

Momentum Practicum Using Video Analysis for Graph Interpretation Capabilities

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Abstract. Current technological developments have been widely used in physics research, such as the use of tracker programs used to analyze videos. This is very useful when studying or analyzing motion. This study aims to design physics practicums (momentum and collisions) by analyzing position, speed, and time using video analysis Tracker to improve students' ability in interpreting graphics. The method used in this research is the experimental method. The technique of collecting data uses tracking video using video analysis. The results of this study indicate that the momentum practicum design developed can be used to improve students' ability to interpret graphs. Other physical phenomena can also be analyzed using video analysis Tracker.

1. Introduction

The concept of momentum and collision is very easy to find in everyday life. For example, a heavy truck has greater momentum than a light car that moves at the same speed [1], then a billiard ball collides, collides a baseball with a bat. In physics, there are two kinds of momentum, namely linear momentum (p) and angular momentum (L). In this study only linear momentum will be discussed. The momentum of a particle is explained as a multiplication between the mass of matter and velocity. Therefore, every moving object has momentum. Mathematically, linear momentum is written as follows:

$$p = m v \quad (1)$$

p is momentum (vector quantity), m mass (scalar quantity) and v speed (vector quantity).

One application of momentum conservation law is in the event of collisions of two objects. In a collision always involve at least two objects. Collisions are divided into three types, which are perfectly resilient collisions, collisions are not resilient at all, and partially resilient collisions. In accordance with the conservation law of energy, conservation law also applies to momentum where the momentum of objects before and after collisions is the same. Therefore, it can be concluded that: in the event of a collision, the amount of momentum of objects before and after the collision remains as long as there is no external force acting on these objects. Mathematically for two colliding objects can be written:

$$p_A + p_B = p_A' + p_B'$$

or

$$m_A v_A + m_B v_B = m_A v_A' + m_B v_B' \quad (2)$$

While the magnitude of the coefficient of restitution (e) for all types of collisions applies:

$$e = -\frac{v_A' - v_B'}{v_A - v_B} \quad (3)$$

Current technological developments have provided convenience in the field of physics research. The latest technological advances have made video capture and analysis in an introductory physics laboratory even more affordable and easily accessible [2] one example is the video analysis of the Tracker model. Tracker is a free downloadable video analysis tool that is used easily to track the movement of objects and produce graphs, time distances [3]. Videos recorded with video cameras are then analyzed with open source Tracker software [3]. Through video analysis a phenomenon or collision physical event can be presented together by reviewing the relationship between position, and speed (v) and time.

Therefore, to observe the symptoms of momentum and collisions in an object can use video recording and image modeling because physical phenomena will be observed [4], the data obtained is more precise and accurate so that this method is very practical to use [5]. In the 21st century, the ability to analyze data, draw conclusions, evaluate with the aim of interpreting data to support an assumption is very important [6]. The increasing development of technology and information at this time, understanding graphics and percentage of data are activities that students will often encounter in their daily lives. In addition, increasing graphic literacy in data analysis and interpretation is very important to improve their science process skills [6].

2. Experimental Method

The method used in this research is the experimental method. In this study only explained the momentum practicum learning method for learning students using video analysis. The materials used in this practical activity are two train tracks, two trains that have a variety of mass, digital balance to weigh the mass of the train, a camera with a resolution of at least 60 f/s , and a laptop tracker software installed. For practical learning steps are as follows:

1. Prepare the train and track according to the guidance of the supervisor
2. Installing springs on both trains and weighing the mass of the train using a balance sheet.
3. Place one of the trains in the middle of the track and give the name of the train as train II.
4. Place another train (train I) at the end of the track, then push it until it collides with train II.
5. Prepare a camera to record videos of train 1 and train II when colliding with each other.
6. After the video is recorded, then the video file is analyzed using Tracker software
7. Repeat steps 5 times to find accuracy

Figure 1 is a tool design that has been arranged.



Figure 1. A series of momentum tools and collisions

Furthermore, doing a tracker, once the video recordings are obtained twice the track, namely for train 1 and train 2. The results of tracking are as shown in graph 1 (train 1), and picture 2 (train 2).

3. Result and Discussion

The first train is a train that runs at an initial speed then crashes into the second train. Whereas on the second train that does not have initial speed, due to the collision of the first train, the second train has speed.

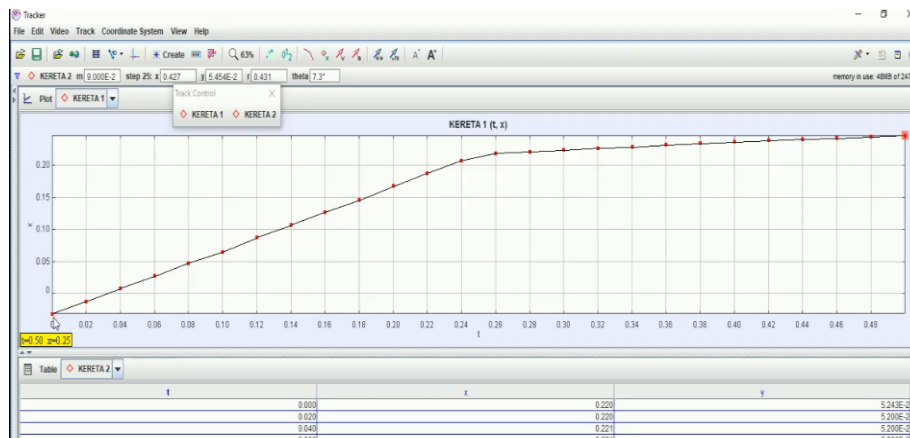


Figure 2. Display Graph tracking results for train one

See in figure 2, graph of the relationship of time and distance on train one, at first the train has speed, then after the collision of the train the speed decreases and then a certain interval of speed is close to zero. The movement can be seen on a graph which initially forms a linear line and then the line becomes horizontal with the same distance position.

In the graphical movement of train one, we can determine the momentum of an object by looking at the initial velocity before the collision according to equation (1). To determine how fast a train is before a collision, it can be seen by fitting a line like in figure 3. The initial speed of a train can be considered as a constant speed or regular straight motion, because the train travels very fast and forms a linear line.



Figure 3. Fitting graphics using the tracker program

If a linear graph of the relationship $y = ax + b$, where y is the distance and x is time, it can be assumed that a (line gradient) is the velocity value of a moving object. From the results of the fitting graph above, the velocity of the object is 0.996 m / s.

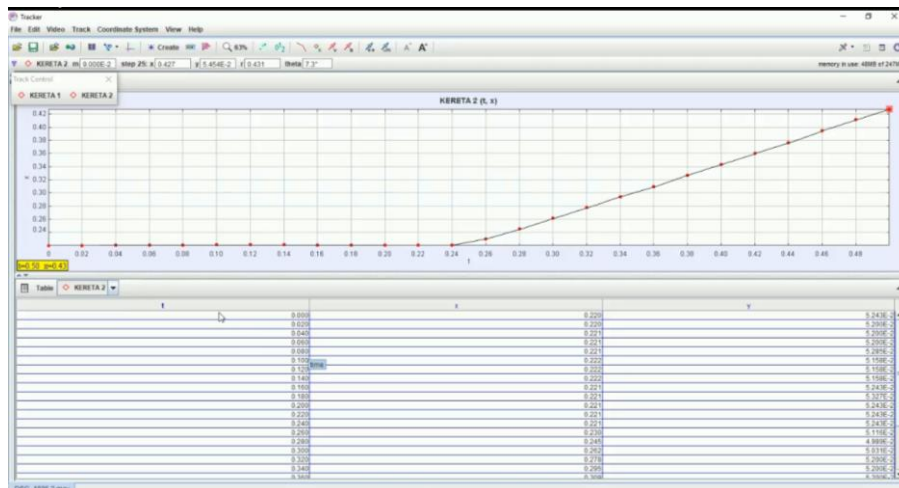


Figure 4. Display graph tracking results for the second train

See Figure 4, on the second train, initially there is no speed because there has not been a collision and the graph show a constant distance at the same distance position. Then after the collision, the graph forms a linear line and has a constant speed. The speed after the collision on this second train can be searched as in the first train, then gaining momentum as in equation (1).

Through this experiment, students can determine several values, namely: first train speed before collision (v_1) and after collision (v_1'), second train speed before collision (v_2) and after collision (v_2'), first train momentum before collision (p_1) and after collision (p_1'), momentum second before collision (p_2) and after collision (p_2'), first train kinetic energy before collision (E_{k1}) and after collision (E_{k1}'), second train kinetic energy before collision (E_{k2}) and after collision (E_{k2}'), and coefficient restitution (e). Students can write as in table 1.

Table 1. Data tables filled by students

Mass (kg)		Velocity (m/s)				Momentum (kg m/s)				Kinetic energy (Joule)				Coefficient of Restitution (e)
Train 1	Train 2	v_1	v_2	v_1'	v_2'	p_1	p_2	p_1'	p_2'	E_{K1}	E_{K2}	E_{K1}'	E_{K2}'	

After students fill in the table, students have performed analysis and graph interpretation in the results of the analysis program Tracker. When students use graphics to understand the data collected during practicum activities, they are developing knowledge about physics concepts and improving the development of cognitive abilities [7,8]. Graphs can describe a relationship that is not seen in raw data because raw data has only a little meaning, therefore by analyzing graphics it helps students think like a physicist because graphics are part of scientific communication [9,10]. In this lab, students directly analyze real-world phenomena using video analysis, collecting data, reading charts, analyzing and interpreting data in the relevant conceptual framework. Graphical interpretations in the real world produce relevant conclusions and contextual problems can be solved [11], [12].

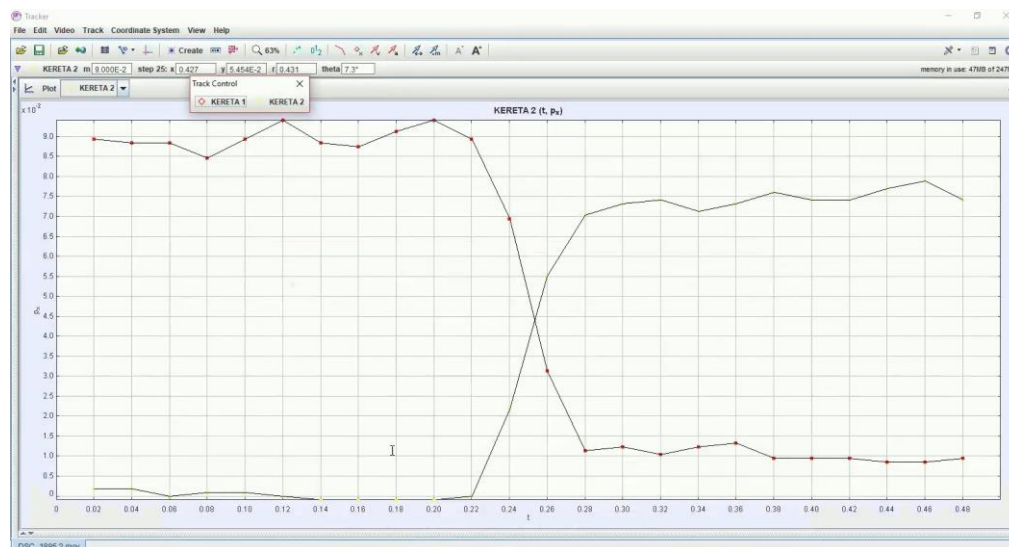


Figure 5. Graph of the relationship between time and momentum for both trains

Figure 5 is a phenomenon formed between the two trains seen by the relationship between time and momentum. It can be seen at first that the first train runs at a great speed, so it looks that the train has a large momentum, after the collision the momentum will decrease. Likewise for the second train, it was obtained before the momentum collision seemed small, and after the collision the train had momentum. If observed in the graph, the value of the combination between the train one and the second train forms a symmetrical line, this is in accordance with equation (2).

4. Conclusion

Learning momentum using video analysis is very helpful for students in improving graphic comprehension. In this practical activity students are asked to study the graph. In this practical activity students are also directed how to connect between line equations with graphs formed. The momentum practicum steps using this analytical video can also be seen in the following video https://youtu.be/_klot_9aUs

5. Acknowledgments

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6. References

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