

The Production of Interactive Software for Supporting the Kinematics Study on Linear Motion and Swing Pendulum

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abstract

Many students assume that physics which is learned at school is considered as a difficult and boring subject. This condition happens because of conventional teaching and lack of visual aids. As a result, the subject is considered boring, not attractive, and difficult to understand. This software is developed to make the student to be more enthusiastic in dealing with physics, not only in schools but also in their personal computer.

This software can help the student in order to learn about kinematics of rectilinear motion and swing pendulum. This software is developed using Borland Delphi 7.0 as interface, Macromedia Flash MX as material delivery, and Microsoft Access as database. This database is used to save the question in the quiz to make it possible to be changed.

Based on the polling result, it is concluded that 80% of the senior high school students 10th and 11th grade agreed that materials in this software is more attractive from the aspect of text layout, picture, and supporting simulation. Besides, 90% of senior high school students said that this software could increase the motivation in learning physics.

Keywords :

Computer Aided Learning, Interactive Software, Physics, Rectilinear Motion, Pendulum Swing.

1. Background

In our daily life, we do motion, such as walk, run or we do motion with tool, such as drive a car. Some motions have certain characteristics. For example, a stright forward with a constant speed. Although very familiar and simple, high school students have some difficulty to understand motion because it can't be imagine easily. To cover this problem, this research designs a tool to help the high school student learning motion by simulating the motion.

This tool is a *Computer Aided Learning* (CAL) software. Commonly, CAL supports students tutorial on a certain topic, so they can learn by themselves. Since the CAL wants to provide a complement material for students, CAL needs something doesn't teached at school. To learn physics well, student want to do some experiments. In this way, CAL will help students to see motion, instead imagine it.

In our developed software, we mean it as an interactive learning method. This software will allow students read tutorial about motion, do an evaluation test, practice motion calculation based on

newton laws, and simulate the motion based on some given input. This kind of learning method has been developed in education recent decades. Some survey on the advantages using this method, said that CAL will increase student's interest on the topic[1]. Usage tools such as CAL also makes the education more effective and efficient than conventional education. It because Cal not only gives student material on the topic of interest, but also show picture and simulation which can explain more detail than words.

Actually, CAL is developed based on human's study method. Some students would like study by reading books while the others by seeing and doing something[2]. Some students will satisfy just with knowing while the others will satisfy with doing. CAL is a tool which help students learning by knowing and doing so they will understand the topic wholely.

2. Linear motion

Linear motion is motion on a stright path[3],[4]. There are two major kinds of linear motion, uniform linear motion and non-uniform linear motion. Uniform linear

motion has constant velocity. Non-uniform linear motion has constant acceleration. The total distant the motion gains can be calculate using eq 1 while the one of non-uniform linear motion can be calculate using eq 2.

$$s = s_0 + v.t \quad (1)$$

Where s is the distant reached by the moving object and s₀ is the original position before the object moves. v is velocity, t is time needed by the moving object to finish the distant.

$$s = v_0.t + \frac{1}{2}at^2 \quad (2)$$

Where v₀ is velocity before the object moves with acceleration. The acceleration itself can be calculated using the equation below.

$$a = \frac{v_t - v_0}{t - t_0} \quad (3)$$

Where v_t is velocity at observed time t while t₀ is starting time when the non linear moving begins. Actually, non linear moving is horizontal moving. This kind of moving can be expanded become vertical moving, such as something falling from above and parabolic moving, such as throwing something above, and after that thing reaches the peak position, it will fall down. The expanding moving can be calculated using the generic equation below.

$$s_x = 2 \cdot \frac{v_0^2}{2g} \sin 2\alpha \quad (4)$$

$$s_y = \frac{v_0^2 \sin 2\alpha}{g} \quad (5)$$

Where s_x and s_y are the distant at horizontal and vertical direction respectively. g is gravity and α is the degree if the object moves in parabolic direction.

3. Swing Motion

3.1. Single Pendulum

Swing motion is a motion of an object with distinct mass to left and right direction[5],[6]. For example, a ball swing using a thread as shown in figure 1.

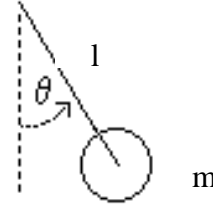


figure 1. Single pendulum.

In figure 1, θ represents angle between pendulum with vertical line in degree. l is thread's length, in meter. To calculate the pendulum's position while swing, is used vector i and j as vertical and horizontal direction representation[5]. The pendulum's position can be calculated using equation 6. While period and frequency of the swing can be calculated using equation 7 and 8 respectively.

$$\text{position} = l \sin \theta \mathbf{i} - l \cos \theta \mathbf{j} \quad (6)$$

$$\text{period} = \frac{2\pi}{\sqrt{g/l}} \quad (7)$$

$$\text{frequency} = \frac{1}{2\pi} \sqrt{g/l} \quad (8)$$

where g is earth's gravity. The Force of swing pendulum will be calculated using equation 9.

$$F = m.g.\sin \theta \quad (9)$$

3.2. Double Pendulum

Double pendulum is two pendulum in one thread. They are tied sequently, as shown in figure 2[6]. Double pendulum's motion represents one of chaotic motion in simple physics. Double pendulum in this CAL is focused on motion with undumping factor. It means motion without any external force works on it.

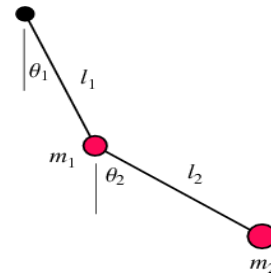


figure 2. Double pendulum

To detect the position of first and second pendulum, used equation 10 and 11. Each position will be represent using vector. x_1 and y_1 is position of first pendulum, x_2 and y_2 is position of the second pendulum. l_1 is thread's lenght from base to first pendulum while l_2 is thread's length from first to second pendulum.

$$x_1 = l_1 \sin \theta_1$$

$$y_1 = -l_1 \cos \theta_1 \quad (10)$$

$$x_2 = l_1 \sin \theta_1 + l_2 \sin \theta_2$$

$$y_2 = -l_1 \cos \theta_1 - l_2 \cos \theta_2 \quad (11)$$

4. Analysis

This CAL is designed for students to learn by themselves. They can make their own schedule, when they will finish their tutorial, they can test their ability by doing the evaluation test by theirselves. If they failed in mastering a distinct part, they can re-learn the part without annoying anyone else. None will wait other student's understanding in the studying process.

Firstly, this CAL wants to accomodate all the student learning behaviours. They will learn not only by reading the material but also hearing the explanation and seeing some support pictures. In this CAL, we adopt S-O-R method. In this method, studying process is started with receiving information, manipulating that information and finally, producing the result[7]. Information is given in text and voice form. Information is arranged based on what-why-how concept[8]. Firstly, give the definition, then, inform the background about the topic, explain equations which are related with, and finally, show how the equations work. After receive the information, student will be guided to manipulate the information. Through showing some examples and their calculations, and also simulate some equations, student will be supported to manipulate information they received before. The last step of S-O-R method is producing the result. This step is done by giving them some test to evaluate their understanding on the topic.

5. Experiments

We had done some experiments to test the simulations. Figure 3 shows the interface of linear motion simulation menu. First user must input the velocity. Then the software will run a ball rolling on a linear line. While it rolls, we will see the distant it reaches each second. In this experiment, we input velocity 5 m/s. This simulation is done for five times. It reaches a distinct distant. Then, the time it needs to reach the distant is calculated using stopwatch, the result are:

Experiment 1 = 21.08 s

Experiment 2 = 21.14 s

Experiment 3 = 20.23 s

Experiment 4 = 20.10 s

Experiment 5 = 20.78 s

The average time is 20.65 s, while according to the equation, it should be 20 s. The error is less than 5%.



figure 3. The interface of linear motion simulation menu.

To test non-uniform linear motion, we set time with 25 s, acceleration 2 m/s^2 and velocity 10 m/s. This simulation can be seen in figure 4.

Figure 5 shows the result of simulation on parabolic motion. Used velocity 100 m/s, 30 degree when throw the ball, the time needed to finish the path is 5.10204 s and the maximum height is 312.5 m this result is same with the

calculation using equation 4 and 5. The last simulation, simulation on swing pendulum is shown by figure 6. Swing pendulum simulation is done by inputting the degree formed while the ball swings.



figure 4. The interface of non-uniform linear motion simulation menu

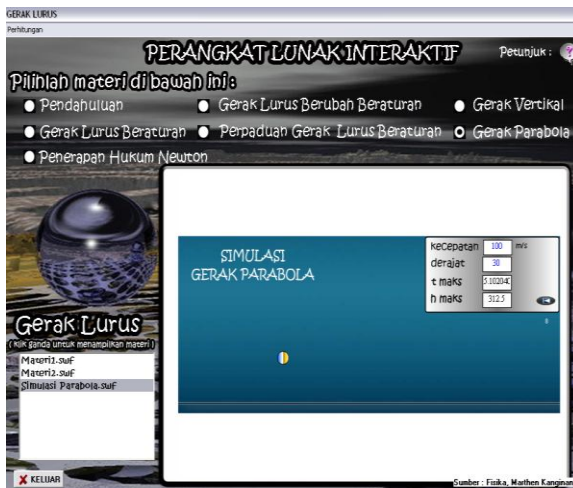


figure 5. The interface of parabolic motion simulation menu



figure 6. Interface of swing pendulum simulation menu

6. Result

The motion simulation makes an error in calculating the time, but the error is not significant, 1-2 seconds different than the ideal calculation. It is caused by the ordering of time checking in the program. Therefore, this CAL can help students to learn motion more interesting and clear. Using questionnaires result, we can conclude that they learn better using our CAL than using conventional method.

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