Universitas Ahmad Dahlan Yogyakarta 41

Cek_Ishafit

CEK TURNITIN 5

INSTRUCTOR-CEK JURNAL 2

Universitas Ahmad Dahlan Yogyakarta

Document Details

Submission ID

trn:oid:::1:3012040525

Submission Date

Sep 18, 2024, 11:06 AM GMT+7

Download Date

Sep 18, 2024, 11:26 AM GMT+7

File Name

020003_1_5.0134173.pdf

File Size

985.2 KB

8 Pages

2,992 Words

13,980 Characters

11% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

- Bibliography
- Quoted Text
- Cited Text

Exclusions

- 8 Excluded Matches

Match Groups

28 Not Cited or Quoted 11%
Matches with neither in-text citation nor quotation marks

0 Missing Quotations 0%
Matches that are still very similar to source material

0 Missing Citation 0%
Matches that have quotation marks, but no in-text citation

0 Cited and Quoted 0%
Matches with in-text citation present, but no quotation marks

Top Sources

3%	Internet sources
10%	Publications
0%	Submitted works (Student Papers)

Integrity Flags

0 Integrity Flags for Review

No suspicious text manipulations found.

Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.

A Flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.

Match Groups

- **28** Not Cited or Quoted 11%
  Matches with neither in-text citation nor quotation marks
- **0** Missing Quotations 0%
  Matches that are still very similar to source material
- **0** Missing Citation 0%
  Matches that have quotation marks, but no in-text citation
- **0** Cited and Quoted 0%
  Matches with in-text citation present, but no quotation marks

Top Sources

3% Internet sources
10% Publications
0% Submitted works (Student Papers)

Top Sources

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	Publication	Nurul Miftakhul Janah, Ishafit, Wipsar Sunu Brams Dwandaru. "Simple vertical u...	8%
2	Internet	pubs.aip.org	1%
3	Internet	aip.scitation.org	1%
4	Publication	Zhang, X. W., R. Fu, T. X. Yu, Kemao Qian, Anand K. Asundi, and Fook S. Chau. "<tit...	0%
5	Internet	pigra.es	0%
6	Student papers	University of Southampton	0%
7	Publication	Vaille Dawson, Grady Venville, Jennifer Donovan. "The Art of Teaching Science - A ...	0%
8	Internet	eprints.unm.ac.id	0%

RESEARCH ARTICLE | APRIL 29 2024

Simple vertical upward motion experiment using smartphone based phyphox app for physics learning FREE

Nurul Miftakhul Janah ✉; Ishafit; Wipsar Sunu Brams Dwandaru

AIP Conf. Proc. 2622, 020003 (2024)
https://doi.org/10.1063/5.0134173

Simple Vertical Upward Motion Experiment using Smartphone based Phyphox App for Physics Learning

Nurul Miftakhul Janah[1, 2, a)], Ishafit[1, b)] and Wipsar Sunu Brams Dwandaru[3, c)]

[1]*Master of Physics Education Study Program, Universitas Ahmad Dahlan, Yogyakarta, Indonesia*
[2]*Muhammadiyah Al Mujahidin Senior High School, Wonosari, Yogyakarta, Indonesia*
[3]*Department of Physics Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia*

[a)] Corresponding author: nurul2007041009@webmail.uad.ac.id
[b)] ishafit@pfis.uad.ac.id
[c)] wipsarian@uny.ac.id

Abstract. A simple experiment of vertical upward motion had been carried out using the smartphone-based Phyphox application (Phyphox app) and a ping-pong ball. A special feature of the Phyphox app utilized in this experiment was the acoustic stopwatch. This feature can measure the time duration between two sound signals using the sensor in the smartphone. This simple experiment coould be used for physics learning or practicum at the high school level. Because of its simplicity, this experiment could be conducted in long distance learning, especially in this pandemic situation. The objectives in this study were i) conducting an experiment of vertical upward motion using the Phyphox app and a ping-pong ball, ii) producing a graph of the height vs time (h vs t) for the vertical upward motion of the ping-pong ball, iii) determining the acceleration of gravity (g) from the h vs t graph, and iv) determining the initial speed (v_o) of the ping-pong ball from the h vs t graph. The experiment was done by flicking the ping-pong ball from a height of h until it hit the surface of a book. The Phyphox app then measured the time of the ping-pong from being flicked until it hit the book. In this case, h was varied and the time duration of the ping-pong ball was determined. The experiment of vertical upaward motion of a ping-pong ball using the Phyhox app had produced a graph of h vs t. The results showed that g was obtained with a value of 10.1 m/s^2 with a relative error of 3% and the v_o of the ping-pong ball was 4.2 m/s.

INTRODUCTION

One of the concepts of physics that is a part of learning physics at the high school level is Mechanics. Mechanics deal with the motion of physical objects [1]. Therefore, Mechanics are certainly essential to be mastered by students as it connects to the movements of objects in their daily life. One part of the topics in Mechanics is Kinematics. Kinematics study motions without discusssing the cause of the change in the motion of the object [2]. One example of simple motions in Kinematics is the vertical upward motion or generally known as the free fall motion. The free fall motion is a vertical motion that is only affected by the acceleration of gravity, g, either up or down. Especially for vertical upward motion, there are three basic mathematical formulas, namely [1]:

$$v_t = v_0 - gt \tag{1}$$

$$h = v_0 t - \frac{1}{2} g t^2 \tag{2}$$

and

$$v_t^2 = v_0^2 - 2gh \tag{3}$$

The 5th International Seminar of Innovation in Mathematics and Mathematics Education (5th ISIMMED) and the 7th International Seminar on Science Education (7th ISSE)
AIP Conf. Proc. 2622, 020003-1–020003-7; https://doi.org/10.1063/5.0134173
Published by AIP Publishing. 978-0-7354-4895-7/$30.00

where v_t, v_o, h, and t are the final and initial velocities, height, and time, respectively. In this study, Equation (2) is used. The concept of vertical upward motion along with Equations (1) to (3) can be understood easily by students [3,4]. This is because the motion itself is simple and can be used as a model for more complicated motions. Thus, because of its simplicity, the concept of free fall motion is appropriate to be used as a smartphone-based experiment topic in physics learning.

Physics experiments are very essential in learning physics so that students can understand the concepts of physics. However, one of the main problems in learning physics in the midst of this COVID-19 pandemic is the inaccessibility of laboratories in schools and universities. Therefore, alternative methods are needed in carrying out experiments without having to be in the laboratory. One method that seems to suit this current conditions, including long distance and/or online learning is to use natural sensors in smartphones.

One application that exploits sensors in smartphones is the Phyphox application (Phyphox app) [5]. The Phyphox app was first developed at the Institute of Physics of the RWTH Aachen University by a group of researchers lead by Sebastian Staacks [6]. Various advantages of the Phyphox app in supporting physics experiments are open source (free of charge), easy to use, easy to control, and do not require electronic sensor cables [7]. A feature of the Phyphox app used in this study is the Acoustic Stopwatch. This feature is based on the sound sensor in the smartphone and is useful for measuring the time duration between two sounds.

Based on the problems of the inaccessibility of laboratories and the ability to accommodate long distance and/or online learning, this study reports for the first time a simple experiment using the smartphone-based Phyphox app and a ping-pong ball for the free fall motion, especially the vertical upward motion. It may be worth noting that this vertical upward motion experiment using the Phyphox app has never been done before so it is not available on the https://phyphox.org site. Thus, the objectives of this study are i) conducting an experiment of vertical upward motion using the Phyphox app, ii) producing a graph of h vs t for the vertical upward motion of the ping-pong ball, iii) determining g from the h vs t graph, and iv) determining v_o from the h vs t graph. Hence, it is hoped that students can also conduct this simple experiment that have been carried out in this study using their own smartphones and materials.

MATERIALS AND METHOD

The method used in this study was experimentation. The experiments were carried out on the vertical upward motion of a ping-pong ball using the Phyphox app. The data obtained were then processed and analyzed using MS Excel. This study was conducted at the author's resident for two weeks.

Tools and Materials

The various tools and materials used in this study can be given as follows. The tools used in this study were i) tall stands [2 units]; ii) a thick cover book [1 unit]; iii) a ping-pong ball [1 ball]; iv) a smartphone [1 unit]; v) metal clamps [2 units]; vi) ribbon [1 stripe]; and vii) a long ruler [1 unit]. The software used in this study were i) Phyphox app and ii) MS Excel.

Experiment Arrangements

The apparatus arrangement in this study can be seen in Fig. 1. The ping-pong ball can be seen in Fig. 2. The arrangement of the apparatus was given as follows: i) placing the tall stands ± 50 cm apart from each other; ii) placing each metal clamp on the top of each of the stand; iii) clamping the thick book at the width of the book such that it is perpendicular to the stand; iv) attaching the long ruler on one of the front side of the stand [on the left stand in Fig. 1]; v) attaching each end of the ribbon on each stand but not to tight but keep the ribbon taut and perpendicular to the stands.

Experimental Procedure

Downloading the Phyphox App

The Phyphox app can be downloaded from the Google Play Store for free (no fee). The display of the Phyphox application and the display of the Acoustic Stopwatch feature can be seen in Fig. 3 on the left and right, respectively.

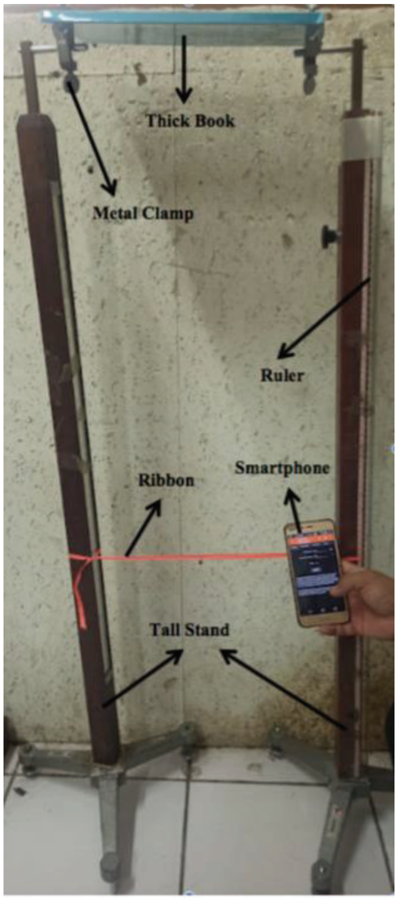


FIGURE 1. Apparatus arrangement.

FIGURE 2. The ping-pong ball.

Data Collection

The steps of the data collection can be explained as follows: 1) assembling the arrangement of the experimental apparatus according to Fig. 1 above; 2) opening the Phyphox app on the smartphone; 3) activating the Acoustic

Stopwatch feature according to Fig. 3 on the right; 4) setting the Threshold value according to environmental conditions, which is to be increased if the environment is noisy and decreased if it is quiet [in quiet conditions the Threshold value is set at 0.01]; 5) setting the minimum delay at a value of 0.1 second; 6) pressing the play button (triangle symbol at the top) so that the numbers appear like a stopwatch; 7) putting the smartphone on a flat surface; 8) placing the ribbon at a height of 65 cm from the surface of the thick book and ensure that it is parallel to the surface of the book (see Fig. 1); 9) holding the ping-pong ball with the left hand in the center of the ribbon (see Fig. 2); 10) flicking the ping-pong ball using the fingers of the right hand so that it hit the book; 11) recording the time displayed on the smartphone screen; 12) repeating steps 10) to 12) for several times; 13) repeating steps 8) to 12) for the heights of 60 cm, 50 cm, 45 cm, 40 cm, 35 cm, and 30 cm from the book.

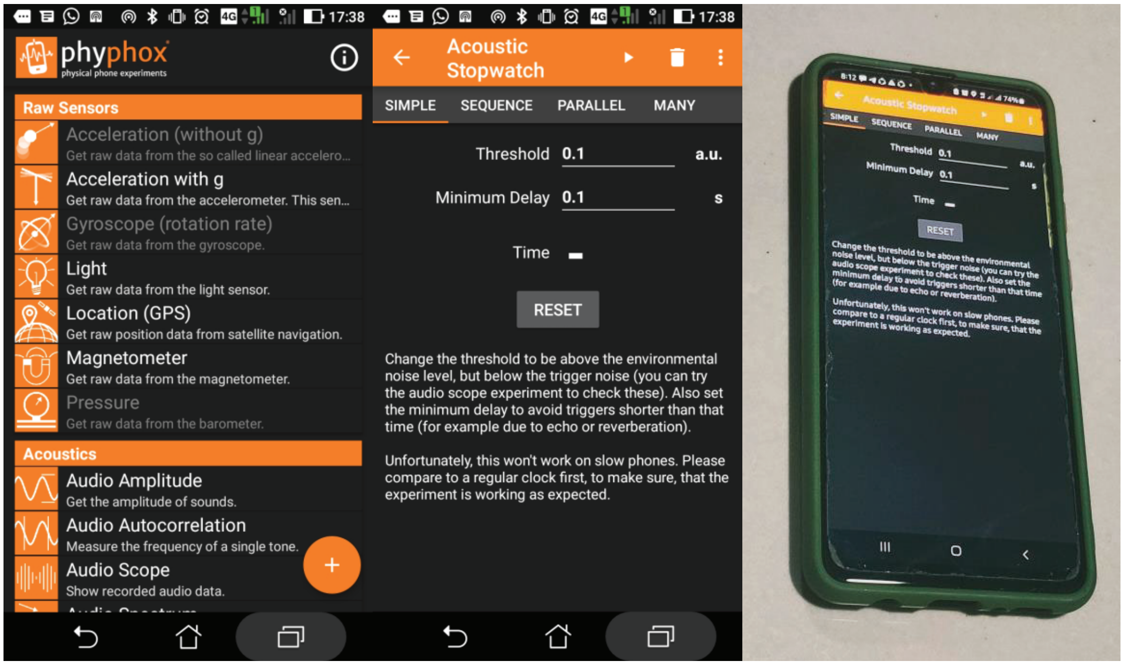


FIGURE 3. Phyphox app display (left), Acoustic Stopwatch feature (center), and the Phyphox app on the smartphone (right).

Data Processing and Analysis

After the data was collected, data processing and analysis were carried out. First, note that the time (t) listed on the Phyphox app was the time it takes for the ping-pong ball from being flicked to hitting the book. Second, the iteration of the data t for each height (h) was averaged and the standard deviation was calculated using MS Excel so that $t + \Delta t$ was obtained for each h. Third, a graph of the relationship between h vs t was made. Fourth, a trend line was made using quadratic interpolation for the data of the h vs t graph to obtain a quadratic equation. Fifth, the quadratic equation resulting from the quadratic interpolation, which takes the form:

$$h = At^2 + Bt + C \tag{4}$$

or

$$h - C = At^2 + Bt \tag{5}$$

was compared with Equation (2) so that we get

$$A = -\frac{1}{2} g \Rightarrow g = -2A \tag{6}$$

and

$$B = v_0 \tag{7}$$

8

RESULTS AND DISCUSSION

In this section, the various results obtained are described. The results in this study are tables, graphs, and analysis of the data obtained. In this case, the Acoustic Stopwatch feature in the Phyphox app is used. This feature uses the sound sensor found in the smartphone. Based on this sound sensor, the time interval (t) between two sound events can be calculated. Two sound occurrences in this study are the sound of the flicking when the ping-pong ball begins to move vertically upwards, and the sound of the ping-pong ball hitting the thick book. This is also the reason that the ping-pong ball is chosen, i.e.: it can produce a loud sound upon flicking and hitting the book. Thus, t in this study is the time required for the ping-pong ball to move vertically upward at a distance h. This is in line with the explanation given in [5]. This may be observed in Table 1.

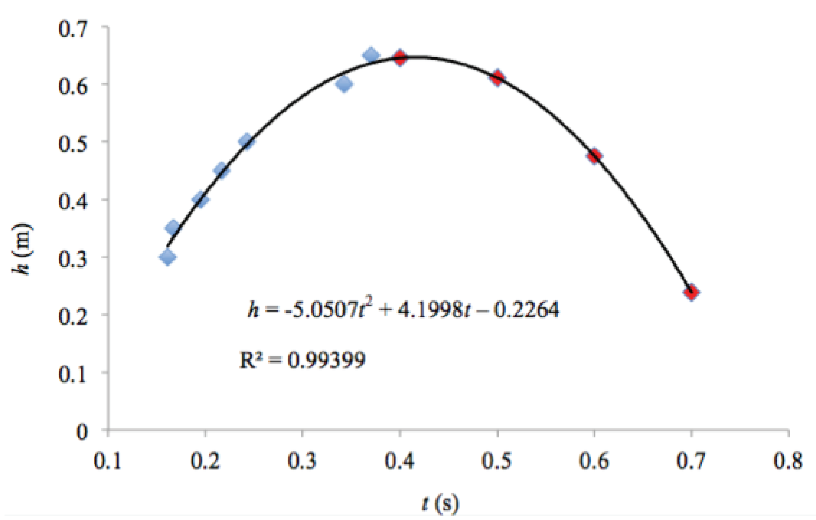
TABLE 1. Average of time (t) with variation of the height (h).

No.	h (m)	t (s)	Relative Error (%)
1.	0.30	0.16 ± 0.06	38
2.	0.35	0.17 ± 0.06	35
3.	0.40	0.19 ± 0.06	32
4.	0.45	0.20 ± 0.10	50
5.	0.50	0.25 ± 0.09	36
6.	0.60	0.34 ± 0.01	29
7.	0.65	0.40 ± 0.10	25

1 Table 1 shows the average time (t) of the upward vertical motion taken by the ping-pong ball from being flicked
1 to hitting the book. It can be observed that the further the h of the ping-pong ball is from the book, the longer t becomes. This is of course in accordance to the nature of the free fall motion, i.e.: longer distance h produces longer time t.

The graph of h vs t from Table 1 can be seen in Fig. 4. It should be noted that when the experiment was conducted, the independent variable was h, i.e.: the height of the ping-pong ball from the book, while the dependent
7 variable was t. However, in Fig. 4, the opposite is done, namely: h becomes the dependent variable (vertical axis), and t becomes the independent variable (horizontal axis). This is done to conform to Equation (2) above.
1 Furthermore, Fig. 4 shows a graph of h vs t for the vertical upward motion of the ping-pong ball. It can be observed that the trend line results are in the form of a quadratic equation, namely:

$$h = -5.0507t^2 + 4.1998t - 0.2264 \tag{8}$$



1 **FIGURE 4**. Graph of h vs t vertical motion up the ping-pong ball.

By comparing Equation (8) and Equation (4), we can identify the coefficients of A = -5.0507; B = 4.1998; and C = -0.2264. Hence, based on Equations (6) and (7), and also the aforementioned coefficients, we obtain:

$$g = 10.1 \, {}^{m}\!/\!_{s^2} \tag{9}$$

and

$$v_o = 4.2 \, {}^{m}\!/\!_{s} \tag{10}$$

The blue data points of Fig. 4 are obtained from the measurement using the Phyphox app, whereas the red data points are extrapolations using Equation (4). The extrapolation shows that h is quadratic with respect to t and satisfies Equation (2). This means that one may predict the maximum height of the ping-pong ball with an initial velocity of 4.2 m/s is between 0.6 m to 0.7 m.

Thus, based on the experiment of the vertical upward motion of the ping-pong ball using the Acoustic Stopwatch feature in the Phyphox app, the acceleration of gravity is 10.1 m/s^2 and the initial velocity of the ping-pong ball is 4.2 m/s. The relative error of the gravitational acceleration to the reference acceleration, which is 9.8 m/s^2 in [1,2] is 3%. Of course, the result of g obtained is larger than the reference result in [1,2] with a fairly small relative error. Moreover, t that is obtained in Table 1 shows a wide range of relative errors from 25% to 50%. This shows that the relative errors of t obtained from the Phyphox app are quite large [8]. Of course, this error stems from the reaction time of the sounds of the flicking and the collision of the ping-pong ball with the book. In addition, environmental noise can also affect the time measurement. Furthermore, the constant in the RHS of Equation (8), i.e.: -0.2264 is considered to be a systematic error of the experiment and can be attributed to the height of the ping-pong ball.

This experiment may be used in a physics learning process using, e.g.: the project based learning (PjBL) [9]. In this case, the project that has to be conducted by students is the above experiment assuming that students have their own smartphones and the Phyphox app can be downloaded. It may also be possible to ask the students to modify the experiment. This can be conducted, e.g.: by moving the book instead of the ping-pong ball or using other kind of balls. Then students are asked to process and analyze the data obtained. It is a good exercise for the students to discuss the errors of the measurement. The students may also be asked to provide ways in order to reduce the errors of t obtained from the Phyphox app.

CONCLUSION

In this study, a simple experiment of the vertical upward motion of a ping-pong ball has been carried out using the smartphone-based Phyphox app. The result is obtained in the form of h vs t graph of a quadratic extrapolation in accordance with the theoretical equation of the free fall motion of Equation (2). Moreover, the acceleration of gravity obtained is 10.1 m/s^2 with a relative error of 3% and the initial velocity of the ping-pong ball is 4.2 m/s. Hence, the Phyphox app can be used for physics learning, especially in the topic of Kinematics. Because of its simplicity, this experiment may be conducted for long distance and/or online learning especially in this pandemic condition.

ACKNOWLEDGEMENT

The authors would like to thank Physics Education Masters Study Program, Universitas Ahmad Dahlan for supporting this study.

REFERENCES

1. P. A. Tipler and G. Mosca, *Physics for Scientists and Engineers 5th Ed* (W. H. Freeman and Company, New York, 2004).
2. L. C. Epstein, *Thinking Physics is Gedanken Physics* (Insight Press, California, 2009).
3. M. El Hadi, A. El Moussaouy, A. Ouariach, R. Essaadaoui, A. Hachmi, K. Laabidi, H. Magrez, and Y. M. Meziani, Phys. Educ., **55**, 055027 (2020).
4. R. Puspitasari, F. Mufit, and Asrizal, "Conditions of learning physics and students' understanding of the concept of motion during the covid-19 pandemic" in *3rd International Conference on Research and Learning of*

Physics, Journal of Physics: Conference Series 1876, edited by Ramli *et al*. (IOP Publishing, Bristol, 2021), p. 1-11.
5. R. Caroll and J. Lincoln, *Phys. Teach*., **58**, 606 (2020).
6. N. N. Phyphox: Physical Phone Experiments. Downloaded from https://phyphox.org on 5 August 2021.
7. A. Suciarahmat and Y. Pramudya, J. Fis. Indones., **55** (XIX), 10-13 (2015).
8. J. P. Holman, *Experimental Methods for Engineers International Edition* (Mc-Graw Hill, 1999).
9. E. C. Miller, S. Severance, and J. Krajcik, J. Sci. Teacher Educ., **32** (7), 757-779 (2021).