angular speed of a wheel small diameter is faster than the large-diameter wheel. The movements of the wheels which touch within the specified time have the opposite direction. The movement of the wheel connected by the rope has the same direction of rotation. Thus, this practicum tool is expected to help make it easier for students to understand the circular motion concept.

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