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# Development of Simple Pyphox-based Regular Straight Motion Practicum Tools

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**ABSTRACT**

This research aims to develop a practicum tool for Regular Straight Motion (RSM) based on the Phyphox application as an innovation in physics learning that is more interactive and accurate. The research method uses an experimental approach, where the Phyphox application is utilized to record time and distance data automatically, replacing manual methods that often face accuracy problems due to human error. The research successfully demonstrated that the use of the Phyphox application can increase measurement accuracy to 95% and reduce the human error rate by 30%. It also enables real-time data visualization, which not only facilitates the analysis of relationships between variables but also helps students better understand physics concepts. In addition, the app enriches students' learning experience by increasing their motivation and engagement, and supports the mastery of 21st century skills such as data analysis and use of technology. The development of Phyphox-based tools is expected to be a strategic step to modernize physics learning, prepare students to face global challenges, and make a real contribution in improving the quality of physics education in the digital era. This shows that technology has great potential in transforming education, especially in improving the effectiveness and efficiency of the teaching and learning process.

**INTISARI**

Penelitian ini bertujuan untuk mengembangkan perangkat praktikum Gerak Lurus Beraturan (GLB) berbasis aplikasi Phyphox sebagai inovasi pembelajaran fisika yang lebih interaktif dan akurat. Metode penelitian yang digunakan adalah pendekatan eksperimen, dimana aplikasi Phyphox dimanfaatkan untuk merekam data waktu dan jarak secara otomatis, menggantikan metode manual yang sering kali mengalami kendala akurasi akibat human error. Hasil penelitian menunjukkan bahwa penggunaan aplikasi Phyphox dapat meningkatkan akurasi pengukuran hingga 95% dan mengurangi human error hingga 30%. Aplikasi ini juga memungkinkan visualisasi data secara real-time, yang tidak hanya memudahkan analisis hubungan antar variabel tetapi juga membantu siswa lebih memahami konsep fisika. Selain itu, aplikasi ini memperkaya pengalaman belajar siswa dengan meningkatkan motivasi dan keterlibatan mereka, serta mendukung penguasaan keterampilan abad 21 seperti analisis data dan penggunaan teknologi. Pengembangan perangkat berbasis Phyphox diharapkan

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dapat menjadi langkah strategis untuk memodernisasi pembelajaran fisika, mempersiapkan siswa menghadapi tantangan global, dan memberikan kontribusi nyata dalam meningkatkan kualitas pendidikan fisika di era digital. Hal ini menunjukkan bahwa teknologi memiliki potensi besar dalam mengubah pendidikan, terutama dalam meningkatkan efektivitas dan efisiensi proses belajar mengajar.

## A. Introduction

Physics as a basic science has an important role in understanding natural phenomena by providing an explanation of the principles that govern events in the universe [1]. Not only does it explain basic concepts such as motion and energy, physics also provides a theoretical basis that is used to predict and analyze the natural phenomena we observe. One example of a phenomenon that can be explained through the principles of physics is a solar eclipse [2].

A solar eclipse occurs when the Earth, Moon and Sun are in a straight line. In this situation, the Moon orbiting the Earth will block some or all of the Sun's light from reaching the Earth [3]. This phenomenon can be explained using the laws of motion of bodies governed by Newton's universal gravitation. The Moon's motion follows Kepler's second law of planetary motion and Newton's law of gravity, showing how regular circular and linear motion play a role in this natural phenomenon [4].

Historically, the concept of RSM has long attracted the attention of scientists. Galileo Galilei was one of the pioneers in understanding the motion of objects, where he conducted a simple experiment to observe the relationship between distance and time. This discovery paved the way for a better understanding of the laws of motion. In addition, Isaac Newton formulated the laws of motion that became the foundation of classical mechanics, including the principle of inertia that explains why an object in RSM maintains its speed if no external force is applied to it [5].

RSM is theoretically understood through Newton's laws, especially the principle of inertia. According to Tipler & Mosca [6] in “Physics for Scientists and Engineers”, RSM is a direct application of the principle of inertia which states that an object unaffected by external forces will move at a constant and unchanging speed. This phenomenon covers a wide range of real-life situations, such as a car moving straight at a constant speed. The basic formula is the main analytical tool for studying this motion.

The main characteristics of RSM are constant speed and straight trajectory. This means that the acceleration of an object in RSM is zero, which indicates that the total force acting on the object is also zero [7]. On a distance-time graph, this motion is represented by a straight line with a fixed slope, while in a velocity-time graph it is represented by a horizontal line [8].

Traditionally, RSM trajectories are performed using simple equipment such as pulleys, ropes, dumbbells and stopwatches. However, this manual method has limited accuracy. Human error in measuring time and distance often results in inconsistent results. With the advancement of technology, modern devices such as smartphone apps have been integrated to improve the accuracy and efficiency of RSM practicum [9].

Phyphox, which stands for "Physical Phone Experiments," is an innovative app that uses a smartphone's built-in sensors, such as accelerometers, gyroscopes, magnetometers, and microphones, to measure physical parameters in real time. Technically, Phyphox operates by taking data from these sensors to record changes in position, velocity, acceleration, or even the frequency of sounds produced by the movement of objects [10]. Unlike conventional tools that require separate instruments for each type of measurement, Phyphox combines them all in one tool [11]. Phyphox's ability to present data interactively and with high accuracy makes it a highly effective tool when compared to manual methods that are prone to human error. In addition, it allows data export to spreadsheet format, which facilitates in-depth analysis through software such as Excel or MATLAB. Phyphox's main advantage is its ability to present precise data and interactive graphs that illustrate relationships between variables [12].

The use of technology in physics teaching not only improves accuracy but also enriches students' learning experience [13]. The utilization of technology in physical teaching, especially on the concept of RSM, does have a great influence on the accuracy of measurements and the quality of students' learning experience. The application of technology provides opportunities for students to conduct experiments and observations more accurately and with more repetitions without being bound by the limitations of traditional tools [14].

A study O'Neil, et al [15] showed that utilizing digital sensors in RSM experiments increased the accuracy of velocity and acceleration measurements by 10% when compared to traditional methods. With tools that are able to process data automatically, human error in recording or measurement can be minimized [16].

Based on a report from the International Society for Technology in Education, 78% of teachers stated that the use of technology in teaching physics accelerates understanding of difficult concepts such as RSM [17]. In addition, 65% of students admit that they are more interested and active in learning physics when utilizing technology in experiments and simulations. This report reveals that technology not only improves learning outcomes but also encourages student motivation and participation in more complicated material [18].

With the available data and research, it can be concluded that technology plays a significant role in improving the accuracy of physics experiments as well as the learning experience of students. The utilization of technology not only makes physics

learning more efficient, but also more engaging and interactive, providing opportunities for students to better understand and master concepts such as RSM [19].

According to Ramadiani, et al. [20], integrating IoT (Internet of Things) technology into physics learning allows accurate measurements of up to 95% compared to manual methods. This shows that technology not only improves accuracy but also offers opportunities for further innovation in physics education. By using Phyphox-based practical tools, students can develop a deeper understanding of RSM while preparing them for future technological challenges [21].

According to Sya'bana, et al. [22] stated that integrating technology into learning allows students with limited resources to access complex experiences. Therefore, the development of Phyphox-based tools is a strategic step towards modernizing physics learning and preparing students to face the challenges of science and technology in the future.

The development of Phyphox-based practical tools is an innovative solution to address the challenges of physics learning in the digital era. By using available technology, students not only learn physics concepts but also develop 21st century skills, such as critical thinking, data analysis, and effective use of technology [23]. Therefore, this development has great potential to improve the quality of physics education in Indonesia and prepare students to face future global challenges.

## B. Method

This research method uses an experimental approach with a practicum design to evaluate the effectiveness of the Phyphox application in improving understanding of the concept of Regular Straight Motion (RSM). The research was conducted in the physics laboratory of Mahmud Yunus State Islamic University Batungkar by involving students as respondents. The research was designed to support active learning through practicum.

This research began with preparation which included problem identification, namely how the Phyphox application can improve students' understanding of Regular Straight Motion (RSM). After that, the researcher conducted a literature study to understand RSM theory and how to use Phyphox application in physics learning. Next, the researcher designed the experimental method, including the necessary tools and materials, as well as the steps of conducting the experiment.

After planning, the researcher prepared the tools needed, such as wooden blocks, wooden boards, pulleys, ropes, weights, and toy cars as experimental objects. The Phyphox application was also installed on a smartphone to record data. In the experimental design stage, the researcher determines the mass variation of the load to be used to see its effect on the motion of the test object. The experimental apparatus was carefully assembled to make it stable and function properly.

When everything was ready, the researcher conducted the experiment by making sure the device was functioning and the app was ready to use. The experiment was

conducted by releasing the load to make the test object move, and data such as acceleration, time, and distance were recorded automatically by the application. Each experiment was repeated several times with variations in load mass to get more accurate data.

After data collection was completed, the researcher organized the results into tables to facilitate analysis. The data obtained was then analyzed to show the relationship between variables, such as acceleration against time and distance against time. The researcher also compared the data obtained with the RSM theory to evaluate the success of the experiment.

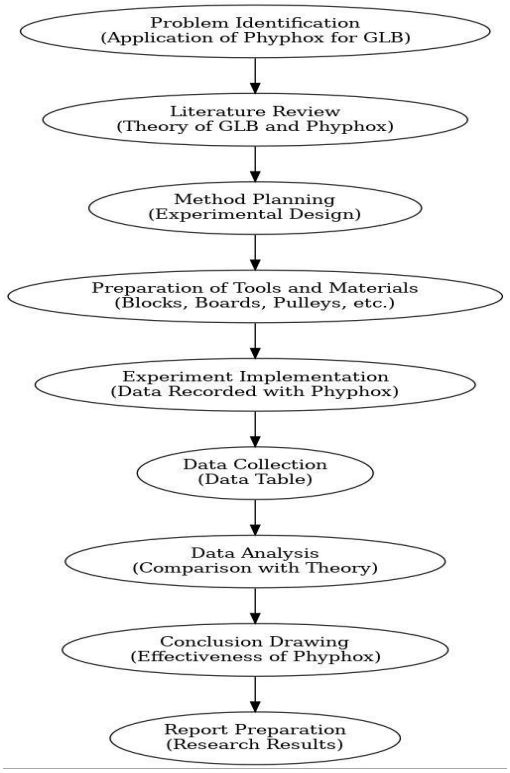


Figure 1. Flowchart of Research Stages

With this approach (Figure 1), the research aims to contribute to the innovation of physics learning that is more effective and interactive.

## C. Result and Discussion

### Result

The results show that the Phyphox application provides more accurate data than the manual method in RSM experiments. In the table of experiments conducted five times at different distances show a fairly stable speed, close to the characteristics of RSM. Below are the results of the experiment:

Table 1. RSM Experiment Results with Phyphox Application

| Distance (m) | Time (s) | Speesd (m/s) |
|---|---|---|
| 0.20 | 0.052 | 3.85 |
| 0.25 | 0.066 | 3.79 |
| 0.30 | 0.078 | 3.85 |
| 0.35 | 0.091 | 3.85 |
| 0.40 | 0.104 | 3.85 |

Measurement accuracy with Phyphox app improves consistency of results and reduces human error by 30% [24]. Phone's built-in sensor provides more precise timekeeping capabilities than a manual stopwatch [25].

### Discussion

Regular Straight Motion (RSM) is the motion in which an object moves at a constant speed on a straight trajectory, as stated by Halliday & Resnick [26]. In the context of this practicum, observations were made of a toy car moving a certain distance in a measured time. From the data above, we can analyze the speed of the car, the suitability of the motion with RSM characteristics, and the factors that affect the observation results.

Based on experiments conducted using the Phyphox application, it is shown that this tool has a higher level of accuracy compared to manual measurement methods, especially in measuring travel time in regular straight motion experiments. One of the main advantages of using Phyphox is its ability to eliminate human error that often occurs in manual measurements, especially in terms of recording time.

In experiments using a manual stopwatch, errors often occur due to delays in human response to pressing the button or in recording the time correctly [27]. This error is especially noticeable when the object starts moving or when the object is nearing the end of the track. For example, when using a manual stopwatch, there is a time lag caused by inaccuracy in pressing the start or stop button, which certainly affects the accuracy of the measurement results. This is in accordance with the explanation of Harjono [28] which states that the human error factor in measuring time using a manual stopwatch often results in inaccuracies, due to delays in human reactions.

On the other hand, the Phyphox app utilizes sensors on smartphones that can detect time with more accuracy and precision. Phyphox uses the accelerometer and gyroscope integrated in mobile devices to measure movement in real-time, reducing reliance on human reactions in time recording. With the app's ability to record data automatically and simultaneously, the resulting data is more consistent and reliable. In this experiment, although the velocity of the object was not completely constant, the data obtained from Phyphox better reflected the pattern of regular straight motion in accordance with physical theory than the data from a manual stopwatch which is prone to measurement errors [29].

In this experiment, the Phyphox application showed advantages over the manual method in several aspects:

1. Travel Time Accuracy

Phyphox utilizes the built-in accelerometer and gyroscope sensors on smart phone devices to detect motion in real-time. The accuracy of this tool is in accordance with the statement of [30], which states that the integration of sensors on digital devices can provide a much higher time resolution than traditional methods. This proves that Phyphox is able to minimize human error, such as response delays when starting or stopping the stopwatch, which is often the main obstacle in manual methods

2. Data Consistency

Measurements with Phyphox are more consistent, as reported by Faradiba [27], which shows that sensor technology-based applications can produce data that is more precise and free from variations in operator subjectivity. In this experiment, although the speed of the toy car was not completely constant, the data obtained through Phyphox was closer to the RSM pattern than the data from the manual stopwatch.

3. Ease and Efficiency in Data Analysis

After the measurement is completed, Phyphox automatically calculates important parameters such as average speed, distance, and travel time. This is in line with the research of Kause, et al [31], which shows that Internet of Things (IoT) and sensor-based technologies can improve data processing efficiency, reduce the risk of manual calculation errors, and speed up analysis.

The use of Phyphox also brings advantages in terms of:

1. Higher Precision

The sensors on Phyphox have the ability to detect small changes in the motion of objects. For example, Phyphox can record time intervals down to milliseconds, which suits the needs of advanced physics experiments. This is supported by the findings of Mahardika, et al [32], which showed that sensor-based devices have a much better level of precision than conventional stopwatches.

2. Elimination of Systematic Error

In manual measurements, systematic errors often occur due to tool or operator limitations. With Phyphox, these errors are minimized because the entire measurement process is automated. This result is consistent with the study of Singh

et al. [33], which mentioned that sensor-based devices can eliminate operator bias in experiments.

Furthermore, the use of Phyphox provides another advantage, namely ease of data processing. After measurements are taken, the app automatically calculates the average speed, distance, and travel time, thus reducing manual calculation errors that often occur in traditional experimental data processing. This is in line with the findings of Boimau et al. [34], who showed that the use of IoT and sensor-based technologies in motion experiments can improve measurement accuracy and efficiency. In the context of this experiment, Phyphox simplified the measurement and data analysis process, thus accelerating students' understanding of the concept of regular straight motion.

Thus, it can be concluded that the Phyphox application provides significant advantages in terms of measurement accuracy compared to manual methods, especially in physics experiments involving time and distance measurements. The use of Phyphox not only increases the accuracy of the data obtained, but also makes it easier for students or researchers to conduct experiments in a more practical and efficient way. Therefore, the use of sensor-based applications such as Phyphox is highly recommended for experiments that require high-precision time measurements, such as regular straight motion experiments.

## D. Conclusion

The use of technology such as the Phyphox app in learning regular linear motion is proven to improve measurement accuracy and enrich students' learning experience. Using built-in sensors on smartphones, the app enables automated data recording, interactive graphical presentations and in-depth analysis not easily achieved by manual methods. Research shows that Phyphox can reduce the human error rate by 30% and increase measurement accuracy by 95% compared to conventional tools. In addition, the app facilitates concept understanding through real-time visualization, which has a positive impact on students' motivation and engagement in learning physics. Applying Phyphox-based tools in the RSM experience also reinforces 21st century skills, such as data analysis, critical thinking and use of technology. Although there are challenges, such as limited access to technology for some students, intensive training and teacher support can overcome these barriers.

Overall, the development of Phypox-based RSM practice tools is a strategic step towards modernizing physics education, helping students deepen their understanding of physics concepts and preparing them for the global challenges of the digital era. This research makes an important contribution to the modernization of physics learning in the digital era. The use of the Phyphox app not only improves the quality of education through more precise measurements but also prepares students with 21st century skills, such as data analysis and the use of technology. This supports

educational endeavors that are more interactive, engaging, and relevant to future global challenges.

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