Development of Mechanical Energy Trial Devices in Rotation Motion Based Arduino Uno Microcontroller

Medya Sartika, Azizahwati, Yennita, Nur Islami, Muhammad Rahmad
Physics Education – FKIP, Universitas Riau
Jl. HR. Soebrantas, Km. 12.5, Pekanbaru, 28293, Indonesia
medyasartika.pku@gmail.com

Abstract. This research aims to develop tools for mechanical energy experiments on rotational motion using sensors and controlled by Arduino Uno. These objectives are motivated by the learning of mechanical energy that is often taught by teachers with the lecture method and students do not understand the concept of mechanical energy which is considered abstract. The working principle of this tool is to pass marbles on a track made of iron. This tool functions to calculate the time when a marble glides with the help of a photodiode sensor and a laser diode in order to obtain the value of translational kinetic energy, rotational kinetic energy and potential energy. This research was conducted at the Laboratory of Physics Education FKIP Riau University. The method used in this research is the Research and Development method and uses empirical test data analysis. Based on measurements of the average time obtained 0.0834 seconds and obtained an accuracy level of 0.9417 which can be categorized as very accurate. This mechanical energy experiment tool succeeded in proving mechanical energy obtained from the amount of potential energy, translational kinetic energy and rotational kinetic energy is constant.

1. Introduction
Physics is the fundamental knowledge needed for future technological advances and the development of creativity is one way to integrate it [1]. Learning physics requires active students so that it will strengthen their understanding of physics concepts. For high school students, the concept of learning physics is increasingly difficult when the topic is abstract and cannot be seen with the naked eye [2] [3]. When using adequate practicum tools, students will deepen their knowledge [4].

The development of experimental tools is important for teachers to assist in the physics learning process and can also increase students' understanding so that students are able to think critically in analyzing the data obtained. The results of the development in the form of learning media that are intact can make students understand more and make it easier for the learning process carried out by teachers and students. It is important to develop learning media to help the learning process of learning physics [5][6].

Teachers only teach with conventional methods (lectures), teachers rarely provide practicum because of the lack of practical tools, and according to teachers' perceptions, learning objectives are difficult to achieve through practicum. This is in accordance with the results of research conducted that there are obstacles that cause teachers to feel reluctant to carry out practicum [7]. Understanding of the basic concepts of mechanical energy is often measured using several standardized tests, including the energy and momentum concept survey [8] and the Mechanic Baseline Test [9].

Mechanical energy research has been carried out making a media for developing a mechanical energy measuring device based on the Arduiono uno microcontroller, but this research only looks at the mechanical energy from translational motion and is only based on one altitude point [10]. Another
research was also carried out by making the Mini Roller Coaster (Miroco) media as a medium for calculating acceleration in terms of mechanical energy in translational motion, the tool developed is still manual in recording time and has not used sensors to perform counting experiments with levels. high accuracy [11].

The research that has been done above still has shortcomings, so the researchers want to develop a mechanical experimental device using a time sensor that is processed using an Arduino uno microcontroller. The experimental tool uses the Arduino Uno microcontroller to produce accurate data and learning media in the form of a developed tool is used as an alternative medium for calculating potential energy, translational kinetic energy, rotational kinetic energy and mechanical energy [12] [13].

2. Methodology

This type of research is research and development. The product being developed is a mechanical energy experimental device on rotational motion based on the Arduino Uno microcontroller. The manufacture of mechanical energy experimental devices in rotational motion is divided into two stages, the first stage is hardware in the form of a physical design of the experimental device and the second stage is software in the form of an Arduino Uno microcontroller program design. The design of this mechanical energy experiment tool is made of lightweight iron, so it is easy to carry anywhere with a distance of 100 cm. The object used in this tool is a marble with a mass of 2.2 grams and a diameter of 2.05 cm. Product design can be seen in Figure 1.

![Figure 1. Design of Mechanical Energy Experiment Tool in Rotational Motion](image)

The physical design of the experimental device in Fig. 1 is carried out first by paying attention to the friction force on the track to be made and also paying attention to the concept of mechanical energy that applies to the experimental instrument. The software design, which is the output of the input processed by the Arduino Uno microcontroller, can display the time it takes for objects to cross the arena, potential energy, translational kinetic energy, rotational kinetic energy and mechanical energy displayed on the LCD.

3. Results and Discussion

The result of the design of the tool in this study is the development of a mechanical energy experimental device in rotational motion equipped with a time sensor and Arduino uno microcontroller and its program is shown in Figure 2.
Figure 2. The developed arduino uno microcontroller based mechanical energy experiment tool

The experimental tool that has been developed is able to display the results of time, potential energy, translational kinetic energy, rotational kinetic energy and mechanical energy as shown in Figure 3.

Figure 3. Display results on the LCD

The measurement results obtained are used to analyze the concepts of mechanical energy in rotational motion. Physical variables that can be calculated using the measurement results of the developed experimental tools are potential energy, translational kinetic energy, rotational kinetic energy and mechanical energy. Measurement data can be seen in Table 1. below. This mechanical energy device experiment was carried out 5 times with the same object and height.

Table 1. Measurement results and calculation of experiment.

| No | t (s)  | EP (J)  | E\text{\textsubscript{k\text{\textsubscript{trans}}} (J)} | E\text{\textsubscript{k\text{\textsubscript{rot}}} (J)} | EM (J) | A  |
|----|--------|---------|----------------------|----------------------|--------|----|
| 1  | 0.0870 | 0.0108  | 0.5813               | 0.0065               | 0.5986 | 0.9569 |
| 2  | 0.0770 | 0.0108  | 0.7421               | 0.0065               | 0.7594 | 0.9236 |
| 3  | 0.0875 | 0.0108  | 0.5747               | 0.0065               | 0.5920 | 0.9509 |
| 4  | 0.0880 | 0.0108  | 0.5682               | 0.0065               | 0.5855 | 0.9449 |
| 5  | 0.0775 | 0.0108  | 0.7333               | 0.0065               | 0.7506 | 0.9293 |
| Average | 0.0834 | 0.0108  | 0.6399               | 0.0065               | 0.6572 | 0.9417 |
Based on the measurement results obtained, the average time obtained is 0.0834 seconds, so that the level of accuracy is obtained with an average of 0.9417. The analysis results obtained from the measurement show that the working time sensor can run well.

In the first experiment, it was obtained $t = 0.0870$ s with an accuracy level of 0.9569. Thus, the results of time measurements using photodiode sensors and laser diodes can be categorized as very accurate. Based on the time measurement data, the potential energy is 0.0108 J, the translational kinetic energy is 0.5813 J, the rotational kinetic energy is 0.0065 J and the mechanical energy is 0.5986 J.

Experiments carried out in the second and fifth time obtained a different result of 0.01 from the first, third and fourth experiments. The accuracy of the data also differs by 0.02 - 0.03. However, from the experiments carried out 5 times, obtained high accuracy results. The use of sensors in experimental tools greatly affects measurement compared to using a simple stopwatch.

The potential energy obtained from the experiments conducted 5 times obtained the same results. This has a constant mass input and altitude. Physical variables that affect potential energy are mass, gravitational acceleration and altitude, so it cannot be proven that the higher the position or location of the object from the earth's surface, the greater the potential energy it has, and vice versa, the lower or denkat the earth's surface, the potential energy is also getting smaller.

The rotational kinetic energy obtained from experiments conducted 5 times has the same results if it is calibrated with a value of 4 digits behind the comma, if the calibration is carried out with a value of 6 digits behind the comma, the results obtained will differ by about 0.000001 - 0.000002. The physical variables of rotational kinetic energy are influenced by inertia and angular velocity. Insertia is influenced by the value of static friction, mass, acceleration due to gravity, radius of mass and acceleration. All affecting variables are constant, except for acceleration because it is affected by velocity and time. Angular velocity is affected by velocity and radius of mass. Just like inertia, the input of the radius is constant. Some of the concepts above affect the value of rotational kinetic energy so that the same measurement is obtained.

The translational kinetic energy obtained from the measurement results is obtained by an average of 0.6399 J. Kinetic energy is the energy possessed by every moving object. In other words, the kinetic energy of the object will only arise when the object is moving. The faster the motion of the object, the greater the kinetic energy that arises on it, conversely, the slower the motion of the object the smaller the kinetic energy. The measurement data obtained from the first to fifth experiments show that the theory mentioned above is correct, the faster the measured time, the greater the translational kinetic energy.

The mechanical energy obtained from the measurement results is obtained by an average of 0.6572 J. The data from the measurement results were carried out 5 times, it was found that the time that will arrive at the end of the track faster will produce large mechanical energy. If the time obtained is long, it is caused when the marble slides, there is friction between the marbles and the walls on the track, because the resulting friction will reduce the total mechanical energy. Experiments were carried out 5 times, resulting in mechanical energy obtained from the total potential energy, translational kinetic energy and rotational kinetic energy, which are constant.

4. Conclusion
The results of the development of a mechanical energy experiment tool were made well and the accuracy rate was high. However, the measurement of potential energy and rotational kinetic energy is not in accordance with the theory. This mechanical energy experimental tool succeeds in proving that the mechanical energy obtained from the total potential energy, translational kinetic energy and rotational kinetic energy is constant and if the time obtained is long it is because when the marble slides there is friction between the marbles and the walls on the path, because of the force. the friction caused will reduce the total mechanical energy. Translational kinetic energy experiments can prove that the faster the motion of the object the greater the kinetic energy arising on it, conversely the slower the motion of the object the smaller the kinetic energy.
Reference

[1] Klieger, Aviva and Sherman G 2015 Physics Textbooks: Do They Promote Or Inhibit Students’ Creative Thinking Journal of Physics Education 50(3) 305-309

[2] Marilyn 2012 Assessment and Teaching of 21st Century Skills (London: Springer)

[3] Gusmida R and Islami N 2017 The Development of Learning Media for the Kinetic Theory of Gases Using the ADDIE Model with Augmented Reality Journal of Educational Sciences 01(01) 1-10

[4] Widodo A Y P, Yennita, Azhar and Islami N 2019 Development of Physics Learning Media on Rotational Materials Based on Interactive Multimedia Journal of Physics: Conference Series 1351 1-5

[5] Mariyo H, Islami N and Azizahwati 2019 Development of Sound Wave Experimentation Tools Which Influenced by Relative Humidity Using Audacity Journal of Physics: Conference Series 1351 1-4

[6] Azriani N, Islami N, Hermita N, Nor M, Syaodih E, Handayani H, Zulirfan Z, Suhandi A, Malik A, Mahbubah K and Samsudin A 2019 Implementing inquiry learning model to improve primary school students’ critical thinking on earth and universe concept Journal of Physics: Conference Series 1227 1-6

[7] Yennita, Mugi S and Zulirfan 2012 Hambatan Pelaksanaan Praktikum IPA Fisika Yang Dihadapi Guru Smp Negeri Di Kota Pekanbaru Jurnal Pendidikan 3(01) 994–1006

[8] Singh C and Rosengrant D 2003 Multiple-choice Test of Energy and Momentum Concepts American Journal of Physics 71 607-617

[9] Hestenes D and Wells M 1992 A Mechanics Baseline Test The Physics Teacher 30 159-166

[10] Saputri Y, Hakim Y and Fatmaryanti S D 2017 Pengembangan Alat Pengukur Energi Mekanik Pada Pokok Bahasan Usaha Dan Energi Berbasis Mikrokontroler Arduino Uno Untuk Meningkatkan Aspek Psikomotorik Siswa Radiasi 10(1) 29-34

[11] Erlangga S Y and Handoyo S 2018 Mini Roller Coaster (Miroco) sebagai Media untuk Menghitung Percepatan Ditinjau dari Energi Mekanik Risalah Fisika 2(02), 29–33

[12] Elyana, Azizahwati, Islami N and Rahmad M 2019 Development of Microcontroller-Based Straight Motion Experiment Devices Journal of Physics: Conference Series 1351 1-5

[13] Suhartiw F, Islami N, Fakhruddin and Yennita 2019 The Development of Learning Module Environmentally Friendly Technologies Based Creative the Problem Solving Journal of Physics: Conference Series 1351 1-4