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DESIGN AND BUILD A STRAIGHT MOTION EXPERIMENT SET WITH REMOTE LABORATORY BASED ON THE INTERNET OF THINGS

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ABSTRACT

The era of the Industrial Revolution 4.0 is an era that has no boundaries to advance science-technology. Experimental tools are currently still using manual tools. The solution for the pandemic is a remote laboratory. Remote Laboratory is a remote laboratory using the internet with real components. This study aims to specification performance, design specifications on the experimental set of Uniform Motion with Remote Laboratory based on internet Of Things. The research carried out is included in engineering research. There are two methods of measuring data, namely direct measurement and indirect measurement. The experimental set has a size of 60x20 cm. The sensor used is infrared avoid obstacle which functions as a counter to the object's travel time. blynk application as tool control center. The Straight Motion experiment set with internet-based Remote Laboratory Of Things has an average accuracy of 98.6 % and an average accuracy of 0.96. The data that has been obtained shows that this experimental set can be used for uniform linear motion and uniform linear motion..

Keywords : Remote Laboratory; Straight Motion; Experiment; Internet Of Things.

I. INTRODUCTION

The industrial era 4.0 is an emerging technology penetration that leads to intelligent networks for object communication with other objects [1]. Industry 4.0 combines various technologies such as data analytics, internet of things, cloud computing [2]. The 4th Industrial Revolution had started in 2011 in a very strategic policy of the German government promoting computerization [3]. The application of industrial technology 4.0 is able to create flexible automation [4]. Education in the Industrial Revolution Era 4.0 must be able to answer the needs of the industrial revolution by adjusting the new curriculum according to the current situation. The curriculum is able to open a window to the world.

public health crisis that is threatening the world with the emergence of the corona virus [5]. The spread of the corona virus has turned into a crisis [6]. One way of spreading this virus is through the air from one individual to another. During the current pandemic, we must maintain physical distance [7]. During this pandemic, many fields were affected, one of which was education. The government has disabled face-to-face classes and activated online classes [8]. Many media facilitate online learning, such as Google Classroom, Edmodo, Zenius, Zoom Meeting and others. Media (platform) [9]. However, this learning media has a weakness, namely it cannot carry out practical/experimental activities.

Physics is a part of science that discusses and analyzes events that occur in nature and the surrounding environment [10]. Physics is so closely related to the experiment [11]. The experiment aims to display the phenomenon/event [12]. the application of physics will facilitate human work [13]. Electronics is one of the rapidly growing fields of physics study.

From the real conditions, it is known that the straight motion experiment in the basic physics laboratory of Padang State University for straight motion experiments still uses a manual tool, namely the ticker timer.

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Limitations on the ticker timer Readout the time of objects using a stopwatch. Research that has been developed by physics students is a straight motion experiment using "Air Track" using a photogate sensor as a counter to the travel time of objects. Limitations on Air Track use is still manual and cannot be controlled remotely. As for the development of the Virtual Laboratory in straight motion, it is not yet effective because it is only a simulation and makes students unable to see how the real tool works [14].

Based on the real conditions described using manual tools, there are several problems. The first problem is measuring the travel time of objects using a manual stopwatch. The second problem, to change the angle is done manually. The previously developed solution using a virtual laboratory is still not effective. Reminding how important physics practicum activities are, the researchers developed an experimental set using a remote laboratory. Remote Laboratory is developing because of advances in communication technology and information technology today. The use of the Remote Laboratory can operate equipment/perform real experiments remotely [15]. Remote Laboratory-based tools can display how the tool works. Showing how the tool works will make students more enthusiastic and enthusiastic in carrying out practical activities

The reason researchers choose straight motion is that straight motion is one of the physical phenomena that is often encountered in the surrounding environment. The reason the researchers chose Remote Laboratory was the ineffectiveness of online learning during the covid 19 pandemic. It hampered lessons that had practical activities. The solution proposed is a virtual laboratory, but it is still not effective. The development of experimental sets using a remote laboratory is the most effective solution for now. The interest of researchers to research this is because of technological advances in the 21st century, everyone is competing to create applications and tools that make it easier for users. Researchers really hope that Remote Laboratory is very effective during the covid 19 pandemic. Set of straight-motion experiments with internet-based remote laboratory of things. These experimental sets are created automatically and these experiment sets can be performed remotely. This experimental set makes it very easy for students during the covid 19 pandemic. Based on the background described, the researchers are interested in the title of this study Designing a Set of Uniform Motion Experiments with Remote Laboratory Based on the Internet of Things. Determine the velocity for uniform straight motion using the equation 1.

$$v = \frac{\Delta x}{\Delta t} \tag{1}$$

Based on equation 1 the relationship between speed and time is horizontal. The longer the track, the more time it will take and the speed will be constant. In uniform motion in a straight line, the acceleration will remain constant. for the velocity is in equation 2.

$$a = \frac{\Delta v}{\Delta t} \tag{2}$$

based on equation 2 is to calculate the value of acceleration. In uniform motion, the acceleration will be constant. Constant acceleration means that the magnitude and direction of the acceleration are constant at all times. In a straight line, the velocity changes in a straight line with time. As seen in equation (2) that v = speed (m/s) and t = time (s).

Remote Laboratory is an experiment using real components using a computer connected to the internet [16]. Remote Laboratory experiments are controlled remotely via the internet. Experiments use real components in different locations from where they are controlled [17]. Remote Laboratory aims to provide a means to experiment remotely with real equipment, but via the Internet, in a manner similar to a live laboratory [18]. Remote Laboratory has several characteristics, one of which is that it has a set of hardware that passes for the adaptation process using a certain software architecture to allow students anywhere and anytime to carry out activities via the Internet. This Remote Laboratory is supported by several hardware and software modules designed to allow remote Internet users access to the functionality of the experiment under test [19]. Internet of Things is a communication system that involves objects through the internet network [20]. The internet of things technology connects every sensor, every software will be connected to each other and the device can be accessed remotely via a smartphone or via a computer [21]. The internet of things provides innovative solutions to various challenges and problems that occur in the surrounding environment [22]. Blynk is one of the platforms that can be obtained for free through IOS and Android. Blynk can function to control Arduino, Raspeberry Pi, and the like via the internet [23]. The Blynk application got the ability to read the stored data from Internet Of Things servers [24]. The data received in the Blynk application will be displayed through the mobile screen [25].

II. METHOD

Engineering research has steps. The steps of engineering research are determining ideas and clarity of tasks, conceptual design, arrangement, geometry, functionality, detailed design, making modeling tools, and testing. In carrying out the research, the Digital Uniform Straight Motion experimental set used some of the equipment and materials needed to achieve the research objectives. The equipment used consists of a Personal Computer (PC) which is used in making the Node MCU ESP 8266 program, an infrared avoid obstacle sensor as a time measurement. Making a straight motion experimental set requires several electronic components, namely Node MCU ESP 8266, ESP Cam 32, Motor Driver Tb 6600, Liquid Crystal Display, Limit Switch, Stepper Motor, 12V Power Supply. The independent variable, the independent variable in this study is time. The dependent variable, the dependent variable of the study is distance, speed, and acceleration. The control variable, the control variable in this study is the electronic component.

The components of the system to be made are arranged geometrically according to their respective functions. The composition of the Uniform Motion Experiment System Design can be seen in figure 1.

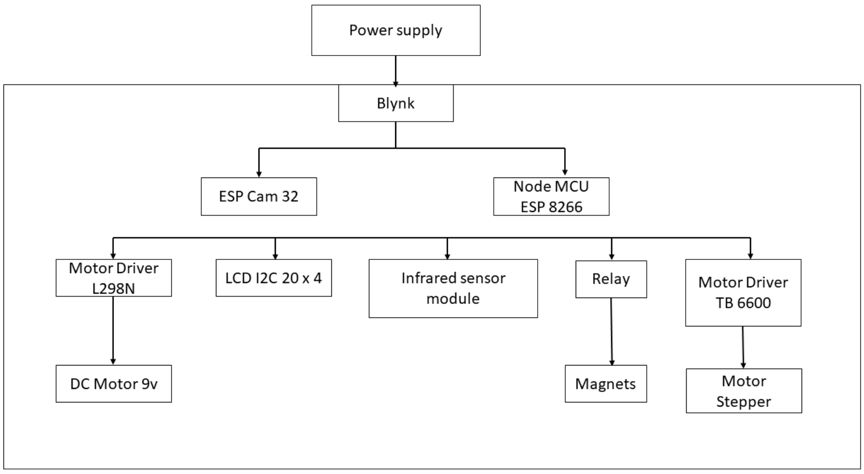

Fig. 1. Uniform Straight Motion Experiment Set Arrangement With Internet Of Things Based Remote Laboratory

Based on Figure 1, the making of a Straight Motion Experiment Set Design Based on the Internet of Things. Data input is carried out in the Blynk application and then forwarded to the ESP 8266 MCU Node as a microcontroller and ESP Cam 32 displays the video. Node MCU ESP 8266 to the relay to activate the magnet, L298N motor driver to run objects, Driver TB 6600 to run Stepper motor to form an angle, Limit switch as a barrier, infrared avoid obstacle sensor will read the travel time of objects, LCD I2C 20x4 will display travel time things. Staright motion hardware design with remote laboratory is shown in the figure 2

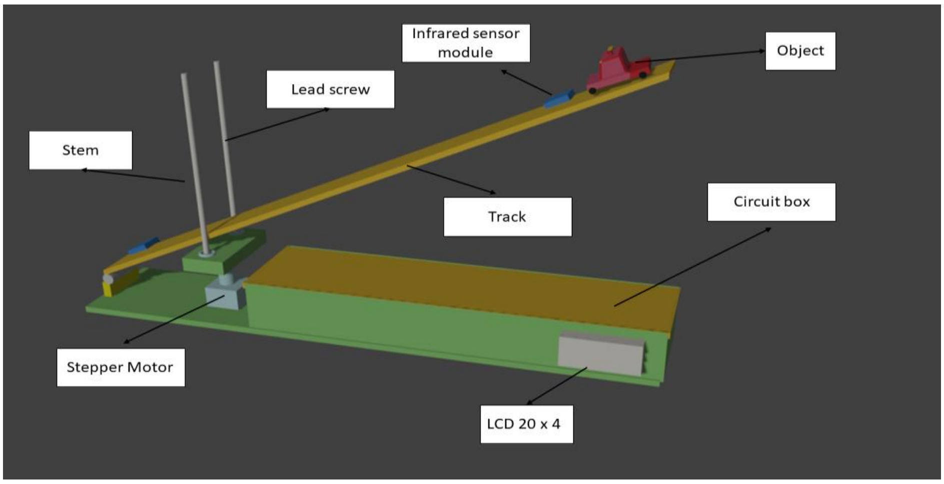

Fig. 2. Uniform Motion Experiment Set Design With Internet Of Things Based Remote Laboratory

Figure 2 Design and Build of Digital Uniform Motion Experiment System Based on Internet Of Things. The stepper motor functions to push the track upwards to form a predetermined angle. The lead screw that has been installed with the T8 nut will lift the track until the stepper motor has stopped. The axle serves as a support for the track. Infrared sensor module as the start stop of the timer. The LCD functions to display the time from the start to the end sensor.

When inputting the angle through the blynk application and received by the MCU Node, the stepper motor rotates. The stepper motor which has been fitted with a Leadscrew iron and a T8 nut will rotate up and push the track upwards. After that the motor will move from the first sensor to the end. The time elapsed by the motor will be displayed via the LCD. ESP Cam 32 will show you how the tool works in the Blynk app.

The software used to operate the tool for programming on the Node MCU ESP 8266, Arduino IDE is used for programming. Arduino is a C++ language. ESP Cam 32 as video display. The software design for an experimental set with an internet of things (IoT) based remote laboratory is shown in Figure 3.

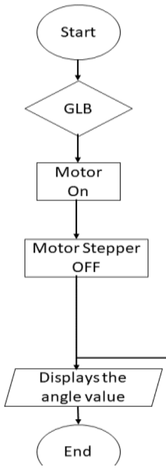

Fig. 3. Design of Uniform Motion Experiment Set With Remote Laboratory Based on Internet Of Things

Based on Figure 3, the experimental test kit will give you two choices, namely GLB or GLBB. When selecting GLB the DC motor will be On while the stepper motor will be Off. When selecting GLBB, the experimental set of tools asks for angle input, after that the DC motor will be off while the stepper motor is On. The result displayed at the end is the distance traveled by the object.

III. RESULTS AND DISCUSSION

Performance specification Set of experiments Straight motion is the identification or description of the function of each part of the system. The set of experiments for straight motion consists of trajectories. The Experiment Set has two infrared avoid obstacle sensors. This experimental tool set also has a magnet from the pool to hold objects. The object that passes through the sensor is a car with a length of 12 cm. All components will be placed in the circuit box. All hardware materials use acrylic with a thickness of 3mm. The experimental form of a straight motion experimental set with a remote laboratory is shown in Figure 4.

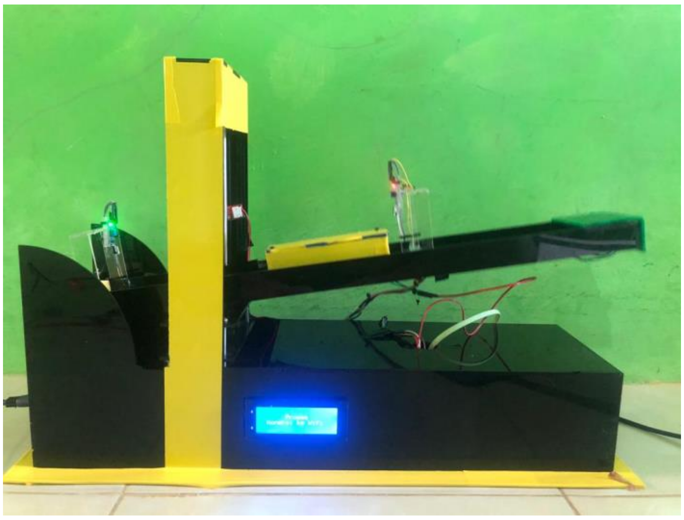

Fig. 4. Uniform Straight Motion Experiment Set

Based on Figure 4, it can be explained that the Uniform Straight Motion experimental set has a track length of 60 cm, the track has 2 axles and 1 leads screw. In the straight motion experimental set at the beginning, there are 2 infrared avoid obstacle sensors located at the beginning and end of the track which function as start/stop of the tool timer. Performance specifications Set of experiments Straight motion is the identification or description of the function of each part of the system. The straight motion experimental set has a length of 60 cm. The hardware material uses acrylic with a thickness of 3mm.

The results of the hardware design of the straight motion experimental set can be seen in Figure 4. The infrared avoid obstacle sensor is placed on acrylic with a length of 6 cm and a width of 2 cm. The infrared avoidance sensor is placed at the top so that the time reading of objects passing through it is more accurate. The distance between sensor 1 and sensor 2 is 32 cm. In the Experiment Set, the straight motion of objects that pass through the infrared avoid obstacle sensor uses a 9v dc motor. The object that passes through the infrared avoid obstacle sensor is a car with a length of 12 cm. Objects made of acrylic material. All circuit components are placed in the circuit box. The circuit box has a length of 60 cm and a width of 20 cm. The series box is made of acrylic material which has a thickness of 3 mm. The circuit box serves to protect all components from outside influences that result in damaged components.

Design specifications are often referred to as product specifications. Design specifications depend on the nature of the materials used. Design specifications describe product static characteristics, tolerances, system constituent materials, system sizes, and system dimensions. Static characteristics generally consist of precision and accuracy of the tool.

Accuracy is defined as the difference or closeness between the value read by the measuring instrument and the actual value. In general, the accuracy of a measuring instrument is determined by calibration under certain operating conditions and can be expressed as a percentage or at a specific measurement point. A good measuring instrument has an accuracy close to 1 or 100%, while accuracy is comparing the results of system measurements with theoretical calculations by means of repeated measurements.

In the GLB and GLBB experiments using two sensors. Sensor 1 as start timer and sensor 2 as stop timer. In the GLB and GLBB experiments, we will compare the time in the standard tool and the time in the experimental set. The accuracy tables for GLB and GLBB measurements are in Table 1.

Table 1. Data GLB accuracy

Speed Variation (PWM)	Stopwatch		Experiment Tool Set		Percent error	Accuracy
	t (s)	v (m/s)	t (s)	v (m/s)		
85	0,759	0,422	0,762	0,420	1,56%	98,43%
95	0,584	0,548	0,585	0,548	0,99%	99,01%
110	0,482	0,664	0,488	0,657	2,31%	97,69%

Based on Table 1, it can be described that the time that is read on the device and the time that is read with a stopwatch is not much different. In table 1 it can be seen that the speed value with PWM variations with a mileage of 32 cm. The comparison between the tool time and the stopwatch got the percentage of accuracy 98.43%, 99.01%, 97.69%.

The next experiment measured the stability of the object's travel time during the GLBB experiment. The accuracy of the GLBB used a standard stopwatch. The accuracy of GLBB with three different slopes, namely with an angle of 10 , 12 , 14 . The accuracy of the GLBB experiment is shown in Table 2

Table 2. GLBB accuracy

tilt angle	Stopwatch			Experiment Tool Set			Percent error	Accuracy
	t (s)	v (m/s)	a (m/s^2)	t (s)	v (m/s)	a (m/s^2)		
10	0,637	1,01	1,59	0,638	1,01	1,58	1,09%	98,91%
12	0,528	1,21	2,30	0,527	1,22	2,32	1,33%	98,67%
14	0,446	1,44	3,23	0,450	1,42	3,17	1,72`%	98,28%

Based on Table 2, experimental sets have been carried out with three different slope angles. In the GLBB experimental set, the comparison of the stopwatch time with the tool time gets the error percentage values of 1.09%, 1.33% and 1.72%. Meanwhile, the accuracy values for the GLBB experiment are 98.91%, 98.67, and 98.28%. After conducting two experiments, GLB and GLBB, the experimental set shows that the experimental set has precise accuracy.

In this experiment, ten measurements were repeated three times. The results of the experiments that have been carried out will be analyzed on the experimental set of tools. The results obtained on the experimental tool are in the form of speed values. The speed value obtained on the experimental set is shown in Table 3.

Table 3. Speed Value Accuracy

No	measurement to -										Percent error	Accuracy
	1	2	3	4	5	6	7	8	9	10		
1	0,446	0,409	0,419	0,410	0,406	0,409	0,427	0,447	0,413	0,418	1,56%	0,97
2	0,547	0,535	0,555	0,520	0,565	0,550	0,550	0,553	0,562	0,540	0,99%	0,98
3	0,688	0,635	0,619	0,652	0,656	0,674	0,652	0,663	0,674	0,654	2,26%	0,98

In Table 3, it can be stated that the velocity value in the experimental set of straight motion for each measurement is not constant and exists. This is due to the surface of the track and the cable contained in the object. The accuracy values obtained were 0.97, 0.98, and 0.98 and the percent errors were 1.56%, 0.99%, and 2.26%. This shows that the experimental set of tools has good accuracy.

The next experiment was carried out ten times with repeated measurements of three experiments. The results of the experiments that have been carried out will be analyzed in a straight motion experimental set. The results obtained on the experimental set of tools are in the form of acceleration values. The acceleration value obtained in the experimental set is shown in Table 4.

Table 4. Accuracy of Acceleration Value

No	measurement to -										Percent error	Accuracy
	1	2	3	4	5	6	7	8	9	10		
1	0,869	0,809	0,715	0,719	0,827	0,668	0,794	0,919	0,849	0,755	2,17%	0,93

2	1,157	1,144	1,225	1,216	0,968	1,174	1,170	1,148	1,085	1,295	2,66%	0,95
3	1,747	1,573	1,546	1,623	1,526	1,559	1,616	1,553	1,573	1,526	3,37%	0,97

In Table 4, it can be stated that the acceleration value on the straight-motion experimental set for each measurement has different results. This is because the object experiences acceleration caused by the surface of the track and the accuracy of the sensor reading the object. same. The accuracy values obtained are 0.97, 0.97, and 0.95. The percent errors obtained were 2.42%, 2.55%, and 3.07%. This shows that the experimental set of straight motion has good accuracy.

In the GLB experiment, researchers distinguish the speed of objects by adjusting the PWM value. There are three different PWM values, of the three PWM values the researchers grouped these values, namely PWM 85 (slow), PWM 95 (medium), PWM 110 (fast). In the GLB experiment, researchers determined the relationship between distance and time, and the relationship between speed and time. The relationship between distance and time can be seen in Figure 5.

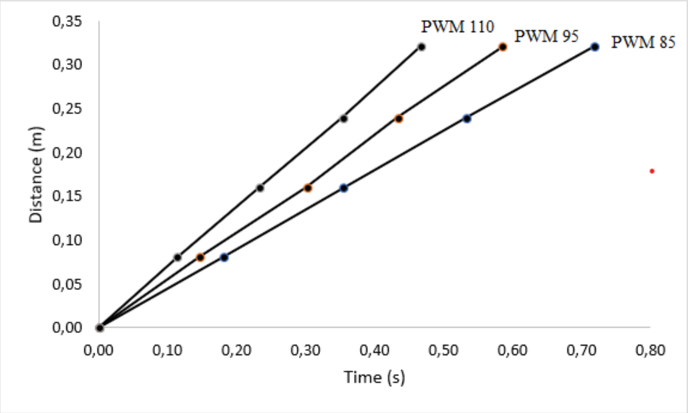

Fig. 5. The Relationship between Distance and Time in GLB Motion

Based on Figure 5 the relationship between distance and time is directly proportional to changes in time. the black graph is the time obtained from the tool. The average time read on the experimental set is 0.762 s, 0.585 s, 0.488.

In the GLB experiment there is the effect of speed on time. At the time of the influence of speed on time using three different speeds. The shape of the influence of speed on time during GLB is shown in Figure 6.

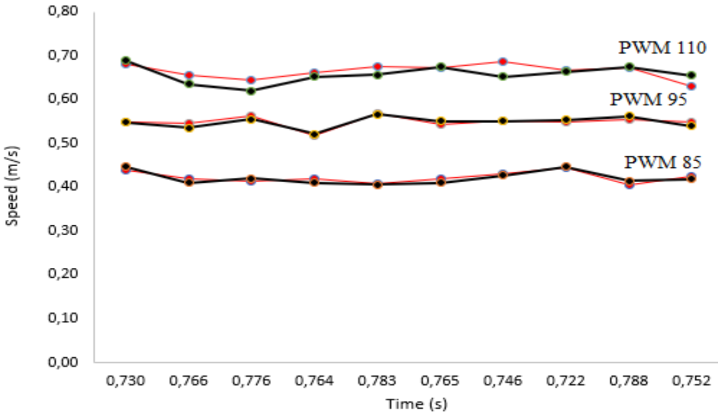

Fig. 6. The Relationship of Velocity to Time in GLB Motion

Based on Figure 6, it can be described the relationship between speed and object travel time. From the graph it can be seen that the speed of an object is not affected by the travel time of the object. Speed is affected by the magnitude of the thrust when the object is launched. The average speed produced by the straight motion experimental set is 0.420 m/s, 0.548 m/s, and 0.657 m/s

Based on the data produced by the experimental system of uniform straight motion and changing regularly when compared to the existing theory, it is very appropriate. The high precision and accuracy of the tool proves that the tool works well. The quantities obtained by the straight-motion experimental system with a remote laboratory for remote measurements work in accordance with the existing theory. Experiment set that uses two infrared sensors to calculate the distance traveled by objects. The stepper motor regulates the slope of the track. The results obtained after measuring the values obtained with standard tools are the same as the values obtained with experimental tools. The results obtained prove that the tool is feasible to use for experiments with uniform straight motion and uniform changing straight motion

IV. CONCLUSION

Based on the data that has been obtained and has been analyzed, it can be concluded that the results of the performance specifications of this study consist of a Set of Uniform Motion Experiments with Remote Laboratory Based on the Internet Of Things measuring 60x20 cm, with two infrared sensors avoiding obstacles as start and stop. The results of the design specifications from the Uniform Motion Experiment Set with Remote Laboratory Based on the Internet of Things consist of accuracy and precision values. The accuracy value of the uniform straight motion experiment obtained is 98.38% and the error percentage is 1.62%. While the value of the accuracy of uniformly changing straight motion obtained is 98.65% and the percent error obtained is 1.38%. The speed accuracy value obtained in the uniform straight motion experiment is 0.97 and the percent error is 1.60%. The acceleration accuracy value obtained in the uniformly changing straight motion experiment is 0.95 and the percent error is 2.74%. Effect of speed, acceleration, and distance on time. In the experiment of uniform straight motion the effect of distance on time is directly proportional, while the effect of speed on time is constant.

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