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Simulation using VBA in Microsoft Excel to Enhance Pre-service Physics Teachers' Motivation

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Abstract:

There are many difficult topics to teach directly in physics learning. Some concepts are abstract or difficult to show one by one. Not a few studies that use applications or media that serves to help the learning process. However, most of the media is offered use some of the most complex and complicated new apps. Even sometimes it's make difficult for teachers. To overcome this, this study offers learning media using spreadsheets that simple and easy. Topics in this study is simple harmonic motion in physics lessons. The method is used VBA in Microsoft Excel. Sample of this research were 86 student on pre service students from Tanjungpura University. They were given a task to make this simulation and interviewed as randomly to know their motivation on physics learning. As the result, we created a studying media to simulate harmonic wave motion that can be varied according to the needs of teachers during the learning process. Their motivation also increase to learn more about physics simulation. The practical application of this paper is helping teacher to teach physics more effective especially in visualizing of simple harmonic motion. This article also adds intellectual property to easy and effective simulation-based learning.

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Introduction

Physics is known as one of the most difficult subjects (Guido, 2018) and boring (Gökalp, 2018). This is due to the abstract material (Battaglia, Pascanu, Lai, & Rezende, 2016) or difficult to be sensed (Zakaria, Supriadi, & Prihandono, 2018). Some of these abstract materials are very small things such as gas and atoms. Other material that is difficult to see directly, such as force, electric current, or large objects in space. To help teachers and students, some education specialists develop learning media in the learning process. There are many media that have been developed by educational experts both real and virtual. Not a few inventions of props in physics learning such as rockets, miniature of the universe, or atomic modeling. However, in the last 10 years the discovery of learning media began to pursue the use of technology. Some inventions take advantage of technology as a basis for development or so-called e-learning. E-learning that ever use is certain applications such as augmented reality (Strzys at all, 2018), virtual lab applications (Galan, Heradio, de la Torre, Dormido, & Esquembre, 2018; Masril, Hidayati, & Darvina, 2018) and video simulation (Chen, Wei, & Li, 2016). There is also a media that is connected with internet network such as scaffolding (Bhattacharya, Chowdhury, & Roy, 2018; Bautista, 2013) , edmodo (Maryem & Iman, 2018) , interactive web simulation (Perkins, & Wieman, 2018), and online discussion (Fernandez, Simo, Castillo, & Sallan, 2014). Almost all learning media in the 21st century is using modern technology, the latest applications or at least connected to the Internet network. If they are not easy to use, it can make be difficult for teachers and students. Although it can provide many benefits, teachers tend to avoid using e-learning when difficult to use. To overcome this, the need to develop learning media that is easy to use and useful but still in accordance with current technological developments. Technology is playing an important role in assisting teachers in their activities (Kallas, & Ornat, 2012). Alhajya, Alzaghamim, & Arouri, (2018) found that there were statistically significant differences (α=0.05) between means of students' achievement test scores attributed to teaching method variable, and in favor of the experimental group when using a virtual trip on learning language. Experiences with a simulated learning environment on learning process has positive impact for the students (Navarro, Aguado & Ortiz, 2014). Another studies show that using online quizzes that such quizzes have a proven positive influence on students' academic performance (Salas, Azofra, & Hernández, 2012). In physics, the students' conceptual understanding as well as interest in circuits was increased after study with interactive online physics labs. One of the learning media that is easy to use and close to the teacher and students is Microsoft excel. Microsoft excel already known by teachers and students even while in elementary school. This media is considered very easy to use, in addition to not need to connect to the Internet network. Learning with Microsoft Excel does not need other applications. This study focuses on the development of learning media using Microsoft Excel 2016. The topic is principle of simple harmonic wave motion in physics learning.

In wave motion, teachers need to display waveforms for each equation. This will be difficult to display one by one because there are many possible wave images to display. Therefore in this material required media that can display the waveform on certain conditions. The condition can be how much the deviation (y), velocity (v), amplitude (A), time (t) and distance of objects (x). Through the simulation of Microsoft excel this condition can be changed as desired. When each condition is changed will produce a different waveform, so it will facilitate students in learning the concept of simple harmonic motion.

The use of Microsoft excel in the last five years proves a positive influence for the learning process both students and teachers. In physics learning, this software is quite often used in teaching such as on thermodynamic topics (Tanaka, Asakura, & Avramidis, 2017), waves on the membrane (Eso, Safiuddin, Agusu, & Arfa, 2018) and several other topics. Using e-learning tools have positive impact of the methodology on the students' engagement and motivation (Fabregat-Sanjuan, A., Pàmies-Vilà, R., Ferrando Piera, F., & De la Flor López, S. (2017). This simple software is helpful in e-assessment (Azevedo & Pedrosa, 2017). Beyond these highlighted benefits for students, teachers gain time, effort and workload reduction when using automatic spreadsheet corrector (Serra, Bikfalvi, Masó, Carrasco, & Garcia, 2017). Because of that, this research developed Microsoft excel as a learning media in the classroom.

Simple Harmonic Motion

A common, very important, and very basic kind of oscillatory motion is simple harmonic motion such as the motion of an object attached to a spring. In equilibrium, the spring exerts no force on the object. When the object is displaced an amount x from its equilibrium position, the spring exerts a force -kx, as given by Hooke's law: F = -kx where le is the force constant of the spring, a measure of the spring's stiffness. The minus sign indicates that the force is a restoring force; that is, it is opposite to the direction of the displacement from the equilibrium position. The acceleration is proportional to the displacement and is oppositely directed. This is the defining characteristic of simple harmonic motion and can be used to identify systems that will exhibit it: Whenever the acceleration of an object is proportional to its displacement and is oppositely directed, the object will move with simple harmonic motion (Tipler & Mosca, 2007). Consider a mass attached to a spring with spring constant k. The spring exerts a force –kx, where x is the displacement of the mass from equilibrium. The law F = ma is thus

$$F = m\frac{d^2x}{dt^2} = -kx$$

We can integrate this equation twice to obtain the solution, which is

$$x = A\cos(\omega t + \varphi)$$

Where

$$\omega = 2\pi f = \sqrt{\frac{k}{m}}$$

You can confirm that equation is indeed the solution of by differentiating. Thus:

$$v = \frac{dx}{dt} = -A\omega\ \sin(\omega t + \theta)$$

$$a = \frac{d^2x}{dt^2} = -A\omega^2\ \cos(\omega t + \theta)$$

The parameters A, ω, and f are constants of the motion. To give physical significance to these constants, it is convenient to form a graphical representation of the motion by plotting x as a function of t. First, A, called the amplitude of the motion, is simply the maximum value of the

position of the particle in either the positive or negative x direction. The constant ω is called the angular frequency, and it has units 1 of rad/s. It is a measure of how rapidly the oscillations are occurring; the more oscillations per unit time, the higher the value of ω (Serway & Jewett, 2018). The maximum value of x is A, the maximum value of v is Aω, and the maximum value of acceleration (a) is $A\omega^2$. When the displacement is large, the mass stops and v = 0. At this point the spring is fully stretched and F and a are both large (but negative) (Browne, 2013).

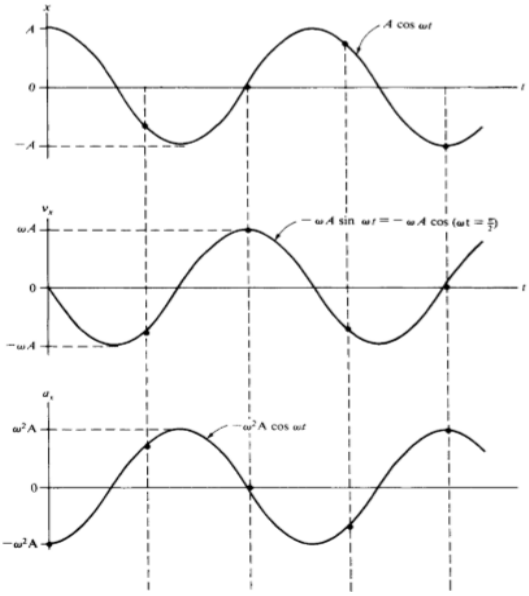


Figure 1. Simple Harmonic Motion Wave (Stanford & Tanner, 2014)

Method

The method in this research is using Visual Basic of Application (VBA) in Microsoft excel. There are 86 pre-service teacher asked to create the simulation using VBA. This VBA is one of the features in Microsoft excel program. Through this feature the user can create various work function in accordance with the desired. In this research the form of VBA is to make the equation of wave function by making definition on some symbols. The following coding data on VBA is designed to simulate wave equations.

```
(General)                                   Start_CLick

Private Sub Stop_Click()
End
End Sub

Private Sub Start_CLick()
Dim n
For n = 1 To 200
Range("Time") = n * 0.1
DoEvents
Next n
End Sub

Private Sub ScrollBar1_Change()
Dim Score1
Score1 = ScrollBar1.Value
Range("Amplitude").FormulaR1C1 = Score1
End Sub

Private Sub ScrollBar2_Change()
Dim Score2
Score2 = ScrollBar2.Value
Range("Omega").FormulaR1C1 = Score2

End Sub

Private Sub ScrollBar3_Change()
Dim Score3
Score3 = ScrollBar3.Value
Range("Time").FormulaR1C1 = Score3

End Sub
```

Figure 2. VBA of the Wave Equation

Each coding data in the image has a different meaning. In the first column the code " Private_sub stop_click end end sub", this code means that the key provided to stop working function. The purpose of this code is when the stop button is pressed the resulting simulation will stop working. This makes it easy for the user to make the image annotations do not keep moving. In the second column, "Private_sub Start_click Dim n for n = 1 to 200 etc.", this code means that on start / play button provided run function. The purpose of this code is that when the button is pressed, the simulation will start working from 1 to 200. This facilitates the user when starting an explanation of simple harmonic motion. In the next column, each shows three variables that can be changed. The three variables are amplitude (A), angular velocity (w) and time (t). By using the scroll bar principle, the three variables can be changed according to the desired value. In this development all variables have a minimum value of 0 and a maximum of 50. This value can be set according to the needs of users when will explain the concept of waves in simple harmonic motion. After coding the data on the VBA sheet, the user can directly use the coding result on Microsoft excel sheet 2016. However, before running this application the user needs to restart the document, by first selecting the developer menu, then selecting macro security option, sub macro setting. Then proceed by clicking enable all macros. The goal is that all the coding from VBA that has been done can run. Simulation with Microsoft excel not only can display simple harmonic waveform waveform. In this study it will also be shown that the excel can automatically calculate the size of the deviation and the speed at which time, certain amplitude, and a certain angular velocity. To display this, separate tables should be created on the document. As shown in the following figure:

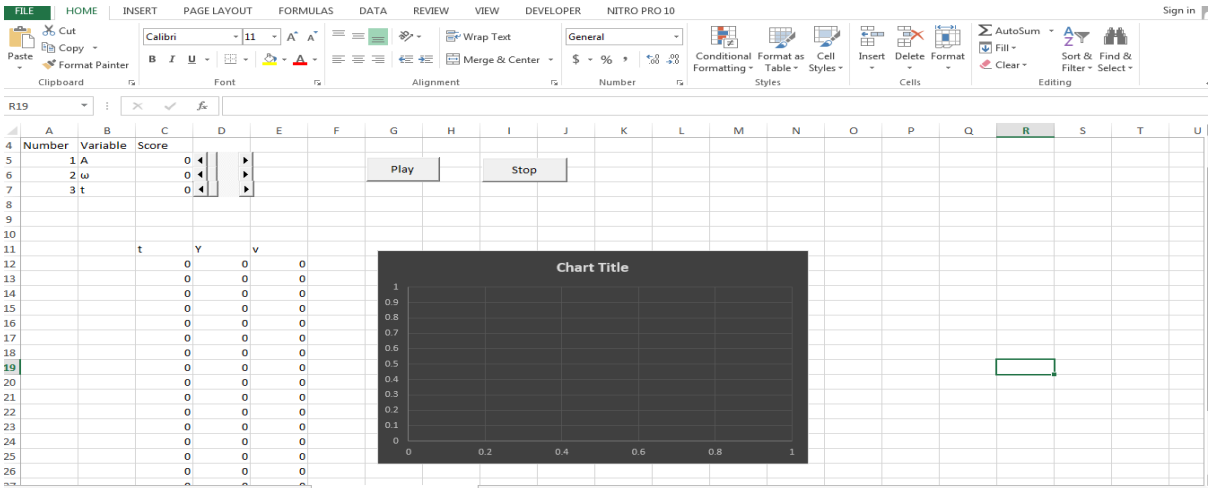


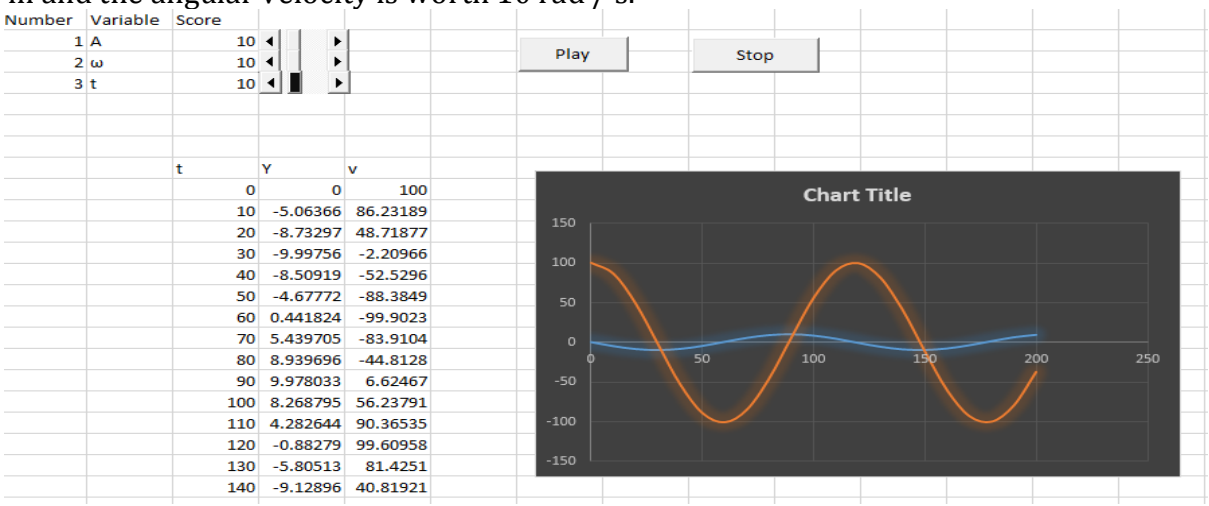
Figure 3. Variable Column

In column B5 denotes the amplitude symbols (A) and C5 indicates the number of the amplitude value of the scroll bar of column D5. In column B6 shows the symbol of angular velocity (w) and C6 indicates the number of angular velocity values resulting from scroll bar column D6. The Last, in column B7 denotes the time symbol (t) and C7 indicates the number of the scroll bar result time bar of column D7. Column C5 (amplitude) and C6 (angular velocity) are independent variable columns that can be changed according to desired conditions. While the time column will change automatically during wave motion ranging from 0 -50 s, according to the maximum value set.

In columns C12, D12 and E12 each show the time value, wave deviation and velocity. In column C12 it loads the initial time of 0s, and in C13 it will increase according to the time column change in C7. For columns D12 and E13 will show the result of automatic calculation of deviation and speed. With each column first filled with the formula: D12: = Amplitude * SIN (Omega * C12)
E13: = Amplitude * Omega * COS (Omega * C12)
Through this equation will be determined waveform and calculation results automatically.

Findings

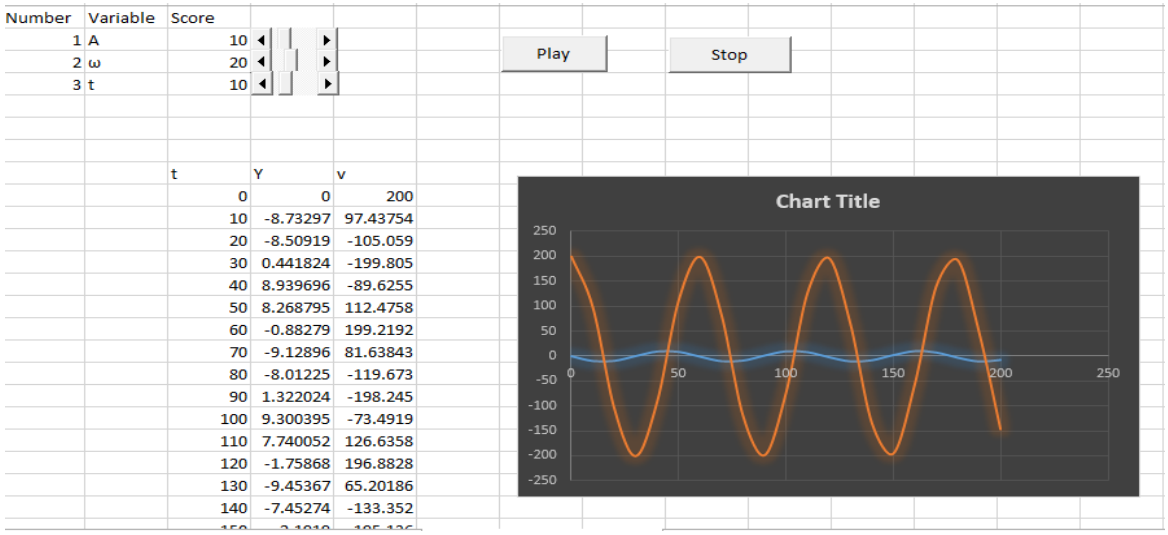
The finding in this research is simulation of wave equation with various value variations. In the first stage it can vary the angular velocity (w) make the amplitude variable (A) of fixed value. The result of the first variation can be seen that there is a change of waveform running all the time. The following waveform is generated in the first 0 seconds when the amplitude is 10 m and the angular velocity is worth 10 rad / s.



Number	Variable	Score
1	A	10
2	ω	10
3	t	10

t	Y	v
0	0	100
10	-5.06366	86.23189
20	-8.73297	48.71877
30	-9.99756	-2.20966
40	-8.50919	-52.5296
50	-4.67772	-88.3849
60	0.441824	-99.9023
70	5.439705	-83.9104
80	8.939696	-44.8128
90	9.978033	6.62467
100	8.268795	56.23791
110	4.282644	90.36535
120	-0.88279	99.60958
130	-5.80513	81.4251
140	-9.12896	40.81921

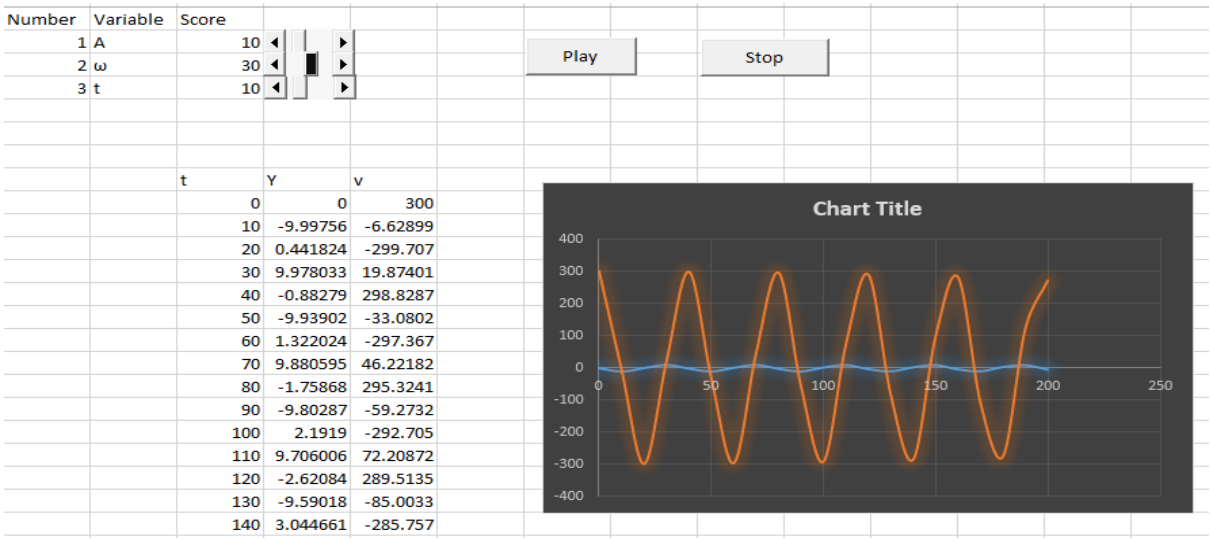
Figure 4. The waveform when the amplitude (A) is 10 m and the angular velocity is 10 rad/s



Number	Variable	Score
1	A	10
2	ω	20
3	t	10

t	Y	v
0	0	200
10	-8.73297	97.43754
20	-8.50919	-105.059
30	0.441824	-199.805
40	8.939696	-89.6255
50	8.268795	112.4758
60	-0.88279	199.2192
70	-9.12896	81.63843
80	-8.01225	-119.673
90	1.322024	-198.245
100	9.300395	-73.4919
110	7.740052	126.6358
120	-1.75868	196.8828
130	-9.45367	65.20186
140	-7.45274	-133.352

Figure 5. The waveform when the amplitude (A) is 10 m and the angular velocity is 20 rad/s



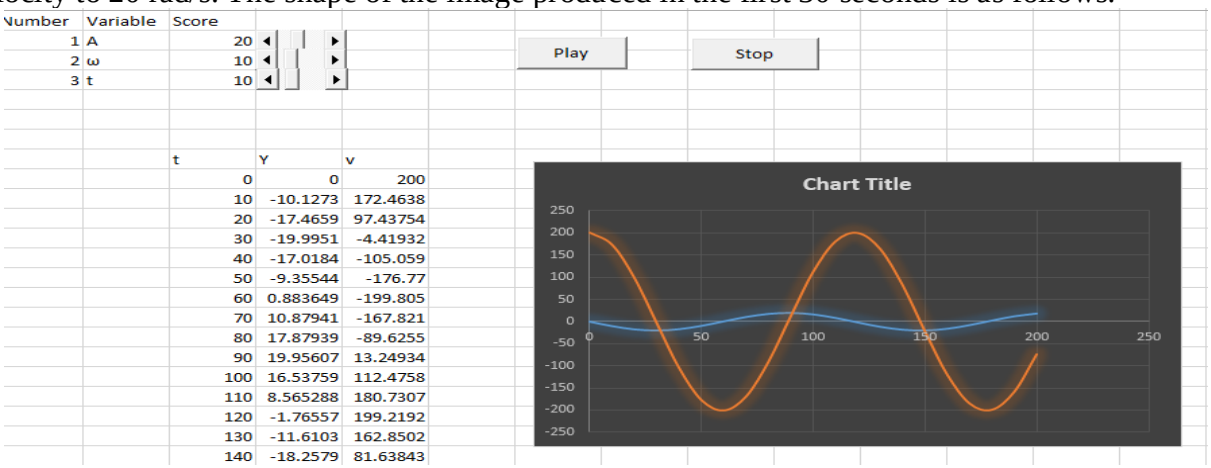
Number	Variable	Score
1	A	10
2	ω	30
3	t	10

Play Stop

t	Y	v
0	0	300
10	-9.99756	-6.62899
20	0.441824	-299.707
30	9.978033	19.87401
40	-0.88279	298.8287
50	-9.93902	-33.0802
60	1.322024	-297.367
70	9.880595	46.22182
80	-1.75868	295.3241
90	-9.80287	-59.2732
100	2.1919	-292.705
110	9.706006	72.20872
120	-2.62084	289.5135
130	-9.59018	-85.0033
140	3.044661	-285.757

Figure 6. The waveform when the amplitude (A) is 10 m and the angular velocity is 30 rad/s

In the same way the user or the teacher and the students can freely vary the value on amplitude (A), angular velocity (w) and time (t) . For example, make a fixed amplitude and change the angular velocity to 20 rad/s. The shape of the image produced in the first 30 seconds is as follows:

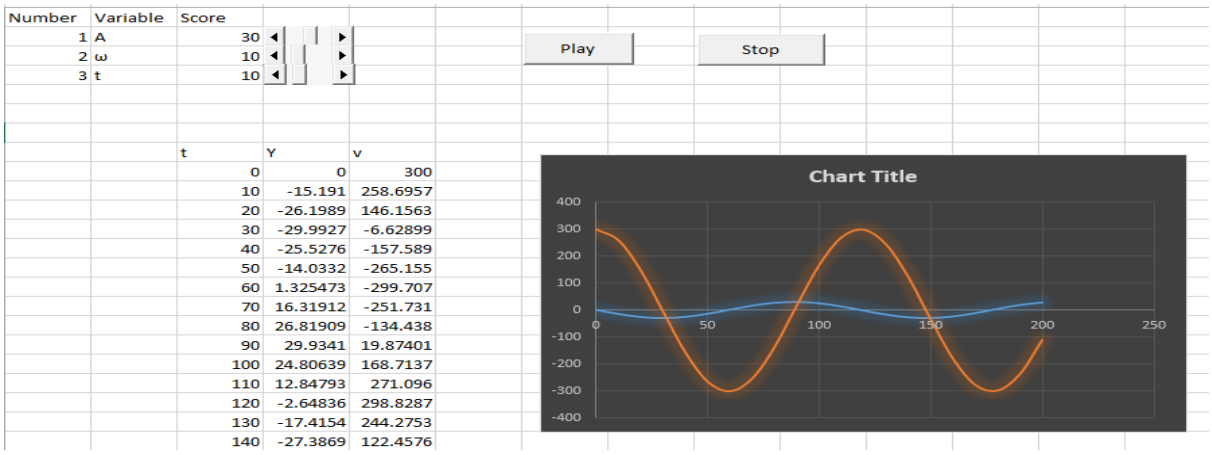


Number	Variable	Score
1	A	20
2	ω	10
3	t	10

Play Stop

t	Y	v
0	0	200
10	-10.1273	172.4638
20	-17.4659	97.43754
30	-19.9951	-4.41932
40	-17.0184	-105.059
50	-9.35544	-176.77
60	0.883649	-199.805
70	10.87941	-167.821
80	17.87939	-89.6255
90	19.95607	13.24934
100	16.53759	112.4758
110	8.565288	180.7307
120	-1.76557	199.2192
130	-11.6103	162.8502
140	-18.2579	81.63843

Figure 7. Waveform when the Amplitude (A) is 20 m and the angular velocity 10 rad/s



Number	Variable	Score
1	A	30
2	ω	10
3	t	10

Play Stop

t	Y	v
0	0	300
10	-15.191	258.6957
20	-26.1989	146.1563
30	-29.9927	-6.62899
40	-25.5276	-157.589
50	-14.0332	-265.155
60	1.325473	-299.707
70	16.31912	-251.731
80	26.81909	-134.438
90	29.9341	19.87401
100	24.80639	168.7137
110	12.84793	271.096
120	-2.64836	298.8287
130	-17.4154	244.2753
140	-27.3869	122.4576

Figure 8. The waveform when the Amplitude (A) is 30 m and angular velocity of 10 rad / s

From all the images, it can be seen that there are two waves, blue and red. Blue waves represent waves denoting waves (y) whereas red indicates wave velocity (v). In addition to showing the waveform, this simulation can also show the result or the size of the deviation and the wave velocity at any given time. For example in figure 2, the following data is obtained at t = 0 s, the deviation y = 0 m and the speed v = 100 m/s. At 10 s, the deviation y = -5.06366 m and the speed v = 86.23189. This value is an automatic calculation of the wave and speed are:

$$y = A \sin \omega t \text{ dan } v = A\omega \cos \omega t.$$

Based on the interview, we know that the motivation of participant was increase after made and used this simulation. They are interested more about simulation and want to develop another topic using simulation. It's similar with Chen, (2014) found that using simulation in physics learning can enhance motivation of students.

Conclusion

Based on the results that obtained, it can be concluded that by using a simple application from Microsoft excel can be generated simulation wave equation. By using the easy and practical way the waveforms are generated which can be continuous at any time or stopped at any given time. In addition, through this simulation can also be obtained automatically calculations the value of deviation and speed at a certain time, with certain amplitude, and a certain angular velocity. Through this simulation is expected to assist teachers in teaching the wave principle in simple harmonic motion and students in understanding this topic. Based on the convenience and practicality of this simulation that helps calculate the value automatically is expected to help the learning process. This research can continue to be developed by investigate the effect of simulation made on student achievement. In addition, through this research has added the intellectual property of the invention of learning media that is easy and practical, but still in accordance with current technological developments. Students' motivation also enhance after made and used this simulation.

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