

# Simulation of the use of analysis video tracker software in kinematics material as an alternative distance learning

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Physics learning can be designed with a contextual approach and is relevant to students' daily lives. Physics is very relevant in various fields, one of which is the field of technology. The aim of this research is to create a simulation of the use of video analysis tracker software in kinematics material as an alternative to distance learning. This research uses descriptive methods. The kinematics material that will be discussed in this research includes rectilinear motion, parabolic motion and circular motion. This research uses video analysis tracker software to obtain information from the movement of an object. The results of this research have produced a simulation of the use of video analysis tracker software as an alternative to distance learning. The use of video analysis tracker software can be used to carry out experiments on motion and optical phenomena. From investigative activities, students are able to prove physical theory with the results of investigations or experiments using video analysis tracker software. Researchers suggest that simulations using video analysis tracker software can be applied in classroom learning, especially in kinematics material. The use of video analysis tracker software in the classroom learning process can improve students' problem solving skills and learning independence.

*Keywords:* Kinematics; tracker video analysis; experiments.

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## 1. Introduction

Physics learning can be designed with a contextual approach and is relevant to students' daily lives. Physics is very relevant in various fields, one of which is the field of technology. The foundation of physics is the basis for the development and innovation of various devices and systems, telecommunications, transportation, renewable energy, and medical technology [1]. However, often the relevance of physics to technological development is not explained adequately. This problem was also raised by [2,3] who said that there is a lack of relevance of physics learning to technological developments. In learning physics, it is necessary to emphasize how physics concepts can be applied in the development of technology around students. For example, the concept of solar energy conversion is widely used to produce electricity using solar panels [4]. By explaining the relevance of physics to technological developments, students will more easily see and appreciate the important value of learning physics in everyday life. This was also conveyed in the research [5] which states that physics learning must emphasize its relevance to the development of modern technology.

Physics learning is ideally presented by presenting facts, objects or phenomena directly to students. The problem is that there are phenomena that are observed directly, but cannot be analyzed easily by students. For example, rectilinear motion, parabolic motion and circular motion are easy to ob-

serve in the real world, but when observing these phenomena, not much information is obtained. Apart from that, the lack of direct practice with learning material through science projects can also cause low problem solving skills. Physics learning places emphasis on teaching based on scientific processes and products so that it can improve students' problem solving skills and learning independence [6].

The increasingly rapid development of information technology as it is today means that the need for technology-based teaching and learning concepts and methods cannot be denied. Technology is currently widely used in the realm of education, many educational research findings have proven that technology is easily incorporated into the curriculum [7]. The first step that must be taken is to identify relevant technological competencies to be included in the curriculum. Relevant technology in the physics curriculum such as video analysis trackers used in kinematics material. In the kinematics material, students can analyze information about physical quantities that can be observed through the analysis video tracker [8]. Several studies that have used video analysis trackers include [9,10] The results of this research show that the use of video analysis tracker software is effective and feasible to use to explain motion phenomena. This research can also explain and prove physical theories with experiments through video analysis trackers. Other research [11], related to physics practicum using Tracker video analysis software in distance learning has been carried out. This re-

search was conducted to improve the competence of physics teachers as distance learning material for students. The results of this research show that the training carried out can increase teacher insight and competence. Tracker software training also provides an alternative solution for implementing practicums when there are restrictions on face-to-face learning activities. Apart from that, research from [12] also uses video analysis tracker software for high school students. The results of his research show that this simple experiment can be used in high school physics courses to guide students in developing a conceptual understanding of uniform circular motion with a less mathematical approach. However, previous research was limited to only a few phenomena, not all movement phenomena were analyzed.

The physics curriculum covers basic concepts in physics, principles, applications, and relevant experiments. Physics is a science that studies nature systematically to obtain facts, concepts and principles that can later be applied in everyday life [13,14]. Learning physics can also be interpreted as a science that is close to everyday life. So physics is not always synonymous with formulas for solving problems but is more than that. Physics learning is also defined as a process to guide students in a learning process that implements physics principles in everyday life

The learning process is characterized by educational interactions that occur. The learning process is carried out systematically through the stages of design, implementation and evaluation. Therefore, physics is a collection of knowledge, thought patterns, and one way to solve problems faced in everyday life [15]. In studying physics, students must engage in their own active construction. Therefore, physics learning should be facilitated by studying problem solving as practiced by scientists [16]. So the aim of this research is to create a simulation of the use of video analysis tracker software in kinematics material as an alternative to distance learning

## 2. Theory

### Straight Motion

A moving object remains in a straight line, its movement is called rectilinear motion [17]. The acceleration due to gravity is expressed as  $g$

$$g = 9.81 \text{ m/s}^2. \quad (1)$$

Constant acceleration means that the velocity changes linearly with time. The velocity is  $v_0$  when  $t = 0$ , and the velocity  $v$  at any time  $t$  is given by the following equation:

$$v = v_0 + at. \quad (2)$$

Thus, distance and displacement can be found using the following formula:

$$x = x_0 + v_0t + \frac{1}{2}at^2. \quad (3)$$

### Parabolic motion

Velocity components on the  $x$  axis  $v_x$  at each position are equal to the initial velocity component  $v_{0x}$ :

$$v_x = v_{0x} = v_0 \cos \alpha. \quad (4)$$

Meanwhile, to find the horizontal distance  $x$  traveled during time  $t$ , we use:

$$x = v_x t, \quad (5)$$

$$x = v_0 t \cos \alpha. \quad (6)$$

The velocity in the vertical direction ( $y$  axis) at time  $t$  can be written as:

$$v_y = v_{0y} - gt. \quad (7)$$

Since the vertical component of motion is uniformly accelerated, the height of the object at time  $t$  is:

$$y = v_{0y}t - \frac{1}{2}gt^2. \quad (8)$$

### Circular Motion

In uniform circular motion, the relationship between angular displacement and angular velocity is:

$$\theta = \omega t. \quad (9)$$

In circular motion, the physical quantities include angular position, angular displacement, angular velocity, and angular acceleration. The displacement  $s$  in terms of angular position  $\theta$  is:

$$s = \theta R. \quad (10)$$

The angular velocity equation is:

$$\omega_t = \omega_0 + \alpha t. \quad (11)$$

The angular position at time  $t$  is:

$$\theta_t = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2. \quad (12)$$

By using these equations, students can analyze the motion of moving objects.

## 3. Method

This research uses a qualitative descriptive method. The kinematics material that will be discussed in this research includes rectilinear motion, parabolic motion and circular motion. This research uses video analysis tracker software to obtain information from the movement of an object. The procedure for using the tracker software is as follows:

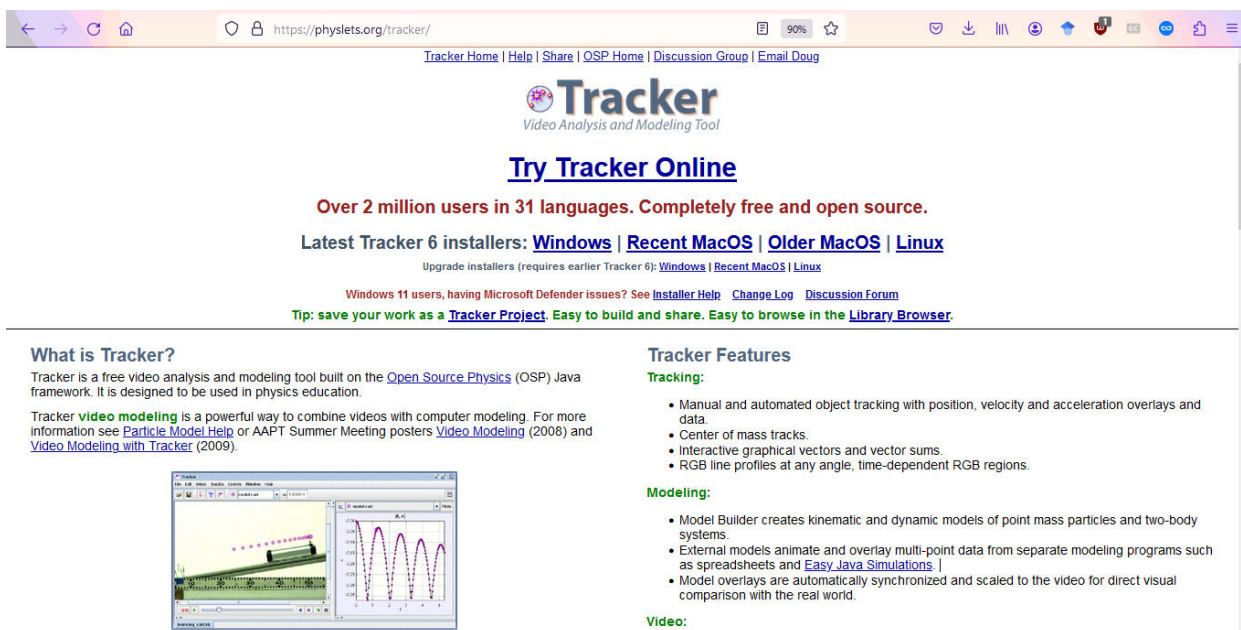


FIGURE 1. Download the video Tracker application.

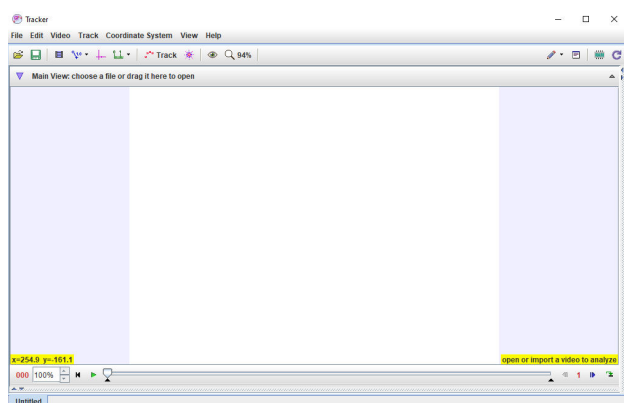


FIGURE 2. Default video Tracker display.

### Video modeling application (tracker analysis)

1. Download the application on the link <https://physlets.org/tracker/> (see Fig. 1).
2. Install the Tracker application.
3. Video Tracker application display, (see Fig. 2).
4. The video that will be analyzed is the movement of an object. Make sure the object has a color contrast to the video background, so that the object's movement can be seen clearly. Next, mark the distance of the object's path with a ruler and give it a mark.

### Activity procedures

1. Open the Tracker software.

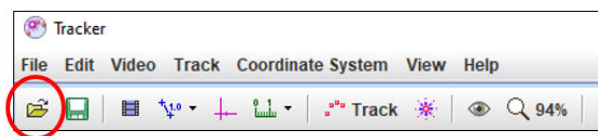


FIGURE 3. Tracker software toolbar display.

2. Click file on the toolbar in the top left corner, then click open file or with ctrl+O, (see Fig. 3).
3. Select the file to analyze.
4. Set start and end frames.

The initial frame is the frame when the object starts moving, while the final frame is when the object reaches the final point. To set the frame to be analyzed, right click on the video tracker display and select clip setting then fill in the initial start and end times or by moving the frame at the bottom of the video (Fig. 4).

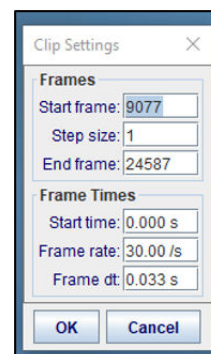


FIGURE 4. Display of frame settings.

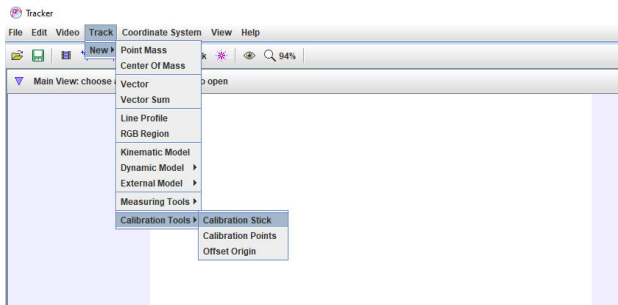


FIGURE 5. Calibration Stick display.

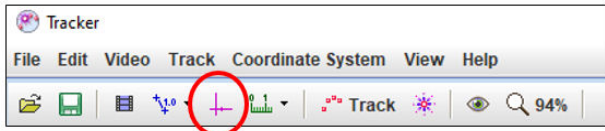


FIGURE 6. Display icon Coordinate Axes.

#### 5. Stick calibration.

This section is carried out to calibrate the path distance in the video with the real distance when carrying out the experiment. Click menu **Track >> New >> Calibration Tools >> Calibration Stick**. Press the shift key and left click the mouse twice to mark the start and end points of the scale calibration line and fill them in according to the actual trajectory distance when conducting the experiment (see Fig. 5).

#### 6. Setting the $x$ and $y$ axes.

Determine the direction of motion of an object in two dimensions by giving positive or negative values to the  $x$ -axis and  $y$ -axis by clicking the menu **Track >> Axes >> Visible**. Move the line to a position that corresponds to the direction that will be used in the analysis (see Fig. 6).

#### 7. Mass points.

Used to observe objects to be analyzed. Click menu **Track >> New >> Point Mass**. To change the name of the mob A klik pada mass A, then fill in the name of the object that we want for tracker analysis (example: ball A) (see Fig 7).

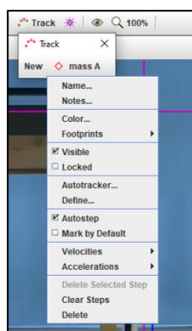


FIGURE 7. Point mass of an object.

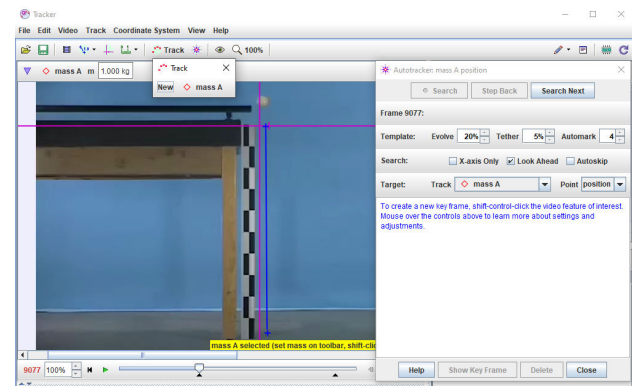


FIGURE 8. Display of the Autotracker dialog box.

#### 8. Autotracker.

Used to analyze moving objects. Click menu **Track >> ball A (according to the name of the object being analyzed) >> Autotracker**, (see Fig. 8).

9. Pres the button CTRL+SHIFT simultaneously and click on the object to be analyzed then in the autotracker dialog box clink Search so the graph appears on the right side.

10. If the tacker process is complete, click Close on the Autotracker dialog so that graphs and tables of analysis results are produced. Double click on the graph to increase the size of the graph. Then clink Analyze to analyze the graph that appears in the fitting according to the graph.

## 4. Results and discussion

### The role of kinematics

Kinematics is very important for technological development because it is the basis for understanding and designing systems that involve movement. Understanding the movement of objects makes it possible to create technologies such as autonomous vehicles, robotics and moving electronic devices. In addition, an understanding of kinematics contributes to increased efficiency and safety in industry, transportation and sports. Therefore, it is necessary to analyze the material in the concept of motion so that students can easily understand and apply physics knowledge in real situations. Material analysis taking into account projects that students can undertake has been carried out. The results of the material analysis are in the form of simulations to illustrate the concept of rectilinear motion through practical observations, so that you can observe the influence of speed, acceleration and distance in real situations on material in rectilinear motion, parabolic motion and circular motion. Next, analyze the data using simple software to describe the motion trajectories resulting from objects moving in a straight line.

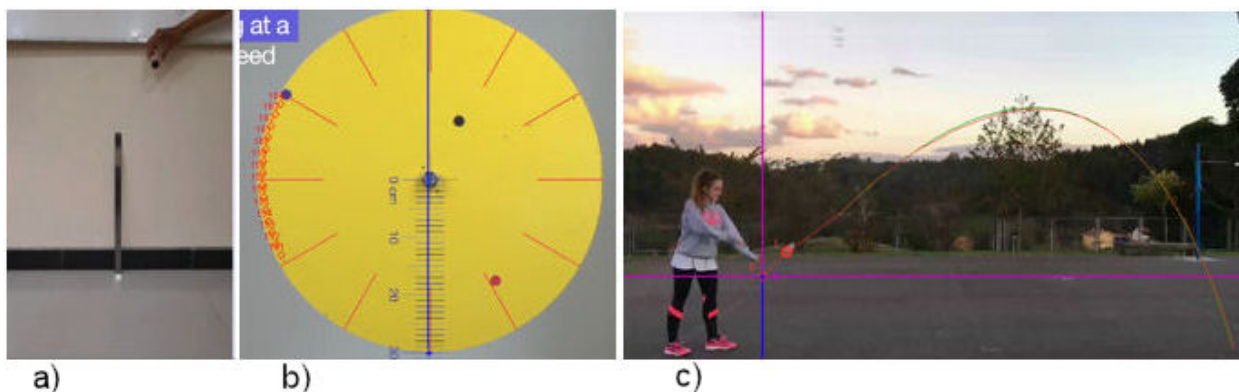


FIGURE 9. a) Straight motion. b) Circular motion. c) Parabolic motion.

### Straight motion

Straight motion is divided into uniform straight motion (GLB) and uniformly changing straight motion (GLBB). In uniform straight motion (GLB), the speed experienced by the object changes uniformly. This change in speed is called acceleration. The amount of acceleration in GLBB is constant. Constant acceleration in nature is often found, for example near the earth's surface all objects that are not supported will fall vertically with constant acceleration due to gravity.

### Parabolic motion

Parabolic motion is often found in the motion of bullets shot into the air. When a bullet is shot into the air at a certain angle called the elevation angle, the trajectory the bullet takes is a parabola. In parabolic motion, the movement in the vertical direction/ $y$ -axis is influenced by constant acceleration, so GLBB occurs on the  $y$ -axis. Meanwhile, on the  $x$ -axis there is no acceleration or it has a value of zero, which means GLB occurs.

### Circular motion

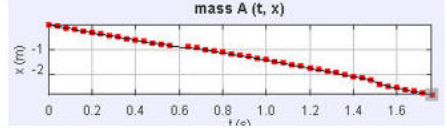
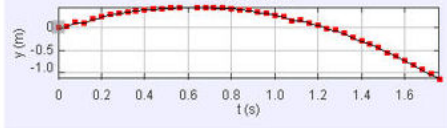
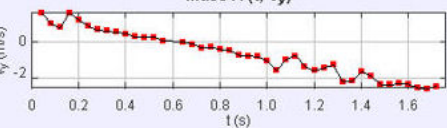
Circular motion is often encountered in everyday life. For example, the earth revolves around the sun in an orbit that is close to a circle, a wheel rotates in a circle, and a car moves in a circle when it goes around an angle. Circular motion of a particle if it moves with a constant speed  $v$  in a circle of radius  $r$ , the particle has an acceleration that is large and directed towards the center of the circle. This acceleration is called centripetal acceleration. In circular motion, physical quantities include angular position, angular displacement, angular velocity and angular acceleration. The experiment was carried out easily, as written in the research method. First, prepare a video of straight motion, circular motion and parabolic motion which will be analyzed as shown in Fig. 9.

The next step is to create a coordinate axis, create stick calibration and finally the track menu to obtain a motion graph of the object. After the graph appears, the next step is graph analysis by determining the curve fitting. The data obtained is then entered into an observation table as shown in Table I, II and III.

TABLE I. Observation results of free falling motion (straight motion).

Chart (axis $y$ , axis $x$ )	Picture	Fit Equation	Parameters A dan B (Value)
Chart $Y(m)$ , $t(s)$		Fit Equation: $y = A*t^2 + B*t + C$ Fitting Parabolic	-5.000E0 -8.307E-2
Chart $V_y$ (m/s), $t(s)$		Fit Equation: $v = A*t + B$ Fitting Linier	-1.130E1 -8.356E-1

TABLE II. Results of observations of parabolic motion.

Chart (axis y, axis x)	Picture	Fit Equation	Parameters A dan B (Value)
Chart x(m), t(s)		Fit Equation: $x = A \cdot t + B$ Fitting linier	-1.540E0 3.866E0
Chart y(m), t(s)		Fit Equation: $y = A \cdot t^2 + B \cdot t + C$ Fitting parabola	-5.00E0 1.745E0
Chart Vy(m/s), t(s)		Fit Equation: $v_y = A \cdot t + B$ Fitting linier	-2.472E0 1.540E0

In Table I, the graph of  $y$  against  $t$  forms a parabolic curve; therefore, a parabolic model is applied. The equation of the graph is expressed as:

$$y = At^2 + Bt + C,$$

with the coefficients  $A = -5.00$  and  $B = -0.083$ . The negative values of  $A$  and  $B$  indicate the direction of motion.

According to the kinematic equation of uniformly accelerated motion:

$$x = x_0 + v_0t + \frac{1}{2}at^2,$$

the parameter  $A$  in the parabolic model corresponds to  $1/2a$ . Thus, the acceleration due to gravity ( $g$ ) can be determined as:

$$g = 2A = 2 \times 5 = 10 \text{ m/s}^2.$$

Furthermore, the value of the initial velocity is  $v_0 = 0.083$  m/s, which is sufficiently small and can be considered approximately zero  $v_0 \approx 0$ .

In Table II, the graph of  $x$  against  $t$  forms a straight-line curve; therefore, it is modeled linearly. The equation of the graph is expressed as:

$$x = At + B,$$

with coefficients  $A = 1.54$  and  $B = 0.038$ . According to the kinematic equation of projectile (parabolic) motion:

$$x = v_{0x}t,$$

the parameter  $A$  corresponds to the initial velocity in the  $x$ -axis direction, so that:  $v_{0x} = 1.54$  m/s.

Furthermore, the graph of  $y$  against  $t$  forms a parabolic curve; therefore, a parabolic model is fitted. The equation of the graph is given by:

$$y = At^2 + Bt + C,$$

with  $A = -5.00$  and  $B = 3.80$ . In the equation of motion for the vertical component of a projectile:

$$y = v_{0y}t - \frac{1}{2}gt^2,$$

the parameter  $A$  is equivalent to  $-1/2g$ , hence:

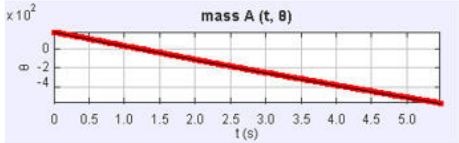
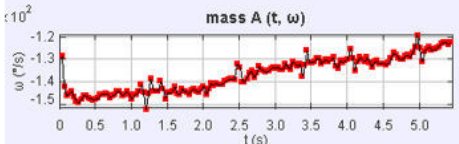
$$g = 2|A| = 10 \text{ m/s}^2.$$

Meanwhile, the initial velocity in the vertical  $y$  direction is:

$$v_{0y} = 3.8 \text{ m/s}.$$

In Table III, the graph of  $\theta$  against  $t$  forms a straight line curve so it is fitted linearly. The graph has the equation  $\theta = At + B$  with an  $A$  value of  $-2.38$  and  $B$  with  $2.94$ , negative values indicate direction. While the physics equation of regular circular motion is known  $\theta = \omega t$  then the value of  $A$  is equivalent to  $\omega$  so that the angular velocity value is worth  $2.38$  m/s. In Table I, II, and III it can be seen that by providing graphs of curve fitting results, we can determine the physical quantities we are looking for. In Table I we can determine the acceleration due to gravity and show that the initial velocity is zero in free fall. Meanwhile, in Table II, for parabolic motion, we can determine the acceleration due to gravity and the initial velocity in the  $x$  direction and the initial velocity in the  $y$  direction. The initial velocity values in the  $x$  and  $y$  directions can be used to determine other physical quantities such as the highest point of the object, the farthest point and the time taken by the object in parabolic motion. Meanwhile, in Table III, we can show that the angular velocity is constant in uniform circular motion.

TABLE III. Results of observations of regular circular motion.

Chart (axis y, axis x)	Picture	Fit Equation	Parameters A dan B (Value)
Chart $\theta(m)$ , $t(s)$		Fit Equation: $\theta = A \cdot t + B$ Fitting linier	-2.385E0 2.943E0
Chart $\omega$ , $t(s)$		Fit Equation: $\omega = A \cdot t + B$ Fitting linier	$\omega = \text{constant}$ (rad/s)

This video analysis tracker software has advantages as stated by [18]. The advantage of this tracker software is that it is able to present accurate and representative data data in the form of graphs, curves, tables and physics equations so that students are able to analyze the movement of objects easily. Especially in the material of rectilinear motion, parabolic motion and circular motion. The use of this tracker software is easy for students to use, as in research from [19]. In addition, research from [21], states that students are able to use tracker software to prove theories with experiments through graphs. However, this tracker software also has a weakness, namely the limited number of computer uses.

### Implementation in learning

Distance learning is learning carried out by educators and students who do not carry out the learning process face-to-face but are carried out in different places [22]. The teacher centered paradigm so far where the teacher is the center of learning is no longer relevant due to current technological developments. Currently learning is required to use student centered or students as the center of learning. The teacher only acts as a facilitator and provides various media that supports student learning. Students are required to learn independently and teachers design learning materials through online media. It is hoped that this can also increase students' learning independence. Distance learning methods are sought to be effective because of their importance in transferring knowledge to students. The effectiveness of distance learning using easy-to-

use and effective media, namely video analysis tracker software. Things that need to be considered when using video analysis tracker software for distance learning include providing initial knowledge and supporting media such as modules for students. With the project through video analysis tracker software, students are able to solve problems in kinematics material, apart from that, students are able to improve their skills in using technology which will be useful in the future world of work.

### 5. Conclusion

The teacher centered paradigm so far where the teacher as the center of learning is no longer relevant due to technological developments. Learning requires students to be the center of learning. Teachers act as facilitators and provide various media that support student learning. Students are required to learn independently and the teacher designs learning materials through online media. In this research we have shown that using a video analysis tracker can be used to search for physical quantities contained in moving objects. From investigative activities, students are able to prove theories in physics with the results of investigations or experiments using video analysis tracker software. Researchers suggest that simulations using video analysis tracker software can be applied in classroom learning, especially in kinematics material. The use of video analysis tracker software in the classroom learning process can improve students' problem solving skills and learning independence.

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