

Mobile Learning of Physical Pendulum in Android-Based Smartphones

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Abstract – Many high school students have difficulties in learning physics. These difficulties occur due to inappropriateness models, methods, and instructional media used by teachers. One way to solve this problem is to create a mobile learning. This study produces a mobile learning of physical pendulum on Android-based smartphones. Theory and experiment of physical pendulum have been conducted previously for validation. The physical pendulum system consists of a metal rod and two identical cylinders attached together at the rod where the attachment position can be changed along the rod. Simulation parameters are initial angle ($0^\circ \leq \theta_0 \leq 90^\circ$), rod mass (m_b), rod length ($0 < L \leq 1.5\text{m}$), total mass of cylinders (m_s), radius of cylinders ($0 < R \leq 0.2\text{m}$), and distance from upper end of the rod to center mass of the cylinders ($0 < OA < L$). The simulation parameters are used to determine the oscillation period (T) of physical pendulum and the acceleration due to gravity of the earth. The period T remains constant with the variation of θ_0 , m_b , m_s , and R . However, T changes linearly against L . The position of the cylinders determines the center of mass of physical pendulum and T changes linearly against the distance from rotation axis to the center of mass of the system. The acceleration due to gravity of the earth remains constant with the changes of the simulation parameters. This simulation is done using eclipse program and can be run at least at Android 2.2-based smartphones. Simulation for a number (n) oscillation can also be shown. In addition to the simulation, physical pendulum material is also provided in this mobile learning.

Index Terms: physical pendulum, android, mobile learning

1. Introduction

The results of a survey by a senior high school in Semarang have shown that 88% of its students have difficulties in learning physics. These difficulties occur due to inappropriateness models, methods, and instructional media used by teachers. [1].

This paper discusses about the use of instructional media to clarify the presentation of abstract concepts into concrete and overcome the limitations of space and time. Mobile learning now becomes an instructional media which is appropriate to reduce students' difficulties in learning physics. Mobile learning has a facility that provides information to learners with educational content of the material to assist the attainment of knowledge without dispute location and time [2]. The advantages of mobile learning for users are as follows: users can learn where and whenever [3], users can increase their understanding [4], and mobile learning supports users' learning [5]. Besides having advantages, the mobile learning also has some drawbacks, namely, limited display, storage capacity, and power [6].

In 2013 the number of mobile phone users in the world was 6.8 billion from 7 billion of world population. In addition, a survey conducted by Yahoo and mindshare in mid-year 2013 has found that there were 41.3 million people who had smartphones in Indonesia and the largest users (39%) adolescents aged 16-24 years who are studying in high school and undergraduate program. Smartphone is a mobile phone that has a high ability to functionally resemble a computer. Smartphones have their own operating systems such as Android, iOS, Windows Phones, and Blackberry. Android has several advantages compared to other operating systems including a new generation of mobile platforms. Android is the first open and complete mobile platform [7].

Mobile learning of a simple pendulum has existed in android-based smartphone. This research is to develop a similar simulation of a physical pendulum by allowing the users to enter the value of simulation parameters. Physical pendulum is often used in everyday life such as the swing and grandfather clock. Hopefully this study will be very useful for teachers, high school students, and first year undergraduate students. Teachers can demonstrate the experiment in class to explain the concept of a physical pendulum. Students can study whenever and wherever about this concept in order to improve the understanding of the material.

2. Method

Hardware in this study consisted of a set of Personal Computer (PC) using SDRAM 4 GB, HDD 500 GB and GT-S7262 Android-based smartphone version 4.1.2. Software in the study is Windows 7 operating system and eclipse that is already included as Integrated Development Environment (IDE), the emulator, and Java (TM) SE Development Kit 6.4. Cover of simulation was made by Adobe Photoshop Creative Cloud. The flowchart in developing mobile learning of physical pendulum is shown in Figure 1.

The material in mobile learning is delivered as follows. Physical pendulum is a finite size rigid body which is hung at a point so that the body can swing in a vertical plane without friction about an axis [8,9]. In this simulation, the physical pendulum consists of a homogeneous rod that has a number of holes and two identical metal cylinders attached to the rod. Figure 2 shows physical pendulum system with the distance from the upper end of the cylinder rod (OA), cylindrical mass (m_s), rod mass (m_b) and rod length L with centered mass at point C having distance x_{pm} from the rod

end and has a center of rotation at point P. The distance between the axis of rotation to the center of mass of the system is x_2 and the distance between the center of mass to cylinder is x_3 .

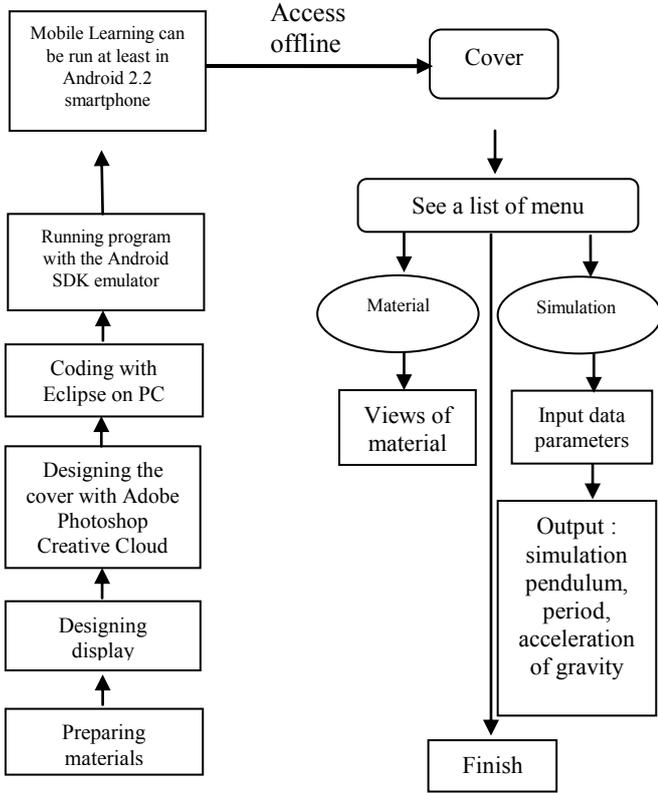


Fig. 1 The flowchart for developing mobile learning of physical pendulum.

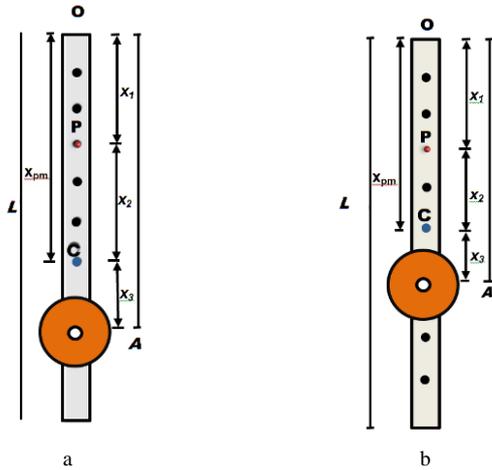


Fig. 2 a. The position of the cylinder was fixed on a physical pendulum
b. Cylinder position is changed (x_{pm} , x_2 , x_3 also change).

The coordinates of the center of mass on physical pendulum is determined as follows:

$$x_{pm} = \frac{\frac{1}{2}m_b L + m_s OA}{m_b + m_s} \quad (1)$$

Moment inertia of the system to the point P is:

$$I_p = \frac{1}{12}m_b L^2 + m_b \left(\frac{L}{2} - x_1\right)^2 + \frac{1}{2}m_s R^2 + m_s (x_2 + x_3)^2 \quad (2)$$

Physical pendulum is distorted with the initial angle θ_0 . At the time t , the deviation angle is θ as shown in Figure 3. At the moment it appears torque (τ) which is against the direction of the physical pendulum movement.

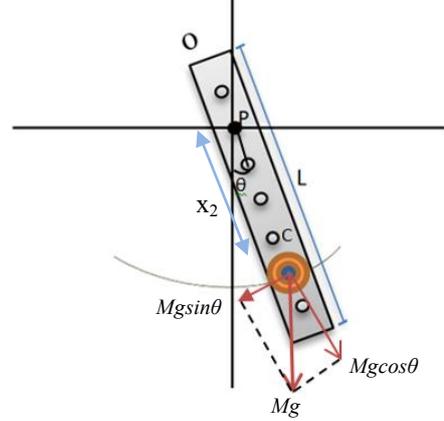


Fig. 3 Physical pendulum is distorted at an angle θ

If the object is released, the object is oscillating around its equilibrium position. Torque always acts to reduce the angle θ to zero. Torque on the pendulum physical system is distorted physical pendulum at an angle θ .

$$\sum \tau = -x_2 (Mg \sin \theta) \quad (3)$$

If initial angle θ_0 is small, $\theta_0 \approx \sin \theta_0$ is a valid approximation. So that the period for small angles is

$$T_o = 2\pi \sqrt{\frac{I_p}{Mgx_2}} \quad (4)$$

To determine the period with a large angle, it uses the following approach [8,10,11,12]:

$$T = T_o \left[1 + \frac{1}{2^2} \sin^2 \frac{1}{2} \theta_0 + \frac{1}{2^2} \left(\frac{3}{4}\right)^2 \sin^4 \frac{1}{2} \theta_0 + \frac{1}{2^2} \left(\frac{5}{8}\right)^2 \sin^6 \frac{1}{2} \theta_0 + \dots \right] \quad (5)$$

As for the conditions of using equation (5) is

$$T = T_o \text{ if } \theta_0 \leq 5^\circ$$

$$T = T_o \left[1 + \frac{1}{2^2} \sin^2 \frac{1}{2} \theta_0 \right] \text{ if } 6^\circ \leq \theta_0 \leq 25^\circ$$

$$T = T_o \left[1 + \frac{1}{2^2} \sin^2 \frac{1}{2} \theta_0 + \frac{1}{2^2} \left(\frac{3}{4}\right)^2 \sin^4 \frac{1}{2} \theta_0 \right] \text{ if } \theta_0 \geq 25^\circ$$

The next step is to design the display content on mobile learning applications. There are some views contained in the mobile learning, the first display is a cover contains the title, key entry, and exit button. The second display contains a welcome greeting and a menu that contains a list of materials and simulation using java language. The material presents the definition of the physical pendulum, moment of inertia, the period for small and large angles. The simulation, user (students and teachers) can alter simulation parameters to determine the swing period (T) of physical pendulum and the

acceleration of gravity (g). The period of the swing is determined using equations (4) and (5), whereas the acceleration of gravity using equation (4). The input parameters include initial angle $0^\circ \leq \theta_0 \leq 90^\circ$, rod mass (m_b), the length of the rod $0 < L \leq 1.5\text{m}$, the total mass of the cylinder (m_s), the radius of the cylinder $0 < R \leq 0.2\text{m}$, the distance of the cylinder to the upper end of the rod $OA < L$. Coding and running physical pendulum simulation used eclipse program. Eclipse is an Integrated Development Environment (IDE) that is used for coding Android applications. Eclipse workspace consists of the package explorer, toolbar, editor. Eclipse also provides the Android SDK emulator program that can be run on smartphones. Display of the eclipse is shown in Figure 4.

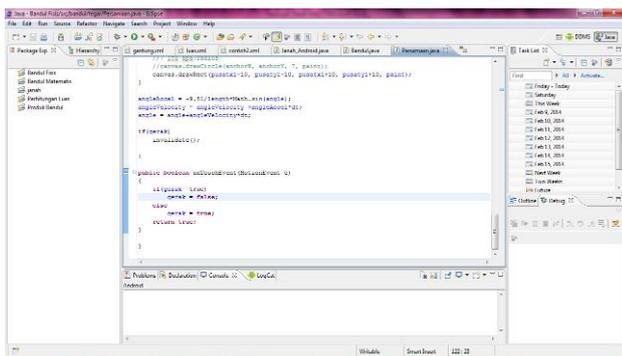


Fig. 4 Display of the eclipse.

Mobile learning can be run using Android-based smartphone minimal version 2.2

3. Results and Discussion

The results of mobile learning are displayed to the readers, especially teachers, students, and first year undergraduate students in Figures 5 to 7. Figure 5 shows a picture of the first display and the second display in Android applications. In the first display there are two option buttons, i.e. in and out of the mobile learning. In the second display there is a button for materials, a button for simulations and a button to back to the first display. The button “Materi” provides a material to enhance the readers in understanding the physical pendulum.

Simulation of physical pendulum in mobile learning is seen in Figure 7. After inputting data for simulation parameters, the program will process and display the results of the period (T), the acceleration of gravity (g), and the simulation of the physical pendulum. In this simulation the axis of rotation is always through the pivot point P, while position of the cylinder can be varied along the rod. Period (T) almost unchanged with the variation of the initial angle (θ_0), rod mass (m_b), the mass of the cylinder (m_s) and the radius of the cylinder (R). However, the value of T varies linearly to changes in rod length (L). The changes of cylinder position (changes in OA) alter the position of the center of mass (x_{pm}) of the physical pendulum system. The value of T varies linearly with changes in the distance between the axis of rotation to the center of mass of the system (x_2). The earth's gravitational acceleration (g) remains constant with the changes of simulation parameters.



Fig. 5 The first and second displays on mobile learning.

The material presented in the application is shown in Figure 6. It was made with using html language in eclipse. This display is also equipped with a zoom to allow the reader to see the sentence that looks small. It is also equipped scrolling to move up and down.

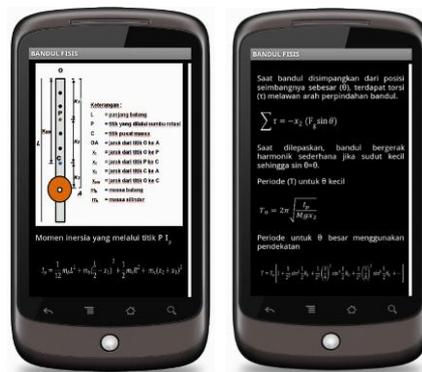


Fig. 6 Display of material on mobile learning.



Fig. 7 Display of simulation on mobile learning.

Some of the parameters have a certain extent, if the data input L and R exceed these limits then the simulation will not appear on the screen of smartphone. If the angle θ_0 , L , and R exceeds the real conditions then this program gives notice to the reader to edit the data in order to simulate the whole swing appeared on the screen. Simulation is equipped with a number (n) oscillation, making it easier for the reader to know about the motion of the swing.

4. Conclusion

Mobile learning of the physical pendulum can be used to understand the concept and the motion of the physical pendulum through its displayed material and simulation. Users can enter the data in the simulation parameters such as initial angle (θ_0), rod mass (m_b), rod length (L) the mass of the cylinder (m_s) radius of the cylinder (R) and the distance of the cylinder to the upper end of the rod OA to study its effect on the swing period (T) and the earth's gravitational acceleration (g). The value of T in the simulation almost unchanged with the variation of the value of θ_0 , m_b , m_s and R . However, the value of T varies linearly with the changes of L . The changes of cylinder position in the simulation (changes in OA) will alter the position of the center of mass of the system (x_{pm}) and the distance between the axis of rotation to the center of mass of the system (x_2). The value of T varies linearly with x_2 . The earth's gravitational acceleration is always constant with the changes of the simulation parameters.

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