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Measuring the Acceleration of Gravity Using a Smartphone, A4-Papers, and a Pencil

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Abstract

The measurement of the acceleration of gravity, g, is usually conducted in the science laboratory, especially in Physics subject. In contrast to the traditional method using a set of ticker timer, we propose a simple method to determine the magnitude of g using a smartphone, unused A4-sized papers, and a pencil. We use the smartphone application called Phyphox, operating in Timers and Acoustic Stopwatch mode to measure the time between two acoustic events. We then fold unused A4-papers together and put a pencil over them. After that, we flick the folded papers so that the pencil falls down. The first jingle from flicking causes the Acoustic Stopwatch to start whereas the second jingle from hitting of pencil on the floor makes it to stop. Through the measured time read by Acoustic Stopwatch and the height of folded papers, we are able to calculate the average of magnitude of the gravitational acceleration at the 5 different heights via (i) arithmetic mean, (ii) graphing by hand, and (iii) graphing by excel. Based on our observation of a free-falling object, we found that the magnitude of g at Bangkok equals to 9.760 m/s^2. Comparison with the standard value of 9.783 m/s^2 measured by the National Institute of Metrology (Thailand), our experimental value for gravity agrees well with the standard value which offers very good accuracy with a percentage of error of about 0.23%. We envisage that this work is not only economical, and can hence be conducted in places with limited access to laboratory tools, but also provides learning opportunities for students in hands-on practicing and data analysis.

Keywords—*Gravitational acceleration, laboratory tool, Physics teaching, smartphone.*

I. INTRODUCTION

For students enrolled in secondary school, practicing with scientific experiment to understand the truth of nature is an important learning process [1], especially for development of practical skill and scientific reasoning skill [2], [3]. One experiment that all students must conduct is to determine the acceleration of gravity using ticker timer [4], [5]. By attaching one end of the paper strip to the object and another end of that to the carbon paper of ticker timer, later, allowing such object to fall freely under the force of gravity, these cause the needle of ticker timer presses onto the carbon paper and spots as black dots arranged on the paper strip with the time between two adjacent dots equally to 1/50 second. After that, students must record the distance measured between two adjacent dots, and then, calculate the average speed between two adjacent dots. Consequently, for the analysis of experimental results, students are assigned to plot the relationship between the average speed and time, draw a straight line called the line of best fit, and then calculate the slope of the line of best fit in which equals to the magnitude of the gravitational acceleration at the Earth's surface, together with the percentage of error from the experiment.

Because of the development of technology, smartphones today come with various sensors (such as microphone, camera, thermometer, gyroscope, proximity sensor, digital compass, and barometer, etc.) to facilitate a better user experience [6]. This opens up new perspectives on using smartphones as the laboratory devices [7]. For example, smartphone can be used as an angle meter to read the angle of the ramp tilted relative to the horizontal plane which is useful in reporting the coefficient of friction [8], or it can even be an acoustic stopwatch to count the time taken from start to stop using sound which benefits for measuring the speed of sound in the air [9].

Toward this end, we are therefore interested in utilizing the smartphone as a tool to determine the magnitude of

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