Physics Instruction Using High-Speed Video Analysis Technique

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Abstract
In this study, we report on the use of tracker video analysis and high-speed camera as an interactive approach to study the free fall. The video camera is used to collect position and time data, which can then be used to mathematically and graphically model. Anything related to the position and motion of the object. In the experiment, we compared the objects from free-falling, wood block and ball in two approach. The camera that recorded the motion of free fall at a frame rate up to 240 frames per second (fps), analysis of the motion is performed at different angles for the wood block and the ball is released from the high that related in the different angles. The results were measured linear speed, angular speed and acceleration in the motion of them. At the same fulcrum point, it was found that the linear speed was changed in different angle, but it did not affect in the angular speed. The free-falling of the ball in this experiment, the distance or the displacement of a ball was proportional to the time squared and the agreement with the theory. The video analysis served as an effective means to collect, analyze, and report data and also enable the analysis of some situations that would not otherwise be possible. Deep learning adds a lot of support to the rapid development in physics classroom.

Keywords: Tracker, High-Speed Video, Video Analysis

Introduction

Physics is a subject that deals with phenomena in the real world. Efforts to model the physical world. In trying to solve physics problems, we often need to understand the physical phenomena that arise because many real-world problems are associated with phenomena. Students are required to have a solid understanding of several fundamental physics concepts in order to solve problems correctly. It has long been understood that textbooks by themselves and it cannot communicate physics concepts effectively to students. (Tuite, 1967) The study of video analysis was established in physics education. The application of research in physics education, combined with computer-based materials that students find exciting to use and helps them learn complex concepts. The video analysis tools can help students develop an understanding of kinematics graphs, a fundamental part of introductory physics. However, the teachers must supply a variety of ways for students to become involved with the content, essentially establishing for learning. (R. Beichner,1996; P. Laws and H. Pfister, 1998)

Currently, there are articles in physics studying a variety of studies in which high-speed video cameras are used to study the motion of objects, such as the study of the air resistance of the free falling of object. Experimental activities can motivate students and open their minds to understanding physics. The experiments of one and two-dimensional motion are the concepts that underlie almost all other concepts in physics. It was important to build student's experiences of the concept based on digital cameras and Tracker software. It can be used as a physics learning media on motion kinematics materials that can display various kinematics graphs so that information about motion is complete. The development and use of technology are important in the field of education to support the need for learning in introducing concepts about motion in physics. (Vera F. and Romanque C.,2009; Bryan, J. A., 2010; Wee, L.K., et al.,2012; Vera, F., Rivera, R. and Fuentes, R., 2013).

The Tracker program was allowed students to create simple of particle motion on a video clip. It makes learning connected to real life and powerful as it provides a mechanism to progressively triangulate their understanding through the video model pedagogy. Analysis of the Tracker program, which uses a high-speed video camera to study the motion of an object, will make it easier to understand its principles than what we have studied in theory. The students can easily download Tracker to their own computers, they can use it for independent projects or extended homework assignments as well. We can also apply them to teaching and learning in physics courses. (D. Brown and A.J. Cox, 2009) Corresponding with Pattar, U., Raybagkar, V.H., and Garg, S. (2012) that student's understanding of physics concepts is improved because they discover them for themselves through hands-on experience through experimental activities.

The solution to increase understanding of physics concepts about motion is an activity real experiment video analysis. This study aims to helping students understand about the free fall of an object. Especially the comparison between the falling of the wooden block at the various angle with the free fall of the ball. Using real studies on the movement of real experiment video clips through video analysis with Tracker program.

Method

In experiment, we set the composition in figure 1. The high-speed camera for video shooting and used the image-to-time ratio (frame rate) at 240 frames/sec. In experiment, we set the composition in figure 1. The high-speed camera for video shooting and used the image-to-time ratio (frame rate) at 240 frames / sec. The students start shooting a video of the fall of the wood block and the free fall of the ball. Then take the videos that have been analyzed with Tracker program. The study was divided into two part. Part one of the experiment was finding the linear and angular velocity of the wood block and the ball with the same position. Part two of the experiment was finding the acceleration of the wood block and the ball with the various position.

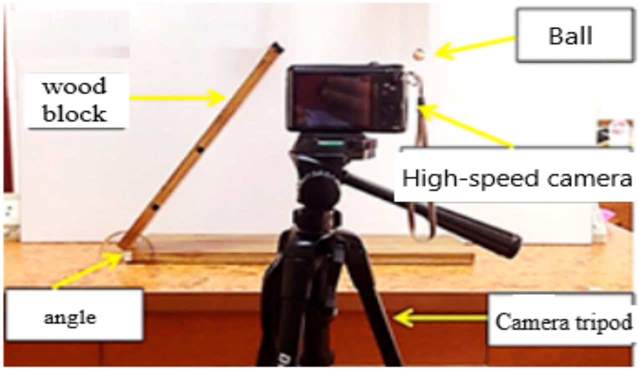


Figure 1: This is an image of experiment 's composition

Results

In this experiment of part one, the relationship between angular and linear velocity at different locations on a falling wood block was studied. It was starting the wood block at an angle of 60 degrees to the level. In figure 2, the study of numerical data in the table. It was obtained by tracking A and B positions of the bars from the Tracker program using the time (t), linear speed (v) and angular velocity (ω) of both positions on the wood block. To find the correlation of such information as shown in Table 1

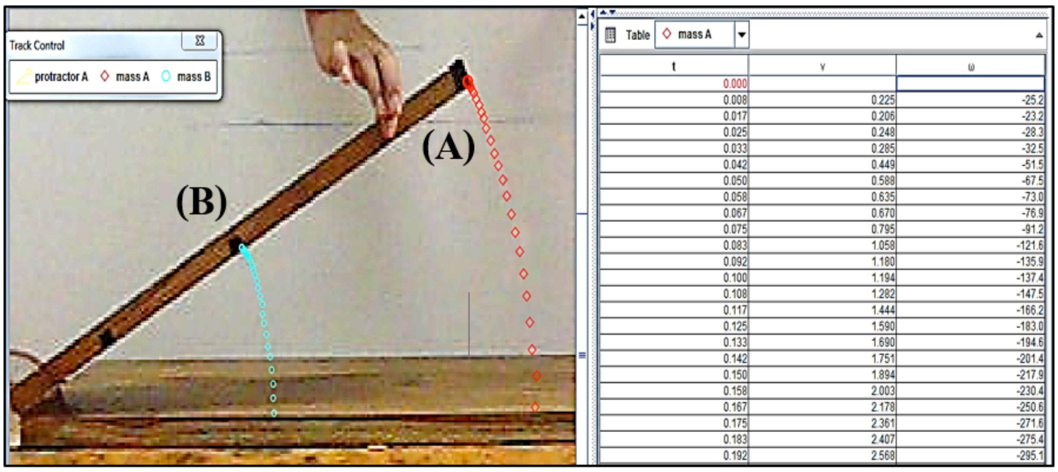
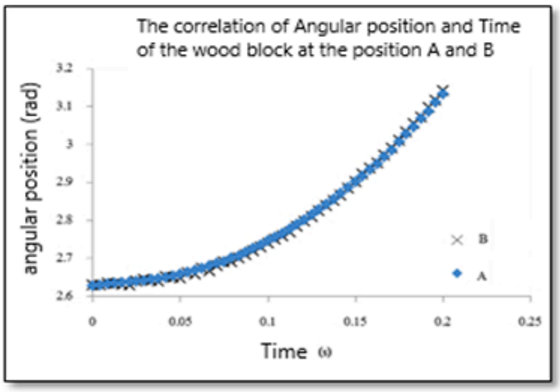


Figure 2: This is an image of the tracking of A and B positions of the wood block from the Tracker program

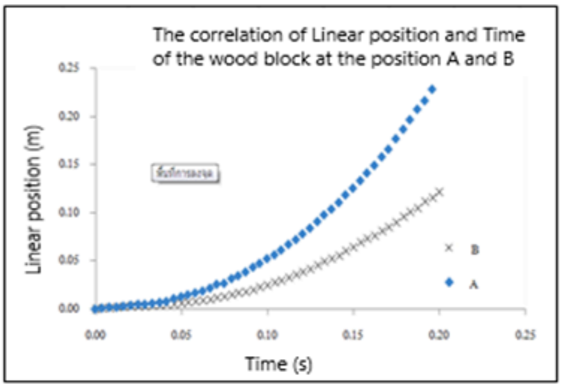
Table 1: Time, Linear velocity, Angular velocity of the A and B positions of the wood block

t (s)	Linear velocity, v (m/s)		Angular velocity , ω (rad/s)			$R_A=\frac{v_A}{\omega_A}$	$R_B=\frac{v_B}{\omega_B}$
	position A	position B	position A	position B	%diff		
0.008	0.284	0.135	0.556	0.541	2.734	0.511	0.250
0.025	0.253	0.135	0.487	0.504	3.431	0.520	0.268
0.033	0.288	0.149	0.577	0.577	0.000	0.499	0.258
0.058	0.572	0.287	1.146	1.141	0.437	0.499	0.252
0.063	0.699	0.351	1.399	1.404	0.357	0.500	0.250
0.121	1.520	0.752	3.049	3.048	0.031	0.499	0.247
0.129	1.660	0.853	3.334	3.337	0.090	0.498	0.256
0.175	2.588	1.258	5.127	5.129	0.039	0.505	0.245
			%diff		0.890	0.504	0.253

The data were analyzed by the Tracker program using the time (t), linear velocity (v) and angular velocity (ω) of both positions on the stick. To find the correlation of such information. Both cases of velocity data are graphed were shown in figure 3



(A)

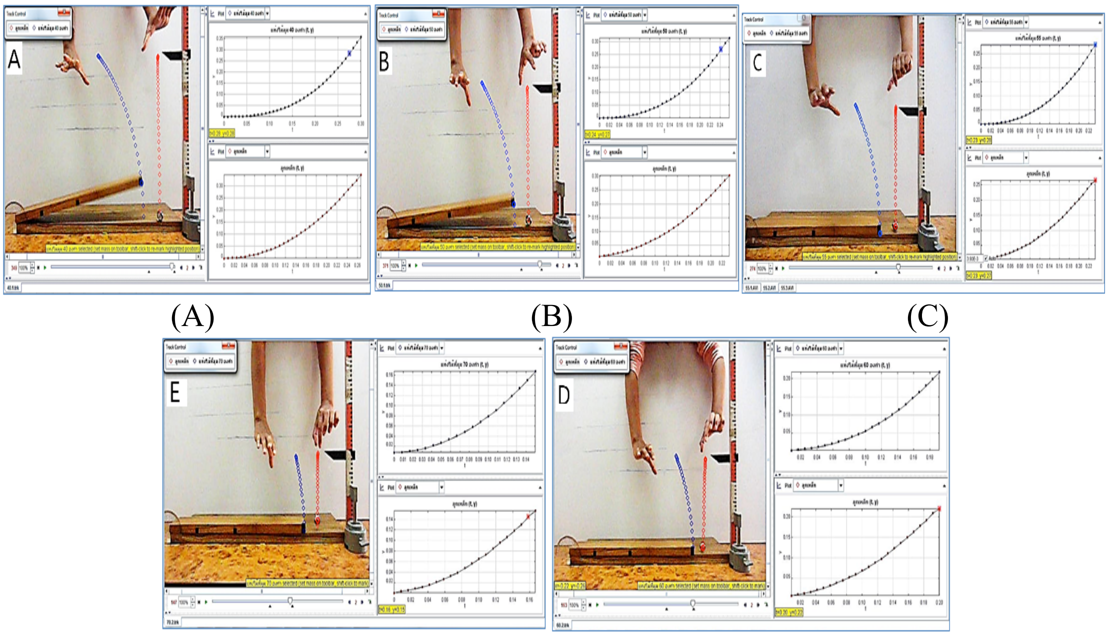


(B)

Figure 3: This is an image of the correlation of such information (A) The correlation of angular position and the wood block at the position A and B (B) The correlation of linear position and the wood block at the position A and B

From figure. 3, it was found that while the wood block falls around a pivot point at a different distance from the pivot point. The linear velocity is different by the closest position. The pivot point has less linear velocity. However, the angular velocity of different positions be equal.

In the part two of the experiment was finding the acceleration of the wood block and the ball with the various position. An experiment was to release the wood block and the ball at the same height, and time, where the bar was tilted at an angle of 40,50,55,60 and 70 to the vertical. It was shown in figure 4.



(A) (B) (C)

(D) (E)

Figure 4: This is an image of the bar was tilted at an angle of (A) 40° (B) 50° (C) 55° (D) 60°and (E) 70° to the vertical

From figure 4, it was found that the wood block and the ball were released at the same height from the ground. The initial angle releasing the wood block were 40 and 50 degrees. The ball reaches the ground first. The initial angle released at 55 degrees, both objects will land at the same time. At the initial angle, releasing more than 55 degrees, the wood block will fall faster. The studying the vertical acceleration of the tip of the wood block and the acceleration of the ball. Which was analyzed by graphing fit with the equation y = 0.5*a* tt + B in Tracker program data tool application tool was shown in figure 5.

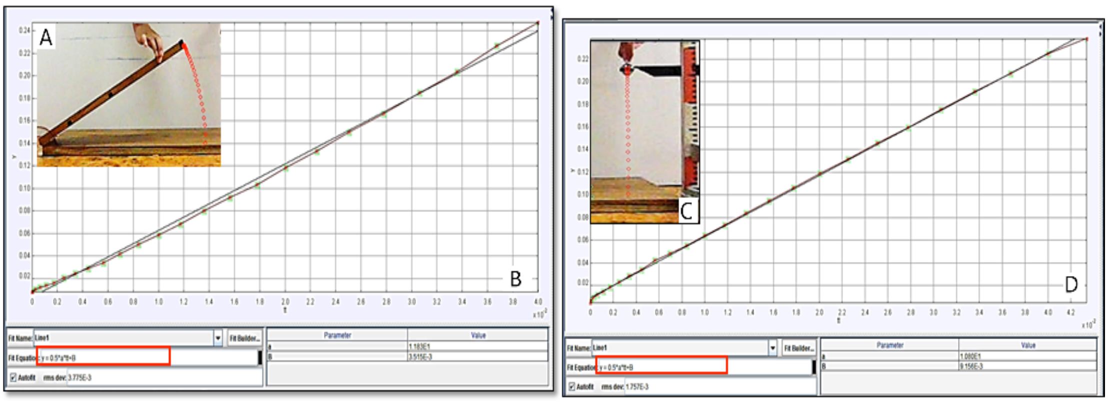


Figure 5: This is an image of the acceleration from the wood block tip and the ball with tracker program analysis (A) Trajectory of wood block tip (B) An acceleration graph from the wood block tip with Tracker program (C) The trajectory of the ball (D) The graph showing the acceleration from the Tracker program of the ball.

From figure 5, the graph of the relationship of the vertical axis position with the time squared. It was found that the graphs obtained were linear when the graph was fitted with the equation y = 0.5*a*tt + B and compared with the linear graph equation $S = ½* gt^2$. The release of wood block and the ball with various initial angles. When data from figure 5 is used to compare the two objects' fall. It was found that the ball reached the ground first, with wood block having an acceleration of 6.47 and 8.84 m/s^2. At the initial drop angle greater than 55 degrees, angles of 60 and 70 degrees. It was found that the wood block falls faster than the ball and an acceleration were 11.53 and 13.21 m/s^2 respectively.

Conclusion

From the experiment of the free falling of the wood block to the ground with an initial angle of 60 degrees to the vertical. The recording video was performed with a high-speed with a frame rate of 240 frames/sec and analyzed by Tracker program to consider two sample positions on a wood block, A and B. Determined from position A and B, where the position A is further from the pivot than the position B. While the stick fell around a pivot point at a position from a different pivot point, linear speed has different values. The angular velocity of both positions is the same. The comparing of the falling of the stick with the free fall of the steel ball. The free falling of the wood block and the ball at the same height from the ground. The initial angle of the beam was 40 and 50 degrees. It was found that the ball reached the ground first, with wood block having an acceleration of 6.47 and 8.84 m/s^2 respectively. When released at an initial angle of 55 degrees, both objects fall to the ground simultaneously with similar acceleration and a percentage difference of 1.01% and at the initial drop angle greater than 55 degrees, angles of 60 and 70 degrees. When released at an initial angle of 55 degrees, both objects fall to the ground simultaneously with similar acceleration and a percentage difference of 1.01% and at the initial drop angle greater than 55 degrees, angles of 60 and 70 degrees. It was found that the wood block falls faster than the ball and an acceleration were 11.53 and 13.21 m/s^2 respectively.

In summary, the using video and multimedia resources in physics education helps students create multiple representations of physical phenomena. Since a large number of physics concepts involve correct visualization to get a good grasp, these resources can take teaching and learning physics to a much higher level.

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