ISSN (Print) : 2337-9030 ISSN (Online) : 2685-2608
PILLAR OF PHYSICS
Vol. 15 (1), 2022, page. 77-87
DOI : http://dx.doi.org/10.24036/12649171074

DESIGN AND CONSTRUCTION OF MODELING TOOL OF LINEAR MOTION EXPERIMENT ASSISTED TOY CARS WITH SPEED CONTROL FOR VIDEO TRACKER ANALYSIS

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ABSTRACT

Experimental activities aim to improve understanding and thinking skills in understanding physics concepts. But in reality, the experiment has not been carried out properly, due to the use of manual instruments so it affects the results of the linear motion experiment obtained. As a solution to the problem, namely by making a linear motion experimental modeling tool assisted by a toy car with speed control for video tracker analysis. The purpose of this study is to determine the performance specifications of the linear motion experimental modeling tool, the accuracy and precision of the time measurement on the linear motion experimental modeling tool, to determine the effect of the relationship between physical quantities on the linear motion. The type of research conducted in engineering research. The data analysis technique used is descriptive data analysis and error analysis. From the data analysis, it can be stated three results of this research. First, the performance specifications of the linear motion experimental modeling tool consist of toy cars measuring 13x7 cm, controlling the dc motor using a step-down xl-6009 dc-dc, measuring angles using mpu6050, trajectory measuring 2.0x0.10 m, processing experimental results using tracking software. Second, the average accuracy of time measurement in LMCV is 98.16% with an average error of 1.93%. The average accuracy of time measurement in LMCV is 98.38% with an average error of 1.53%. Third, the velocity value obtained is proportional to the applied voltage value, while the acceleration value is proportional to the increase in the angle used.

Keywords : Linear Motion; LMCV; LMCA; Video Tracker

I. INTRODUCTION

Physics is part of science that understands natural phenomena that occur in the surrounding environment. Physics does not only study theory but is accompanied by experimental activities carried out in the laboratory. Experimental activities aim to improve understanding and ability to think critically objectively and rationally in understanding physics concepts [1]. To support the implementation of experimental activities, an instrument is needed. The instrument serves as a useful teaching aid for collecting, processing, analyzing, and presenting research data systematically and objectively with the aim of solving a problem or testing a hypothesis [2]. The use of instruments can make measurements easier and the measurement results will be more accurate [3].

One of the physics phenomena that require experimental activities is linear motion. The linear motion experiment in question is an experiment of uniform linear motion and uniformly changing linear motion using a ticker timer. The importance of linear motion experiments can be used to explore the concept of motion, especially linear motion with constant velocity (LMCV) and linear motion with constant acceleration (LMCA). The linear motion experiment is still limited in the parameters of the measurement results. This is indicated by the direct measurement results parameters are only limited to the calculation of time. In addition, the linear motion experiment still uses manual instruments and the speed of the dynamo cars in the ticker timer experiment has the same rate value. As a solution to the problem, namely by making a linear motion experimental modeling tool assisted by a toy car with speed control for video tracker analysis. This can overcome the error of setting the car speed and timing calculations, especially in repeated measurements.

Submitted: .2022-02-08 Accepted: 2022-04-20 Published: .2022-04-28

The advantage of a linear motion experimental modeling tool assisted by a toy car with speed control for video tracker analysis is that it avoids travel time measurement errors, especially in repeated measurements. In addition, the measurement results using a linear motion experimental modeling tool assisted by a toy car with speed control for video tracker analysis are also more accurate in addition to a faster experimental time. This application system analyzes modeling tools and is designed to facilitate data collection because it combines videos of physical phenomena with computer models [4]. Tracker is designed to simplify the implementation of physics experiments because it provides an image and an appropriate video analysis software as a tool to explain physics concepts in the classroom. The tracker software provides tools for multiple representations of experimental data. The use of video analysis using tracker software in solving physics tasks can have a significant impact on knowledge [5]. An object is said to be in motion if it experiences a change in position at a certain time interval [6]. Motion in straight line is one of the essential concepts in school physics lessons. Motion in straight line is the basis for studying the next physical material [7]. Adequate graphs of position, speed, and acceleration of time [8] Linear motion is an object that moves in a linear line trajectory [9]. Based on the speed, linear motion is divided into two, namely linear motion with constant velocity (LMCV) and linear motion with constant acceleration (LMCA). linear motion with constant velocity (LMCV) is an object moving in a linear line that has the same velocity value [6]. Uniform linear motion has no acceleration value or zero acceleration, so distance is the product of velocity and time [1]. The condition for an object to be said to be moving in a straight line is if the object moves in a straight line and the object's speed does not change. In uniform straight motion there is no acceleration (a = 0). So the distance is the speed of time[1]. The formula for uniform linear motion can be seen in Equation 1

$$X = v.t \tag{1}$$

Linear motion with constant acceleration (LMCA) is an object moving in a linear line at a rate that changes every second. Uniformly changing linear motion consists of two types, namely, uniformly changing linear motion is accelerated and uniformly changing linear motion is decelerating [6]. An object is said to be moving in a linear line and is accelerating if the object is experiencing a regular increase in speed, while an object is said to be moving in a linear line and is slowing down if the object is experiencing a regular decrease in speed [9]. The formula for uniformly changing linear motion [10] can be seen in Equation 2.

$$a = \frac{2x}{t^2} \tag{2}$$

Tracker is one of the software from VBL which has the characteristic of being able to provide real physical phenomena and their representations in the form of quantitative data and graphs. The tracker can be used to analyze various videos related to natural events, especially those related to speed, velocity, force, gravitational field, energy conversation [11]. The tracker application is an application that can record and analyze the parameters of an object's motion every time (t), be it the object's position (x, y), the object's speed, or the acceleration of the object's motion so that it will provide convenience in the motion analysis process [12]. Data recording and processing activities carried out will obtain information such as time, distance, speed, acceleration, angle, momentum, angular velocity, so that it can display graphs based on data in tables, such as distance to time graphs [13]. Then interpret the data obtained by using the tracker depends on the design of the modeling tool made. The better the results of the modeling tool made, the better the results obtained by video analysis with tracker software [14].

The control system is the process of setting or controlling one or more quantities (variables, parameters) so that they are at a certain price or range. Another term for control systems or control techniques is control techniques, control systems, or control systems [15]. Control is the control of a work system process that can be controlled following human desires in doing all activities [16]. DC speed control in toy cars is a system made for linear motion experiments. The control is done by using the Speed Controller as a tool for driving the experimental cars. The working principle of this control is in the form of rotating the potentiometer on the Speed Controller, where the potentiometer value will be varied from the minimum value to the maximum value.

Props for linear motion experiments in school laboratories still use dynamo train equipment that does not have variations in speed values so researchers are interested in making a linear motion experimental modeling tool design assisted by a speed-controlled toy car. Measurement of time in the implementation of the experiment is still done manually so that the implementation of the experiment takes a long time, so we need a tracker software application that facilitates the smooth running of experiments in the laboratory. The use of experimental equipment combined with this software can create a physics learning strategy that is more effective, interesting, and fun. Based on the background of the problem that has been described, the researcher is interested in solving this problem. Researchers are interested in making a modeling tool for automatic linear motion experiments. Therefore, researchers are interested in bringing up the title of the research, namely "Design and Build Experimental Modeling Tool for Linear Motion Assisted by Cars with Speed Control for Video Tracker

Analysis. This research has the following objectives. First, determine the performance specifications of the linear-motion experimental modeling tool assisted by speed control cars. Second, determine the accuracy and precision of the time measurement on the linear-motion experimental modeling tool. Third, determine the effect of the relationship between physical quantities on the linear motion.

In the manufacture of this straight motion experimental tool requires supporting components, namely; Arduino, Liquid Crystal Display (LCD), Servo Motor, Step Down XL-6009 DC-DC, and MPU6050. Arduino is an open source gadget for seeming great and supervise a more famous measure of the physical world than your computer. It's an open-source physical enlisting stage reliant on an essential littler scale controller board, and a headway area for making programming for the board. Arduino can be used to make canny things, taking commitments from a different switches or sensors, and controlling an arrangement of lights, motors, and other physical yields. Arduino adventures can be stay lone, or they can talk with programming running on your PC (for instance Streak, Processing, and Max MSP) [17]

II. METHOD

The type of research conducted in engineering research. Engineering research is research that applies science to a design to get performance [18]. Engineering research can also be referred to as a non-routine design activity, so that it includes new contributions, both in the form of processes and products/prototypes. The research procedure carried out in this research consisted of ideas and task clarity, conceptual design, geometric arrangement and functionality, detailed design, prototype/model making, and testing. Ideas and clarity of work are the first procedures that must be carried out, at this stage you are required to look for the latest and creative ideas that are outlined in written form. Experimental modeling tool in linear motion assisted by toy cars with speed control for video tracker analysis is an interesting idea to do because one tool can perform two experiments. The design of the tool in this study consisted of a geometric arrangement, the design of the tool's hardware, and the design of the software.

Second, the design concept, the design in this research is to make a linear motion experimental modeling tool assisted by a car with speed control for video tracker analysis. The modeling tool that has been created will compare the measurement results from the experimental tool using a stopwatch with the analysis results from the tracker software. The third is the geometric arrangement and function, at this stage, all components are designed and arranged geometrically based on their function. The shape of the design and the geometric arrangement can be seen in Figure 1:

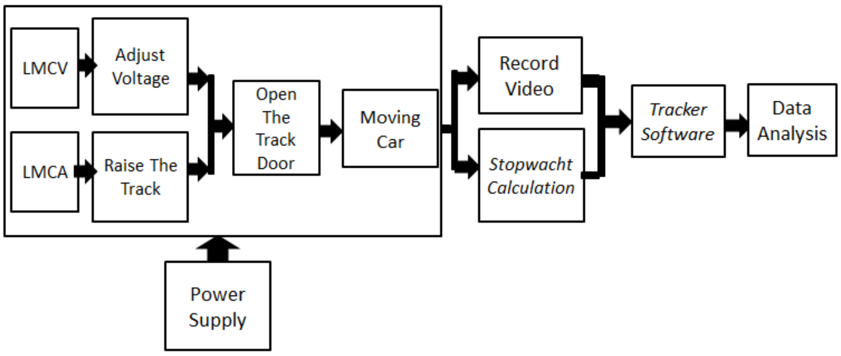


Fig 1. Experimental System Geometric Arrangement Block

Based on Figure 1, can be seen below that the system consists of three blocks, namely input, process, and output. The input block in the LMCV experiment will adjust the voltage to vary the speed of the car, while in the LMCA experiment, it will adjust the height of the track to vary the angle so that the toy can move in the experiment and then be recorded with a camera. In the process section, there is a tracker software that is useful for analyzing videos that have been recorded by the camera in the experiment. In the output section, there is data output after the tracker software analyzes the experimental video where the data is in the form of graphs and takes time measurements manually using a stopwatch. Fourth, the detailed design, the detailed design of the linear-motion experimental modeling tool assisted by a toy car with speed control for video tracker analysis consisting of hardware design and software design. Hardware design relates to the tools and materials used. The design of the software is related to the control system for the running of the experimental tool. Tool Design The linear motion experiment modeling can be seen in Figure 2:

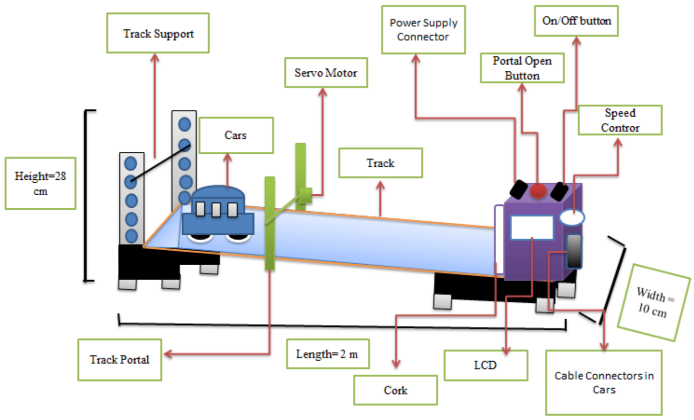
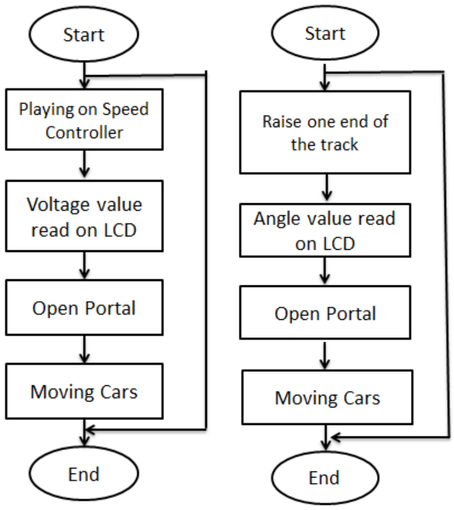


Fig 2. Design of a Linear Motion Experiment Modeling Tool

Based on Figure 2, it can be seen that a car controller using a speed controller consists of various components that have their respective functions. A linear motion experimental modeling tool assisted by a toy with speed control for video tracker analysis is designed with a setting on the speed of the toy. Where the speed value is varied in the toy cars using a speed controller by varying the voltage value in the LMCV experiment, while in the LMCA experiment, setting the track height to vary the angle. Software (software) is closely related to hardware performance. This software serves to provide instructions and run Arduino Nano. The software design can be seen in Figure 3:



(a) (b)

Fig 3. Software Design (a) LMCV and (b) LMCA

Based on Figure 3, it is explained that the system work in the LMCV experiment begins by rotating the speed controller component so that it displays the voltage value on the LCD. Setting the voltage on the tool will cause the wheels of the toy to spin where the higher the voltage value the faster the wheels spin. Then press the button to open the tracking portal and instruct the servo motor to move to open the portal so that the toy cars move on the track. The working system in the LMCA experiment is the same as the LMCV experiment but starts by increasing the track height so that the LCD the angle of the plane on the tool.

The fifth is modeling, which is the stage of uniting all the components that make up the system. The making of this linear motion experimental tool is made with acrylic material that has been designed and cut to a predetermined size. The sixth is testing, at this stage, all components have formed a complete experimental tool. the tests carried out such as accuracy, precision, and error from the linear-motion experimental modeling tool assisted by toy cars with speed control for video tracker analysis. To see the level of accuracy, accuracy, and error of the experiment by comparing the results of the calculation of physical quantities from the tracker software with the results of calculations using formulas based on the theory of equations of uniform motion and linear equations of uniform change.

This study uses data collection techniques through measurements of the physical quantities contained in the system. The measurement technique carried out includes two ways, namely directly and indirectly. The data obtained directly are the path distance, stress, and plane angle. Meanwhile, data from indirect research are accuracy and precision, time, speed, and acceleration. Data analysis techniques in this study consisted of descriptive analysis and error analysis. The descriptive analysis consists of means, Pareto diagrams, and tables, while in error analysis there are errors, accuracy, and precision.

III. RESULTS AND DISCUSSION

This research begins with a study of the instrument literature, determining the parameters and components of the measuring instrument, designing the research design, integrating the components one by one according to the research design, taking linear motion experimental videos, analysis videos, obtaining results, and conclusions. The data obtained from the video analysis is used to calculate the accuracy and precision of the linear-motion experimental modeling tool assisted by speed control toy cars. The results of the analysis can state the relationship between the measured variables. The presentation of the data from the analysis is expressed in the form of tables and graphs.

performance specifications of the motion experimental modeling tool. The performance specification of the linear motion experiment modeling tool describes the functions of each component or part of the linear motion experiment modeling tool. The modeling tool for linear motion experiments is assisted by toy cars with speed control using a toy car as part of the experimental component. The toy cars used in the linear-motion experimental modeling tool are shown in Figure 4:

Fig 4. Toy Car

Based on Figure 4 shows that the linear motion experiment modeling tool uses a white toy car with a length of 13 cm and a width of 7 cm. The DC motor control carried out in this study uses a step-down component xl-6009 dc-dc. Control is done by varying the voltage value from 3.0 volt to 5.0 volt. Varying the value of the input voltage by rotating the step-down component on the tool, the greater the value of the input voltage that we give to the toy, the faster the speed of the wheels will spin. Time measurement when conducting linear motion experiments is carried out using a stopwatch and the use of a tracker software application. The angle measurement in the LMCA experiment uses the mpu6050 component. This component works after we increase the track height on the tool so that the mpu6050 sensor contained in the component box works to read the angle generated in the experiment, the angle reading will be displayed on the 20x4 LCD. The shape of the angle reading displayed on the LCD can be seen in Figure 5:

Fig 5. Display of Angle Reading on LCD

Based on Figure 5, can be seen that the angle display that is read on the mpu6050 component is displayed on a 20x4 LCD. The M input display on the LCD is a display of the voltage values that were varied in the GLB experiment. The LCD will be placed in the box of the linear motion experimental tool assisted by a speed-controlled toy car for video tracker analysis. The form of the display of the experimental tool in this study can be seen in Figure 6:

Fig 6. Linear Motion Experiment Modeling Tool with Speed Control

Based on Figure 6 shows that the shape of the track is made of acrylic with a length of 2 m and a width of 10 cm and wood as a support for the bottom of the track has a height of 10 cm. On the right side of the modeling tool, there is an opening for the trajectory portal that uses a servo motor as a driver, there is also wood that is useful for elevating the track so that it forms an inclined plane, the height of the wood for the track gear used is 28.5 cm. Measurement of the results of the data in the experiment in addition to using a stopwatch also uses a tracker application. The linear motion video display on the tracker analysis can be seen in Figure 7:

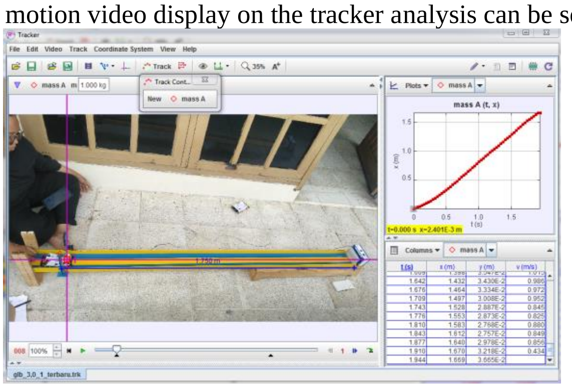


Fig 7. Linear Motion Video Display on Analysis Tracker

Based on Figure 7, it shows that in carrying out experiments using a tracker software application by entering a video that has been recorded into the application. After that, we will set the start of the video to be analyzed in the clip setting software. The data results from the analysis using the tracker software will be displayed on the left side in the form of table data and graphs.

The accuracy and accuracy of time measurement in the linear motion experiment modeling tool. Accuracy data is obtained from a comparison between manual time measurement and time measurement on the video tracker application. Manual time measurement is done using a stopwatch. In the linear motion experiment using a linear motion experimental modeling tool assisted by a toy car with speed control for video tracker analysis, five stress variations were carried out in the LMCV experiment. The accuracy data from the linear-motion experimental modeling tool in the LMCV experiment are as shown in Table 1.

Table 1. Time Measurement Accuracy in The LMCV Experiment

No	**Voltage (volt)**	**Time (s)**		**Accuracy (%)**	**KR (%)**
		Stopwatch	**Video Tracker**		
1	3,0	2,01	1,943	96,67	3,33
2	3,5	1,79	1,774	97,43	2,57
3	4,0	1,60	1,608	99,95	0,5
4	4,5	1,45	1,474	98,34	1,66
5	5,0	1,26	1,240	98,41	1,59
		Average		98,16	1,93

Based on Table 1, it can be explained that the comparison of the measurement of the standard tool with the data on the video tracker can be explained. Of the five stress variations, the average accuracy of the linear-motion experimental modeling tool on the LMCV material is 98.16%. The error percentage of the linear motion experimental modeling tool on the LMCV material ranges from 0.5% to 3.33% with an average error percentage of 1.93%. The linear motion experiment on the LMCA material was carried out with five variations of angles.

The accuracy data from the linear-motion experimental modeling tool in the LMCA experiment are as shown in Table 2.

Table 2. Time Measurement Accuracy in The LMCA Experiment

No	Corner (°)	Time (s)		Accuracy (%)	KR (%)
		Stopwatch	Video *Tracker*		
1	4	2,34	2,312	98.80	1,20
2	7	2,27	2,245	98,90	1,10
3	10	2,09	2,144	97,42	2,58
4	13	1,87	1,846	98,72	1,28
5	16	1,75	1,776	98,51	1,49
		Average		98,3875	1,53

Based on Table 2, it can be explained that the comparison of the measurement of standard tools with the data results on the video tracker can be explained. The experiment was carried out by increasing the track height to produce the angle value; the angle value was varied from 4^o-16^o. From the five variations of the angle value, the average accuracy of the linear-motion experimental modeling tool on the LMCA material is 98.3875%. The error percentage of the linear motion experimental modeling tool on the LMCA material ranges from 1.10% to 2.58% with an average error percentage of 1.53%. The results of the accuracy and precision obtained, proves that the tracker software application is suitable for use in other physics experiments related to motion [19].

The influence of the relationship between physical quantities on linear motion. Measurements are made in the form of time using a linear motion experiment modeling tool. The measurement results, the accuracy value of the linear motion experiment modeling tool is obtained. Measurements were made with five variations of voltage in the LMCV experiment from a voltage of 3.0 volt to 5.0 volt and five variations of the angle value when increasing the track height in the LMCA experiment from an angle value of 4^0 to 16^0. The results of the LMCV experiment with a voltage value of 3.5 volt obtained several graphs of linear-line physical quantities. Tracker software will analyze objects moving on a trajectory in the form of toy cars moving from a linear motion experiment. The graph between the relationship between distance and time with a voltage of 3.5 volt can be seen in Figure 8:

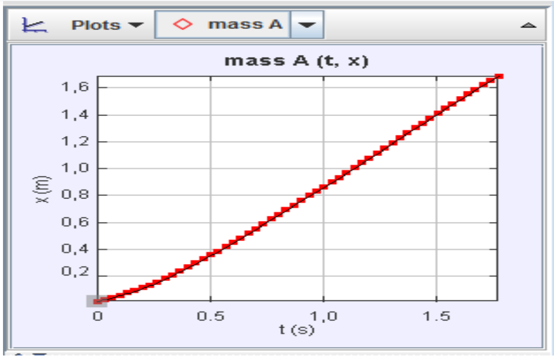


Fig 8. Relationship Of Distance with Time on LMCV with Voltage 3.5Volt

Based on Figure 8, a graph of the relationship between distance and time changes in the LMCV experiment shows. It can be seen in the figure that the greater the distance value on the track, the greater the arrival time of the cars in the study. The graph above is following the theory that the relationship between distance (s) and time (t) is a linear line. The results of the LMCV experiment with a voltage value of 4.0 volt obtained several graphs of linear-line physical quantities. The graph between the relationship between distance and time with a voltage of 4.0 volt can be seen in Figure 9:

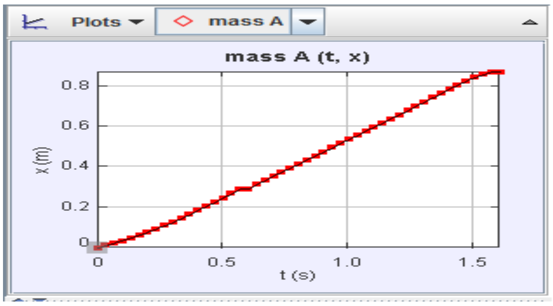


Fig 9. Relationship Of Distance with Time on LMCV with Voltage 4.0 Volt

Based on Figure 9, a graph of the relationship between distance and time changes in the LMCV experiment shows. It can be seen in the figure that the greater the distance value on the track, the greater the arrival time of the cars in the study. The graph above is following the theory that the relationship between distance (s) and time (t) is a linear line. The results of testing the accuracy of the linear-motion experimental modeling tool on the LMCV can be seen in Table 3.

Table 3. Accuracy of The Linear Motion Experiment Modeling Tool on LMCV

Voltage (V)	**Speed (m/s)**		**Accuracy (%)**	**KR (%)**
	Formula	**Video Tracker**		
3,5	0,978	0,9881	99,07	0,93
4,0	1,094	1,096	99,82	0,18
	Average		99,445	0,555

Based on Table 3, it can be stated that the value read on the tracker with the value sought by the formula is not much different. The accuracy value for the speed measurement results ranges from 99.07% to 99.82% with an average accuracy percentage of 99.445%. The percentage of error in the measurement of linear motion experiments ranges from 0.18% to 0.93% with an average value of 0.555%.

The results of the LMCA experiment with an angle value of 10^0 obtained several graphs of linear-line physical quantities. Tracker software will analyze moving objects that are on a trajectory in the form of toy cars that move from linear motion experiments. The graph between the relationship between distance and time with an angle value of 10^0 can be seen in Figure 10:

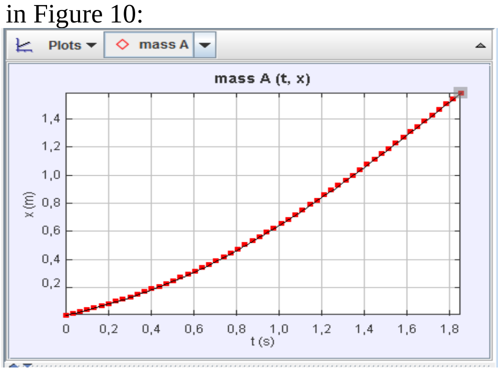


Fig 10. Relationship between Distance and Time in LMCA with Angle 10^0

Based on Figure 10, a graph of the relationship between changes in position and time in the LMCA experiment shows an angle value of 10^0. It can be seen in the figure that the greater the angle value on the track, the greater the arrival time of the cars in the study. From these physical quantities obtained a graph in the form of a parabola

The results of the LMCA experiment with an angle value of 13^0 obtained several graphs of linear-line physical quantities. Tracker software will analyze moving objects that are on a trajectory in the form of toy cars that move from linear motion experiments. The graph between the relationship between distance and time with an angle value of 13^0 can be seen in Figure 11:

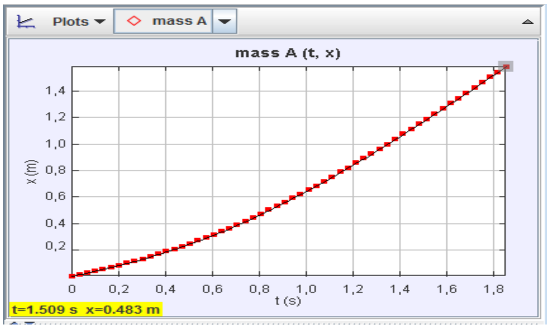


Fig 11. Relationship between Distance and Time in LMCA with Angle 13^0

Based on Figure 11, a graph of the relationship between changes in position and time in the LMCA experiment shows an angle value of 13^0. It can be seen in the figure that the greater the angle value on the track, the greater the arrival time of the cars in the study. From these physical quantities obtained a graph in the form of a parabola. The results of testing the accuracy of the linear motion experimental modeling tool on the LMCA can be seen in Table 4.

Table 4. Accuracy of Linear Motion Experiment Modeling Tool on LMCA

Corner (°)	Acceleration (m/s^2) Formula	Acceleration (m/s^2) Video Tracker	Accuracy (%)	KR (%)
10	0,4006	0,3736	95,58	4,42
13	0,5004	0,5039	99,30	0,70
	Average		97,44	2,56

Based on Table 4, it can be stated that the value read on the tracker with the value sought by the formula is not much different. The accuracy value for the acceleration measurement results ranges from 95.58% to 99.30% with an average accuracy percentage of 97.44%. The percentage of error in the experimental measurements of linear motion ranged from 0.70% to 4.42% with an average value of 2.56%.

Measurements in the linear-motion experimental modeling tool assisted by speed-controlled cars for video tracker analysis were carried out with five variations of stress in the LMCV experiment and five variations in angle values in the LMCA experiment. This measurement aims to determine the effect of speed control on the speed of the toy wheels in a linear motion experiment. The measurement results using the tracker software in the LMCV experiment are as shown in Table 5.

Table 5. Effect of Voltage on The LMCV Experiment

Voltage (Volt)	Time (second)	Speed (m/s)
3,0	1,943	0,9191
3,5	1,774	0,9881
4,0	1,608	1,096
4,5	1,474	1,110
5,0	1,240	1,399

Table 5 is the data from the video analysis tool for modeling linear motion experiments on LMCV using tracker software. From these data, a graph of the relationship between physical quantities from a linear motion experiment is obtained in the form of time and speed. The stress used in the linear motion experiment on the LMCV affects the arrival time of the cars at the end of the track in a linear line. The greater the value of the voltage used in the experiment, the faster the arrival time of the cars at the endpoint of the track. The voltage used in the linear motion experiment on the LMCV affects the speed of the cars. The greater the voltage value used in the experiment, the faster the speed used in toy cars. The measurement results using the tracker software in the LMCA experiment are as shown in Table 6.

Table 6. Effect of Angle on The LMCA Experiment

Corner (^{o})	Time (second)	Acceleration (m/s^2)
4	2,312	0,3336
7	2,245	0,3453
10	2,144	0,3823
13	1,846	9,5039
16	1,776	0,5625

Table 6 is the data from the video analysis tool for modeling linear motion experiments at LMCA using tracker software. From these data, a graph of the relationship between physical quantities from a linear motion experiment in the form of time and acceleration is obtained. The angle value used in the linear motion experiment on LMCA affects the time until the toy car is at the end of the track in a linear line. The greater the angle value used in the experiment, the faster the arrival time of the cars at the endpoint of the track. The angle value used in the linear motion experiment on LMCA has a big influence on the acceleration of the cars. The greater the angle value used in the experiment, the faster the acceleration of the toy car will be.

Based on the data generated from the design of a linear motion experimental modeling tool assisted by a toy car with speed control for video tracker analysis following existing theory. The high accuracy and precision of the experimental equipment prove that the experimental tool has worked well. LMCV and LMCA graphs resulting from research on the design and construction of linear-motion experimental modeling tools assisted by toy cars with speed control for video tracker analysis are following existing theory. It can be concluded that the design of a linear motion experimental modeling tool assisted by a toy car with speed control for video tracker analysis works well so that it can be used properly. A graph of uniform linear motion shows a position or displacement that is getting farther away, the longer it takes to reach a predetermined trajectory. This shows that displacement and time have a value that is directly proportional so that the graphic form of uniform linear motion is in the form of a linear line. The graph of uniformly changing linear motion shows the motion of an object on a linear trajectory with an acceleration that increases regularly or experiences constant acceleration, a graph of uniformly changing linear motion experiences acceleration because the curve opens upwards so that the graph of uniformly changing linear motion is in the form of a parabola [20].

IV. CONCLUSION

Based on the results of measurements and video analysis from a linear motion experimental modeling tool assisted by a toy car with speed control for video tracker analysis, several conclusions can be drawn. First, the performance specification of the linear-motion experimental modeling tool consists of toy cars and tracks. The toy cars used are 13x7 cm in size. Controlling the dc motor on toy cars using the step-down xl-6009 dc-dc which functions to adjust the voltage value, angle measurement using the mpu6050. The props for linear motion experiment modeling tools are in the form of a trajectory measuring 2.0 x 0.10 m. Processing of experimental results using a software tracker application. Second, the accuracy and precision in time measurement are obtained from a comparison of manual measurements and tracker software applications. The average accuracy of time measurement in LMCV is 98.16% with an average error of 1.93%. The average accuracy of time measurement in LMCA is 98.3875% with an average error of 1.53%. Third, the speed value obtained is proportional to the voltage value used, the greater the voltage value used, the greater the speed value obtained. The acceleration value is proportional to the increase in the angle value used in the experiment. The graphic form of uniform linear motion is in the form of a linear line while the graph of uniformly changing linear motion is in the form of a parabola.

ACKNOWLEDGMENT

I am sincerely thankful to the Open Source Physics (OSP) who created and developed tracker software applications.

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