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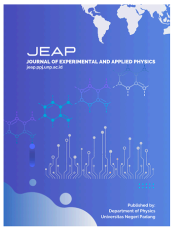

Development of Regular Circle Motion Experiment System with Remote Laboratory Based IoT using Web

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Abstract: Along with the development of Science and Technology, learning media is very diverse. Online learning resources are one of them. The utilization of the remote laboratory in education helps to improve instruction, particularly for experimental learning. The experimental system being built is anticipated to be able to provide reading results on the web, and it has a login system, a web-based queue system, and usage time limits. The Design and Development method is the method chosen in this study. The Design and Development technique is a systematic examination of the design, development, and assessment processes with the goal of establishing an empirical foundation for the development of new or improved models as well as instructional and non-instructional tools and products. The design and development process is described, examined, and assessed in this research as it relates to the tools and products that have been created. In general, this research aims to develop experiments of uniform circular motion using an internet-based remote laboratory. The accuracy value of the experimental system obtained was an average of 98.79% with an average error percentage of 1.21%. The accuracy value of the experimental system obtained is an average of 99.08%. Testing tools for experimental activities on the accuracy of measurement results on the web with manual measurements, obtained an average percentage of measurement errors on the web of 1.25% with an average accuracy of 98.75%.

Keywords: Remote Laboratory, Uniform circular motion experiment, Website

1. Introduction

Along with the development of Science and Technology, learning media is very diverse. In this day and age, the learning media that is often used can be a computer or Android. Not only

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computers and Android can be used as learning media, but there are also web-based learning media. Web-based learning media is learning using internet technology [1]. One form of utilizing web-based learning is the remote laboratory in the remote measurement of regular circular motion experimental systems.

Remote measurement has several purposes and functions. The purpose and function of remote measurement is that control and measurement can be carried out remotely. Remote measurement usually uses the internet in measuring and controlling it. Remote measurements can use websites, applications and the like. The purpose of using remote control is to facilitate human work. The measurement process can be carried out even if the user is not where the measurement occurs [2]. Experimental activities have goals that are expected to be achieved in doing so. The purpose of the experimental activity is the ability to seek and find answers to the problems faced. This experimental activity makes it easier to understand the answers to the problems faced because the experimental activities are done alone. The experimental system is a visual aid that has a goal of effective learning. The requirements of the experimental tool are in accordance with the concepts of physics and are easy to understand and easy to use [3]. In this research, the experiment to be studied is the uniform circular motion experiment.

The limitations of previous research are users who use them where in previous studies they cannot know who is using them and are not limited by the time they are used. It is this deficiency that makes this research less effective when applied to uniform circular motion experimental learning [4]. The development of a circular motion experimental system is based on the deficiencies of previous studies. The experimental system developed is expected to be able to display reading results on the web, there is a login system for controlling the experimental system, a queuing system on the web and usage time restrictions. These characteristics will be an added value in the development of a uniform circular motion experimental system so that its use will be more practical, effective and efficient.

The definition of circular motion is a particle moving at a level with a constant velocity and acceleration. Despite the fact that the velocity is fixed, the velocity vector is continuously changing, resulting in uniform circular motion at a constant velocity. The size of the immediate velocity vector is called velocity [6]. In everyday life circular motion can be associated with several examples. The principle of circular motion helps human life a lot. An example is circular motion that we often encounter, namely motion on wheels, fans, merry-go-rounds and so on [5].

Uniform circular motion has several characteristics. The characteristics of circular motion are that the direction of the velocity of the motion is perpendicular to the direction of acceleration at a constant velocity whose trajectory is a circle. Objects that move in the circular trajectory, the direction of velocity is constantly changing [6]. In uniform circular motion there are physical quantities, namely frequency, period, linear velocity and centripetal acceleration. While period is the amount of time (seconds) required to complete one rotation, frequency is the number of revolutions per unit of time (seconds). [7].

$$f = \frac{1}{T} \text{ where f is the frequency(hz)} \tag{1}$$

$$T = \frac{1}{f} \text{ where T is the period(s)} \tag{2}$$

For an object rotating at a constant velocity (v) to form a circle, it is obtained:

$$v = \frac{2\pi R}{T} \text{ where R is the radius} \tag{3}$$

The acceleration that is constantly pointed toward the center of the circle is known as centripetal acceleration (as), then:

$$as = \frac{v2 - v1}{\Delta t} = \frac{\Delta v}{\Delta t} \tag{4}$$

Δv is the change in velocity over time Δt. Consider the current situation Δt close to zero, so that the instantaneous acceleration is obtained. Because $\frac{\Delta l}{\Delta t}$ is the linear velocity of the object, then:

$$\overrightarrow{a_s} = \frac{v^2}{R} \tag{5}$$

Centripetal acceleration depends on v and R. the greater the speed v, the faster the speed changes direction and the greater the radius R, the slower the speed changes direction. In the figure it can be seen that, the velocity vector always goes in the direction tangential to the circle while the acceleration vector goes towards the center of the circle. The velocity and acceleration vectors are perpendicular to each other at every point of their path for uniform circular motion [8]. A remote lab is one that can be managed and monitored remotely through the internet. Experiments use real components or instrumentation in different locations from where they are controlled [9]. Unlike the virtual laboratory which can only observe without being able to interact with equipment in the laboratory [10]. Remote laboratory is an experimental activity that allows users to do it remotely via the internet [11]. Remote laboratory has several uses in its application. Remote laboratory is widely used in science and engineering. Utilization of remote laboratory is used in physics to be able to carry out remote experiments. Many physical theories require experimentation to be proven. Another use is to realize the effectiveness of experiments because the number of students is usually more than the facilities for experimental activities in developing countries [12].

IoT (Internet of Thing) can be defined as the ability of various devices to be connected to each other and exchange data through the internet network. IoT is a technology that allows control, communication, collaboration with various hardware devices, data via the internet network. So that it can be said that the Internet of Things (IoT) is when we connect something that are not operated by humans, to the internet [13]. The purpose of using IoT in this remote measurement is to allow everything to be connected anytime and anywhere. The concept of IoT refers to something that can be identified with a virtual representation in the structure of the internet. One of the uses of IoT can be from modules connected to IoT devices via wireless [14].

The World Wide Web is widely known as the web (website). The web is an information access system on the internet [15]. The web is composed of pages that use web technology and are related to one another. Another definition states that a website is a series or number of web pages on the internet that have related topics to present information [16]. The web and the internet are two different things. The Internet is more hardware and the web is software. The protocols used by the internet and the web are different; the internet uses TCP/IP as the protocol while the web uses HTTP (Hyper Text Transfer Protocol [17].

The overall goal of this project is to create uniform circular motion experiments using an internet-based remote laboratory. This study's specific goal is to evaluate the outcomes of an internet-based remote laboratory's performance evaluation of the parts of an experimental system for uniform circular motion. Determining the outcomes of tests for precision and accuracy using trials with uniform circular motion in a remote lab based on the internet of things. Establish system test outcomes for studies involving uniform circular motion in remote laboratories connected to the internet.

2. Materials and Method

The method chosen in this study is the Design and Development (D&D) method, which is, "the systematic study of design, development, and evaluation processes with the aim of establishing an empirical basis for the creation of instructional and non-instructional products and tools and new or enhanced models that govern their development". According to Richey and Klein (2007), the D&D model is a systematic examination of the design, development, and evaluation processes with the goal of establishing an empirical foundation for the development of educational and non-educational products and tools, as well as new or improved models [18]. This study raises the problem of limitations in the use of a circular motion experimental system which in the initial study found 3 studies related to this research. In previous research it was found that the use of the existing circular motion experimental system has limitations in its use which can only be accessed through the blynk application. So the researchers found a common problem in this research, namely how to develop an experimental system of regular circular motion so that it can be accessed either on a smartphone/PC.

To alleviate the problems raised in this study, the researchers designed and developed a website that can be accessed via a smartphone/PC that makes it easy for users to access the experimental circular motion system without having to be limited by the Blynk application like previous research. In general, the purpose of this research is to develop an interface in the form of a website which in use has a login system, a queuing system and can find out who is using the regular circular motion experiment system. The specific objective of this research is to test the tools that have been successfully developed. This circular motion experimental system has been designed using both hardware and software. The hardware design comprises of mechanical designs, while the software design consists of block diagram designs, flowchart designs, and web display designs, as shown in the image below.

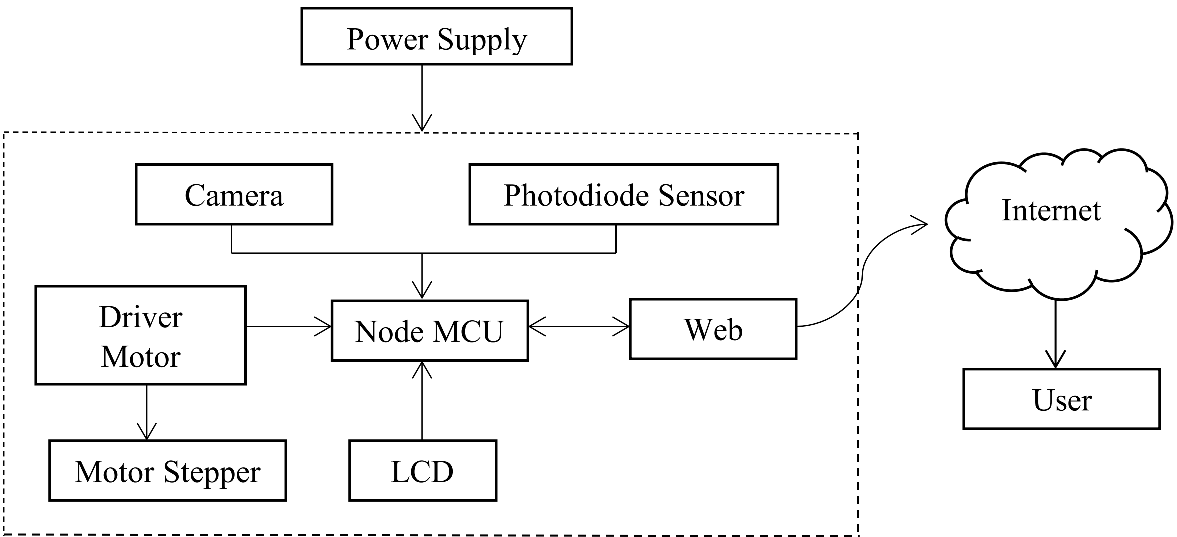

Figure 1. Block Diagram for Making a Circular Motion Experiment System

According to the explanation given in Figure 1's block diagram of a circular motion experiment system with a distant laboratory for remote measurements utilizing the WEB, a power source is required in order to turn on electronic circuits. The WEB as a platform for entering velocity measurements and round counts. The stepper motor will be driven by NodeMCU ESP 8226 after receiving speed input from the user's computer through WEB. Results The NodeMCU ESP 8266 controls the TB 6600 motor driver, which controls the stepper motor's speed. The photodiode sensor will measure the stepper motor speed, which NodeMCU will then analyze and display on the LCD and Web. Figure 2 shows the flowchart for the design of an experimental system for uniform circular motion that includes a distant laboratory for online measurements.

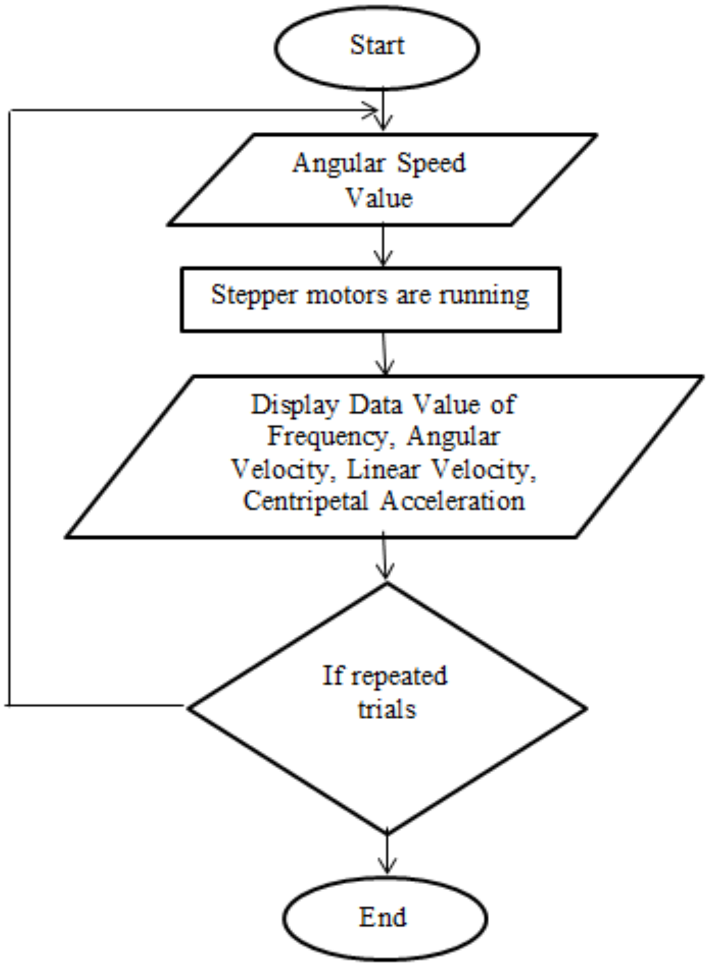

Figure 2. Design of Circular Motion Experiment System Software

A software design for a digital uniform circular motion experiment system is shown in Figure 2. The value or speed value is first entered via WEB. The stepper motor will be driven even at a distance thanks to data input from the WEB entering the nodeMCU. The data of the speed value and the number of revolutions will be displayed on the LCD display. If you want to repeat the experiment, does it again like the first step. The web display design can be seen in Figure 3.

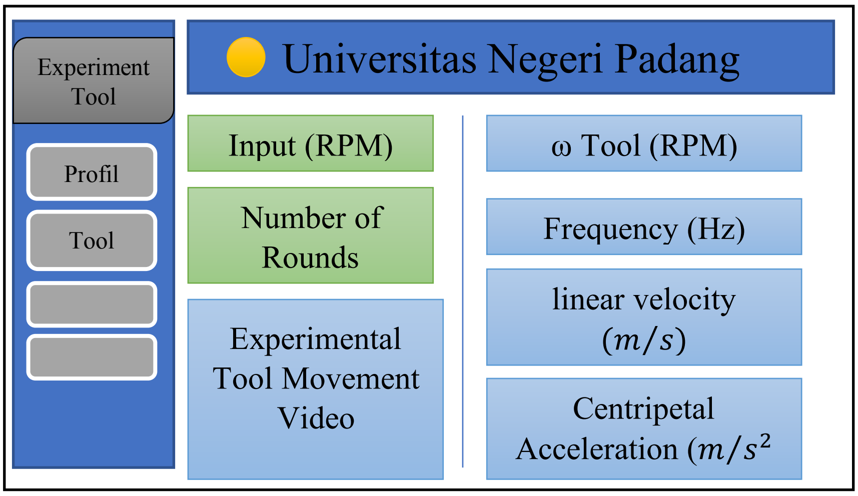

Figure 3. Digital Uniform Circular Motion Experiment System WEB Display Design

In Figure 3 is a website design which displays input in the form of angular velocity and number of revolutions. The measurement results on the website are displayed in the form of angular velocity measured by the tool (RPM), angular velocity (RPS), period (s), frequency (Hz), linear speed (m/s) and centripetal acceleration (m/s^2). The mechanical design of the circular motion experimental system can be seen in Figure 4.

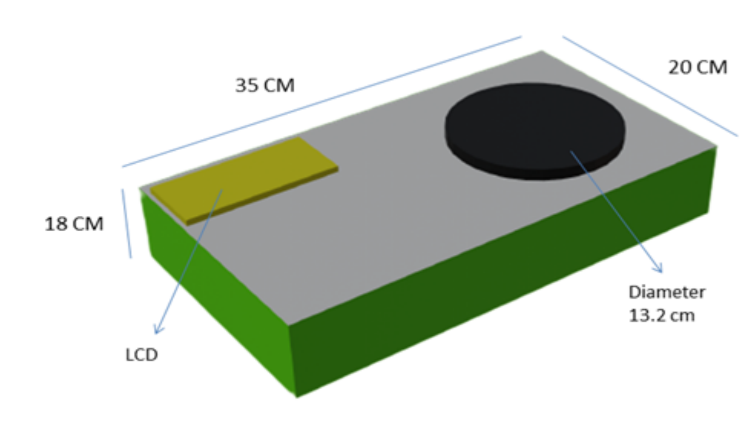

Figure 4. Digital Uniform Circular Motion Experiment System Mechanical Design

Figure 4 shows how the mechanical component of the experimental system for uniform circular motion was designed. The disk drive uses a stepper motor to revolve. TB 6600 motor driver controls speed. The LCD will show the speed and the number of revolutions. The first step can be to conduct the experiment again. After the tool development stage has been completed, the next stage is the tool trial stage. The testing of the tool was carried out on the performance specification trials of the circular motion experimental system components, precision testing, accuracy testing and trials for experimental activities. The trials carried out aim to determine the level of feasibility and effectiveness of the tools that have been developed. The results of the trials for this experimental activity are the basis for carrying out the final revision of the developed tool and then producing the final product. The following are the stages of the test that will be carried out.

The trial of the performance specifications of the components of the circular motion experimental system was the first trial carried out after the circular motion experimental system was developed. Testing was carried out with the aim of knowing the performance of each component in the experimental system. Accuracy testing is carried out by comparing the measurement results in the circular motion experimental system with existing standard measuring instruments. Accuracy testing is carried out by repeated measurements on an experimental system of uniform circular motion. The purpose of this test is to ensure that the measurement results are close to the true value.This is the last trial conducted by researchers to determine the effectiveness of the circular motion experimental system on the practicality of using the circular motion experimental system for experimental activities.

The accuracy and precision found through testing the circular motion experimental system are the outcomes of the accuracy and precision tests. By contrasting the experimental system with a common measurement device, notably the tachometer, the experimental system's accuracy can be determined. The evaluation results can be used to highlight the drawbacks and restrictions of creating an experimental system, which can spark interest in performing additional research.

3. Results and Discussion

Testing the performance requirements of each element of the circular motion experimental system constitutes the study's findings. Testing the circular motion experimental system's precision and accuracy. Experiments to test for homogeneous circular motion. Performance specification is the naming or describing of each system's function that makes up the modeling tool [19]. The uniform circular motion experimental system tool can be seen in Figure 5.

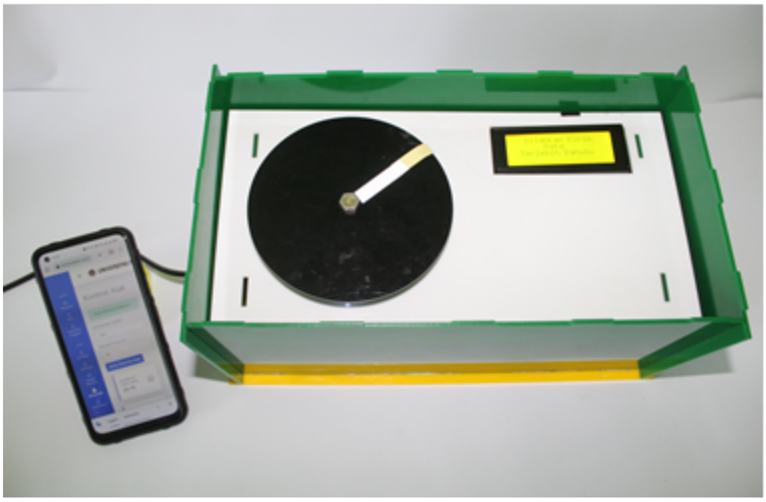

Figure 5. Uniform circular motion experiment system

An electronic circuit makes up an experimental system with uniform circular motion and a distant lab for long-distance measurements. The objective of the electronic circuit in the uniform circular motion experimental system with a remote laboratory is to ensure that the system performs correctly and as required. The primary electrical circuit of the uniform circular motion experiment system with a remote laboratory is made up of a number of parts. The electronic circuit for controlling uniform circular motion with a remote laboratory can be seen in Figure 6.

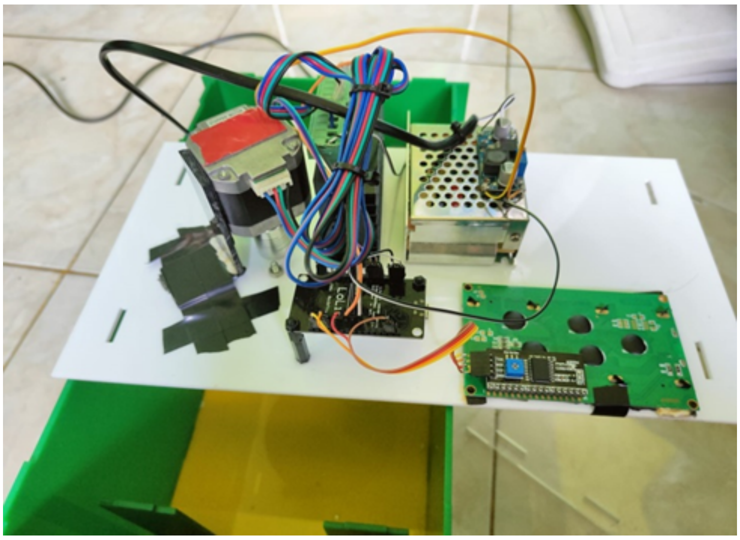

Figure 6. Uniform Circular Motion Control Circuit

The stepper motor functions as a disk drive. The stepper motor will rotate according to the value of the input angular velocity. Stepper motor moves with TB600 driver control. The stepper motor will move according to the digital pulses and not from the continuously applied voltage. These pulses will be translated into shaft rotation. One pulse produces one increase in rotation or commonly called a step. If more pulses or steps are used, the rotation of the stepper motor will be more accurate [20]. The performance of stepper motors and TB6600 drivers can work well, this can be seen from the measurements in Table 1.

Table 1. Performance Data of Stepper Motors and TB6600 drivers

No	ω input (RPM)	ω tool (RPM)	Accuracy (%)
1	40	38,11	95,28
2	80	80,11	99,86
3	120	121,73	98,56
4	160	159,22	99,51
5	200	202,86	98,57
6	240	239,19	99,66
7	280	279,86	99,95
8	320	318,49	99,53
9	340	342,79	99,18
	Average		98,90

The results of reading the motor speed on the apparatus where the stepper motor will move the disc in Table 1 demonstrate that the stepper motor functions properly. Table 1's data indicates that there isn't much of a difference between the angular velocity value at the input and the tool's measurement of angular velocity. An average accuracy of 98.90% was found for measurements taken at the stepper motor's angular speed. The stepper motor's angular velocity measurements yield angular velocity data that are reasonably close to the true angular velocity values.

Power Supply is equipment that provides voltage or a source of power for components in a uniform circular motion experiment system with the principle of changing the available electric voltage from the electricity transmission distribution network to the desired level so that it has implications for changing electric power [21]. Power Supply will supply voltage directly to the components. Table 2 displays the effectiveness of the power supply that was used.

Table 2. Results of Power Supply Performance Measurement

Name	Measurement results
Supply Voltage	85 - 264 VAC, 120 - 370 VDC
Supply Power	60W max
Output Voltage	12V DC
Output Current	5A
Voltage Range	12 V-15V DC

In Table 3 it can be explained that the supply voltage on the power supply ranges between 85-264VAC and 120-370VDC. For supply power with a maximum power of 60W with an output voltage of 12V DC and an output current of 5A. For output voltages with a range between 12V-15V DC. Based on the data in table 3 it can be seen that the power supply in the circuit is working properly. Display on the web is in the form of input and output which is accessed via a web page. On the web display, the input is displayed in the form of angular velocity and the number of revolutions while the output is in the form of frequency, period, angular velocity in units of RPM, angular velocity in units of rad/s, linear speed and centripetal acceleration. The display on the web can be seen in Figure 7.

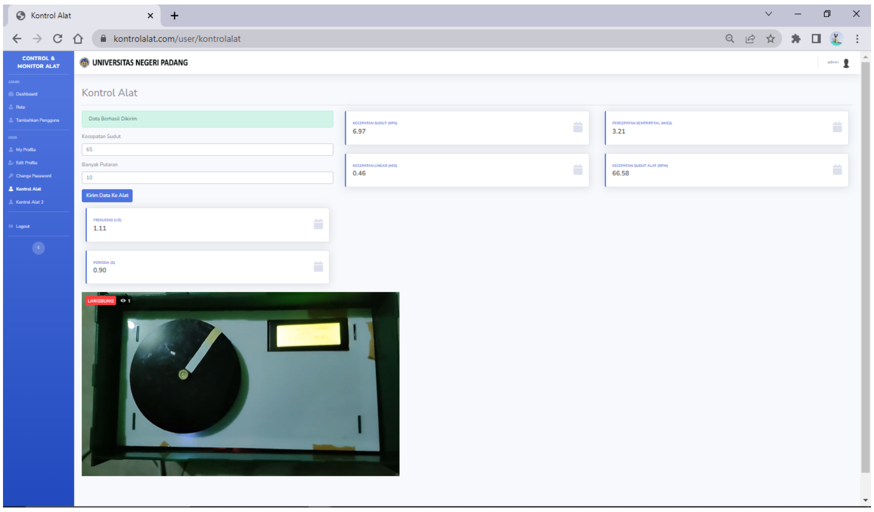

Figure 7. Web display on PC

The display on the web is in the form of input and output which is measured on the tool. the input on the web display is in the form of angular speed in RPM units and the number of revolutions. The tool generates measurements in the form of period, frequency, angular velocity, linear speed, and centripetal acceleration, which are then shown on the web. In addition to showing the tool's input and output online, it also shows real-time videos of the uniform circular motion experiment system in action.

Accuracy is the level of suitability or closeness of a measurement result to the actual price [22]. Comparing the measurement results of the stepper motor with those of a common measuring device, the tachometer, yields information on the accuracy of the angular speed of the stepper motor. Up to ten measurements were taken during the experiment. Table 3 contains information on the stepper motor's angular speed accuracy.

Table 3. Data on Accuracy of Stepper Motor Measurements with Standard Measuring Instruments

NO	ω input (RPM)	ω tool (RPM)	ω tachometer (RPM)	Error percentage (%)	Accuracy percentage (%)
1	60	58,00	56,5	2,59	97,41
2	70	68,99	69,5	0,74	99,26
3	80	77,63	76,4	1,58	98,42
4	90	89,43	88,3	1,26	98,74
5	100	99,06	97,6	1,47	98,53
6	110	110,58	109,7	0,80	99,20
7	120	122,56	121,8	0,62	99,38
8	130	130,36	129,3	0,81	99,19
9	140	142,79	141,2	1,11	98,89
10	150	152,41	150,7	1,12	98,88
Average				1,21	98,79

Based on Table 3, which represents the experimental system's measurement of the accuracy of the angular velocity, it can be shown that the steeper motor performs well and as intended. There is not much of a difference between the tachometer reading and the stepper motor speed. When compared to conventional measuring devices, the experimental system's capacity to manage angular velocity is very near to the actual value. When compared to conventional measuring devices, the experimental system's capacity to manage angular velocity is very near to the actual value. The average rate of error for accuracy measurements using a standard measuring device is 1.21%, and the average accuracy percentage is 98.79%.

Data on accuracy is produced by comparing the input into the tool with the outcomes of measurements made there, where measurements were made there ten times. A percentage of accuracy and a percentage of errors will be produced by comparing the results of the data collected. For each data, the experiment was run ten times. Three data points at angular speeds of 120 rpm, 180 rpm, and 240 rpm show precision. Table 4 contains information on the stepper motor's angular speed precision.

Table 4. Data on Precision of Measurement of Angular Velocity of Experimental System

Measurement to-	ω tool (RPM)		
	120	180	240
1	118,27	179,65	242,72
2	121,64	180,51	239,05
3	117,83	180,08	240,23
4	117,75	179,95	238,86
5	120,92	181,66	240,83
6	120,52	179,68	238,84
7	119,76	180,74	238,75
8	121,16	178,83	240,69
9	122,23	180,92	239,89
10	121,03	179,06	239,43
Average	120,11	180,11	239,93
Eror (%)	1,44	0,19	1,13
Precision (%)	98,56	99,81	98,87

Based on the data analysis in Table 4, it can be deduced that at an angular speed of 120 rpm, the measurement accuracy percentage is 98.56% and the error percentage is 1.44%. The accuracy is 0.19% and the precision is 99.81% for stepper motor angular speed data at 180 rpm. The 240 rpm stepper motor's accuracy for angular speed is 98.87%, and the error percentage is 1.13%. The three stepper motors' combined data accuracy for measuring angular speed is 99.08% on average.

The data obtained from testing tools for this experimental activity is from measurements on the experimental system and manual measurements on the experimental system. Accuracy and errors are obtained by comparing the measurement results of the experimental system with manual measurements on the experimental system. In testing for this experimental activity, 5 trials were carried out with an angular velocity range of 110 to 150 in RPM units. This can be seen in Table 5 and Table 6.

Table 5. Measurement Data on Regular Circular Motion Experiment System

No	ω input (RPM)	Tool (rad/s)	f (Hz)	T (s)	v (m/s)	a (m/s²)
1	110	11,45	1,82	0,55	0,76	8,66
2	120	12,68	2,02	0,5	0,84	10,61
3	130	13,62	2,17	0,46	0,9	12,25
4	140	14,76	2,35	0,43	0,97	14,38
5	150	15,66	2,49	0,4	1,03	16,19

Table 6. Manual Measurement Data on Regular Circular Motion Experiment System

NO	ω (RPM)	ω (rad/s)	f (Hz)	T (s)	v (m/s)	a (m/s²)
1	105,26	11,02	1,75	0,57	0,73	8,01
2	120	12,56	2	0,5	0,83	10,41
3	130,43	13,65	2,17	0,46	0,9	12,3
4	139,53	14,6	2,33	0,43	0,96	14,08
5	150	15,7	2,5	0,4	1,04	16,27

Based on Table 5, which shows measurements on an experimental system for uniform circular motion in which values for physical quantities are derived from readings on a system for circular motion that is exhibited online. Similar to table 6, the physical quantities' values were determined by manually measuring how long it takes for one revolution (period). While calculating the magnitude of the angular velocity, period, linear velocity, and centripetal acceleration using the formulas found in uniform circular motion. Table 7 displays the percentage of accuracy and error. Comparison between angular velocity measurements on tools and manual measurements.

Table 7. Comparison of Angular Speed on Tools with Manual Measurements

NO	ω Tool (rad/s)	ω Calculate (rad/s)	Eror (%)	Accuracy (%)
1	11,45	11,02	3,76	96,24
2	12,68	12,56	0,95	99,05
3	13,62	13,65	0,22	99,78
4	14,76	14,6	1,08	98,92
5	15,66	15,7	0,26	99,74
	Average		1,25	98,75

Based on Table 7 it can be explained that the angular velocity on the web and on manual measurements is not much different. The error in the 5 measurements obtained ranged from 0.22% - 3.76% with an average error of 1.25%. The accuracy obtained ranges from 96.24% - 99.78% with an average accuracy of 98.75%. From the average percentage of error, which is equal to 1.25%, it is found that the reading of the measurement results on the web is close to the actual measurement results.

The relationship between physical quantities can be noticed in regular circular motion tests to test for experimental activities. The formula is used to obtain data on centripetal acceleration, linear velocity, and frequency. The experimental system's angular velocity will be processed to yield frequency information, linear velocity, and centripetal acceleration. Table 8 contains information on the correlation between physical quantities.

Table 8. Relationship between Physical Quantity in Regular Circular Motion

NO	ω input (RPM)	ω Tool (rad/s)	f (Hz)	T (s)	v (m/s)	a (m/s²)
1	60	6,48	1,03	0,97	0,43	2,77
2	70	7,48	1,19	0,84	0,49	3,69
3	80	8,32	1,33	0,75	0,55	4,57
4	90	9,46	1,51	0,66	0,62	5,91
5	100	10,39	1,65	0,6	0,69	7,12
6	110	11,45	1,82	0,55	0,76	8,66
7	120	12,68	2,02	0,5	0,84	10,61
8	130	13,62	2,17	0,46	0,9	12,25
9	140	14,76	2,35	0,43	0,97	14,38
10	150	15,66	2,49	0,4	1,03	16,19

Based on Table 8, specifically the frequency data, linear velocity and centripetal acceleration were calculated using angular velocity. The relationship between the angular velocity and frequency is explicable in Table 8. The frequency of a circular motion is the number of rotations per second. If the angular velocity value is higher, the frequency value will be higher and vice versa [23]. Because the angle traversed per second increases with the number of rotations per second, frequency and angular velocity are directly related. This is consistent with accepted theory. Figure 7 depicts the correlation between angular velocity and frequency.

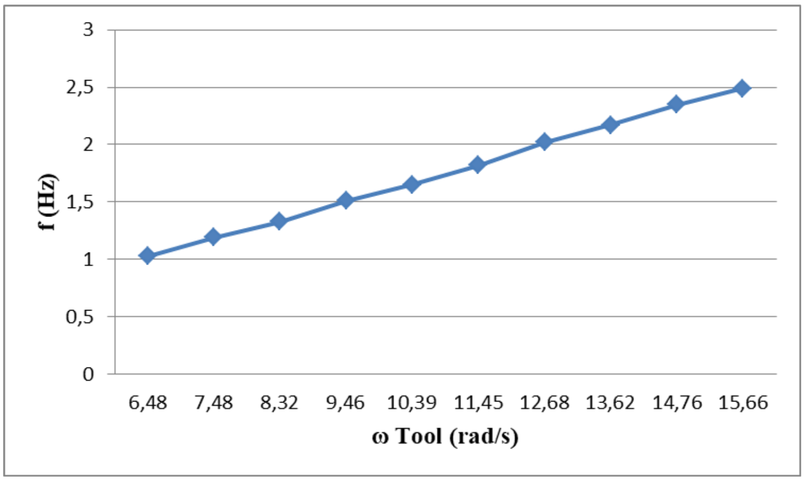

Figure 8. The link between frequency and angular velocity

Using the link between angular velocity and frequency graph in Figure 7. Figure 7 demonstrates how the angular velocity and frequency are inversely related. The frequency increases with increasing angular velocity and vice versa. The graph in Figure 7 supports the accepted idea. The relationship between physical quantities in uniform circular motion is based on Table 8. The relationship between the angular and linear speeds is explicable in Table 8. From circular motion, linear speed is a direction that looks like a tangent to a circle. Figure 8 depicts the link between angular speed and linear speed.

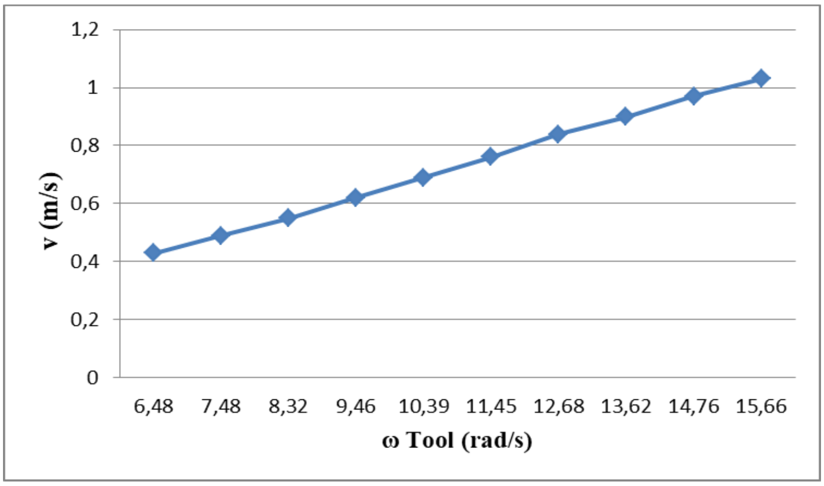

Figure 9. The connection between angular and linear velocities

Specifically, the correlation between angular and linear speed is based on Figure 9. Figure 9 explains how the angular speed and linear speed are proportional. The linear speed increases with increasing angular speed and vice versa. The graph in Figure 18 demonstrates that it is consistent with the accepted idea. The relationship between physical quantities in uniform circular motion is based on Table 8. The relationship between centripetal acceleration and angular velocity is explicated in Table 8. The direction of linear speed is represented as a tangent to the circle of circular motion. According to the accepted hypothesis, if the angular velocity value is higher, the linear speed will also be higher and vice versa. Figure 10 depicts the link between angular velocity and centripetal acceleration.

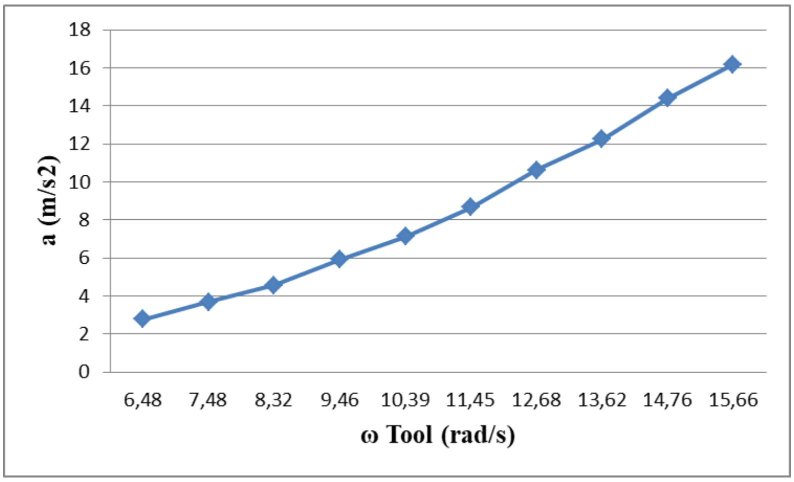

Figure 10. Centripetal acceleration and its relationship to angular velocity

Specifically, the correlation between angular velocity and centripetal acceleration as seen in Figure 10. It is clear from Figure 10 that centripetal acceleration is inversely related to angular velocity. The centripetal acceleration increases with increasing angular velocity. The graph in Figure 10 supports the accepted idea.

4. Conclusion

Based on the test results and data analysis and discussion of the remote laboratory uniform circular motion experimental instrument with angular velocity control, several conclusions can be formulated. First, the performance specifications of stepper motors and TB6600 drivers with 200 steps for each rotation, the angular velocity value at the input is not much different from the angular velocity measurement data on the tool. Power supply which is a voltage provider in a circuit that functions properly with an output voltage of 12V-15V DC. The data display's performance on the web is consistent with the measurements made. Second, the uniform circular motion experimental system's precision and accuracy are fairly near to the actual value when measured against a tachometer, a common measurement device. The experimental system's accuracy value was on average 98.79%, with an average error rate of 1.21%. The experimental system's accuracy value was averaged out to be 99.08%. Based on these findings, the experimental system's angular velocity control, when compared to the tachometer, is near to the actual value. Third, testing tools for experimental activities on the accuracy of measurement results on the web with manual measurements, obtained an average percentage of measurement errors on the web of 1.25% with an average accuracy of 98.75%. The frequency value will be greater by using a greater angular velocity value. The effect of angular speed and linear speed is directly proportional. The value of centripetal acceleration is proportional to the square of the angular velocity.

References

[1] Rusman, "Model-model Pembelajaran", Depok: *Raja Grafimdo Persada*, 2018.

[2] Effendy, M. "Desain Implementasi Pemantauan Jarak Jauh (Remote Monitoring) Pada Sistem Hibrid PLTMH-PLTS UMM (Universitas Muhammadiyah Malang) Berbasis WEB". *Jurnal Transmisi*, 2013. Vol.15, No. 2, 54-59.

[3] Widayanti, & Yuberti, "Pengembangan Alat Praktikum Sederhana Sebagai Media Praktikum Mahasiswa". *Jurnal Inovasi Pendidikan Fisika dan Risistem Ilmiah*, 2018. Vol.2, No.1, 21-27.

[4] Chazanah, Iddya, "Rancang Bangun Sistem Eksperimen Gerak Melingkar Beraturan dengan Remote Laboratory untuk Pengukuran Jarak Jauh". *Padang: Universitas Negeri Padang.* 2022.

[5] Yolenta, D., Sutrisno, L., & Haratua, "Deskripsi Miskonsepsi Siswa SMA Sekecamatan Kapuas Tentang Gerak Melingkar Beraturan Menggunakan Three-Tier Test". 2015. Vol.4, No.3, 1-7

[6] Karyono, Palupi, D. S., & Suharyanto. "Fisika: Untuk SMA dan MA Kelas X". *Jakarta: Pusat Perbukuan, Departemen Pendidikan Nasional.* 2009.

[7] Sumarsono, J. „Fisika: Untuk SMA/MA Kelas X. (D. Nuraini, Ed.)" *Jakarta: Pusat Perbukuan, Departemen Pendidikan Nasional.* 2009

[8] Sutrisno. „Fisika Dasar: Mekanika Dalam Jilid 2". Bandung: *Institut Teknologi Bandun*g. 1977.

[9] Chen, X., Song, G., & Zhang, Y, "Virtual and Remote Laboratory Development", *Houstan: Asce*. 2010

[10] Kustija, J., Ana, A., & Jayanto, N. D, "Web-Based and Thinvnc Remote Laboratory Implementation To Support Students Skills In Mechatronics Course To Face The Indrustial Revolution 4.0", *Journal of Engineering Science and Technology*. 2021. Vol. 16, No. 2.

[11] Cooper, M., Donnelly, A., & Ferreira, J. Remote Controlled Experiments for Teaching Over The Internet: A Comparision Of Approaches Developed In The Pearl Project. 2002.

[12] Fabregas, E., Farias, G., Dormido, S., & Esquembre, F. Developing A Remote Laboratory For Engineering Education. 2011.

[13] R. Hafid Hardyanto, "Konsep Internet Of Things Pada Pembelajaran Berbasis Web", Jurnal Dinamika Informatika Volume 6, No 1, Februari 2017 ISSN 1978-1660 : 87 - 97 ISSN online 2549-8517

[14] Vermesan, O., & Friess, P. (Eds.). Internet of Things-From Research and Innovation to Market Deployment. Denmark: River Publisher Series in Comunication. 2014.

[15] Abdul Kadir. Pengenalan Sistem Informasi Edisi Revisi. Andi.Yogyakarta. 2014.

[16] Ginanjar, T. Rahasia Membangun Website Toko Online Berpenghasilan Jutaan Rupiah. Bandung: Iffahmedia. 2014.

[17] Agus Ali Suharto. Pengaruh Kualitas Sumber Daya Manusia, Komitmen Dan Motivasi Terhadap Kinerja Pegawai Pada Inspektorat Kabupaten Kediri. Jurnal Ilmu Manajemen, Revitalisasi, 2012. Vol. 1, Nomor 3

[18] Richey, R. C., & Klein, J. D. Design and development research. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers. 2007..

[19] E. Triaga, Yulkifli, and Yohandri, "Pembuatan Air Track Untuk Eksperimen Kinematika dan Dinamika Berbasis Mikrokontroler Atmega328," Pillar of Physics, vol. 10, pp. 14–22, 2017.

[20] Ismaranatasia, W., Sistemiawan, B., & Subiyantoro. Kendali Motor Stepper untuk Pergerakan Sumbu X, Y, Z pada 3D Printer Simetris Bilateral. Jurnal Elkolind, 2021. VIII(2).

[21] Almanda, D., & Yusuf , H. Perancangan Prototype Proteksi Arus Beban Lebih Pada Beban DC Menggunakan Mikrokontroller (Vol. 14). Jakarta: Jurnal Elektrum. 2017.

[22] Coper, W. Instrumentasi Elektronika dan Teknik Pengukuran. Jakarta: Erlangga. 1999.

[23] Giancoli, D.C. Fisika Jilid 1. Edisi ketujuh. Jakarta: Erlangga. 1998.