Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/ 9603
DOI URL: http://dx.doi.org/10.21474/IJAR01/9603

ISSN NO. 2320-5407

RESEARCH ARTICLE

SIMPLIFIED MEASUREMENT OF GRAVITY ACCELERATION BASED ON ELECTROMAGNETIC INDUCTION PRINCIPLE.

Liu Jing.
School of Information Engineering,Nanjing Normal University Taizhou college,Taizhou 225300, China.

Manuscript Info

Manuscript History
Received: 20 June 2019
Final Accepted: 22 July 2019
Published: August 2019

Key words:-
electromagnetic induction; free fall motion; audio processing software; gravity acceleration.

Abstract

There are many methods for measuring gravity acceleration in physics experiments. These methods require special experimental instruments. Based on electromagnetic induction principle, this paper introduces a method using free audio processing software to measure gravity acceleration. In this method, no special experimental equipment is needed, and students can even experiment at home. The relative error of local gravity acceleration is 0.3%. This method stimulates students' interest in learning and enhances students' thinking. It has positive significance with hands-on ability, and also enriches the measurement method of gravity acceleration.

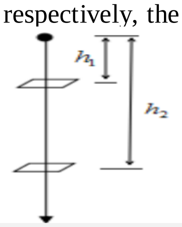
Introduction:-

There are many methods for measuring gravity acceleration in physical experiments. Most of them calculate the gravity acceleration[1] according to the law of free fall motion or measuring the pendulum cycle. These methods all involve the measurement of time. The free fall motion method commonly uses photoelectric gate[2-3].), and the measurement of the single pendulum cycle commonly used stopwatch. Some researchers have improved the free fall experiment instrument, but need to use an oscilloscope[4]; some researchers have improved the method of measuring gravity acceleration using free fall motion, but need to use the special sensor[5]. If you can measure gravity acceleration with some materials that are readily available, it will help to stimulate students' interest in learning, and effectively enhance students' thinking ability and hands-on ability. The development of information technology has turned the ideas into reality[6]. Based on the principle of electromagnetic induction, this paper presents a method based on the free Audacity audio processing software to measure the acceleration of gravity. The items used in the experiment are easy to obtain, and students can even complete the experiment at home.

Experimental principle and experimental device

As shown in Figure 1, h_1 and h_2 are the distance between the static release position of the strong magnetic ball and the middle of the vertical direction of the upper and lower coils, respectively, the relation between h_1 and t_1 is

$$h_1 = \frac{1}{2} g t_1^{\ 2}, \qquad (1)$$



Corresponding Author:-Liu Jing.
Address:-School of Information Engineering,Nanjing Normal University Taizhou college,Taizhou 225300, China.

the relation between h_2 and t_2 is

$$h_2 = \frac{1}{2} g t_2^{\ 2}, \qquad (2)$$

Easy to get

$$g = \left(\frac{\sqrt{2h_2} - \sqrt{2h_1}}{t_2 - t_1} \right)^2, \qquad (3)$$

Figure 1. Schematic diagram

$(t_2 - t_1)$ Measured by the principle of electromagnetic induction. Just measure h_1 and h_2, you can calculate the acceleration of gravity.

The equipment required for the experiment is: one computer, one Aux audio cable, Audacity audio processing software (Gold-Wave, Adobe Adition, etc.), a thin rod that can be placed vertically up to 1 meter in length (or other straight rod-shaped device), two self-made coils, two coil fixing clips (also can directly bonded by tape), and a strong magnetic ball with a diameter of 3 mm. The experimental device is shown in Fig. 2.

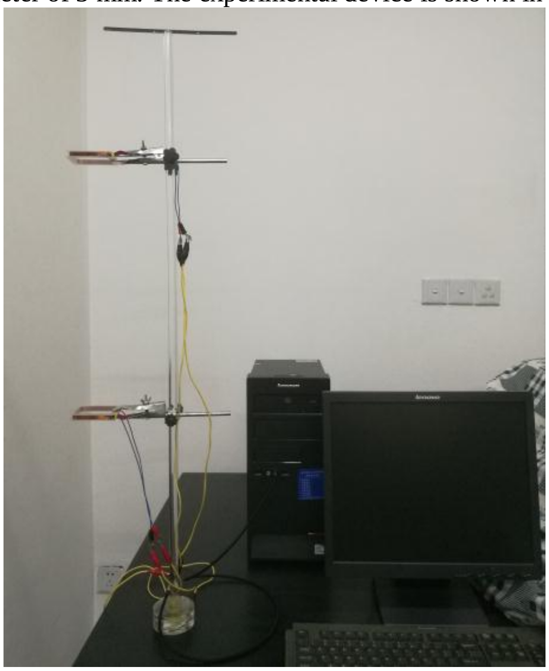


Figure 2:-Self-built experimental device diagram

Experimental steps

1. Install the Audacity audio processing software on the computer, connect the two wires of the upper coil to the left channel wiring and ground of the audio cable, and connect the two wires of the lower coil to the right channel wiring and ground of the audio cable. Plug the other end of the audio cable into the computer microphone jack;
2. The thin rod is fixed vertically. Fix the two coils to the rod so that the plane of the coil is as horizontal as possible. Adjust the relative position of the two coils with the thin line of the hanging weight as a reference to ensure that the magnetic ball is possible to pass through the middle of the two coils ,and measure the distance between the release position of the ball and the vertical direction of the two coils. For the measurement of the height, first hang the small ball at a static drop with a thin wire with a small weight at one end. And use the knot as a mark, then mark the black line point in the middle of the coil, and then hang the thin line on the wall, measure the corresponding height with a tape measure;
3. Open the Audacity audio processing software, click the record button, and release the strong magnetic ball from the fixed position. When the ball passes through the upper and lower coils, the coil will generate the induced electromotive force in the closed loop due to the change of the magnetic flux, and the software will record the curve of the voltage generated by the ball as it passes through the two coils;

4. Find the x-coordinate value of two curves when they intersect the x-coordinate, you can get $(t_2 - t_1)$;
5. Substitute the data into the formula（3）,and calculate the value of gravitational acceleration.

Experimental results

The process of passing the strong magnetic ball through the coil can be divided into three stages: the approaching coil, the critical point close to the coil and away from the coil. During this process, the magnetic flux passing through the coil changes continuously, resulting in the electromotive force generated in the coil. According to the law of electromagnetic induction, when the strong magnetic ball is at the critical point close to the coil and away from the coil, the induced electromotive force in the coil is zero, and the critical point should be in the middle of the vertical direction of the coil. Figure 2 gives The curve recorded by the Audacity audio processing software during the falling of the ball. According to formula (3), we need to know the time difference between the ball passing through the middle of the two coils in the vertical direction. $(t_2 - t_1)$ And the time difference corresponds to the x-coordinate value difference between the two points A and B in Fig. 2. After the curve is enlarged to the appropriate size in the Audacity software, the respective cross can be read.

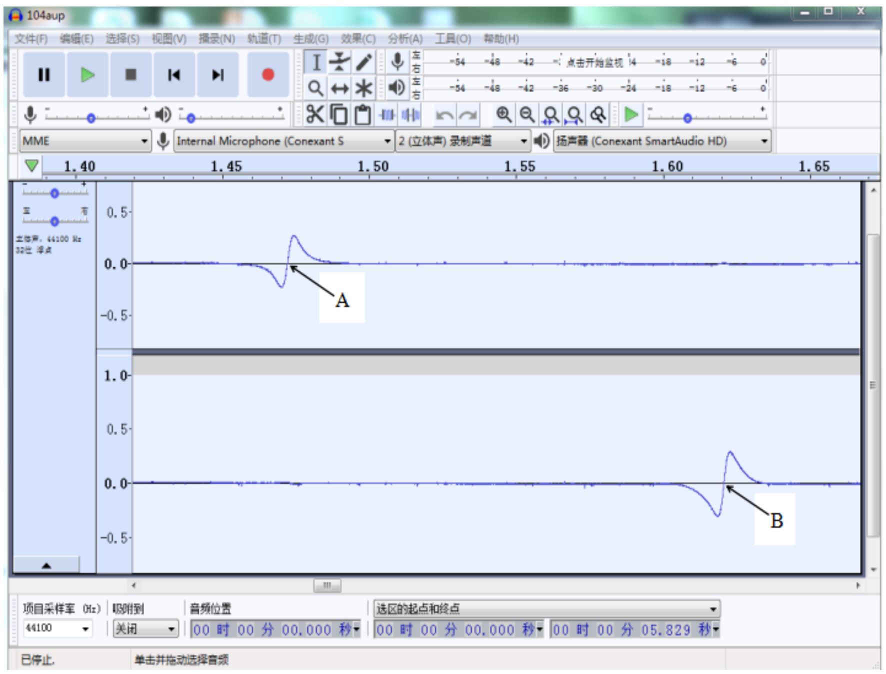


Figure 2:-The voltage versus time curve of a strong magnetic ball recorded by the Audacity software as it passes through two coils.

Two sets of heights were selected for the experiment, and each group was measured seven times. The heights were h_1=0.2835m, h_2=0.7364m and h_1=0.5465m, h_2=1.0032m. The measured data is shown in Table 1 and Table 2:

Table 1:-Experimental data for h_1=0.283m and h_2=0.736m

h_1（m)	h_2（m)	t_1（s)	t_2（s)	(t_2-t_1)　(s)	g（m/s^2)
0.2835	0.7364	1.367766	1.515771	0.148005	9.698
0.2835	0.7364	2.208242	2.355159	0.146917	9.843
0.2835	0.7364	1.838175	1.986491	0.148316	9.658
0.2835	0.7364	2.123367	2.269854	0.146487	9.901
0.2835	0.7364	1.892686	2.040555	0.147869	9.716
0.2835	0.7364	2.219308	2.36593	0.146622	9.883
0.2835	0.7364	2.346202	2.494003	0.147801	9.725

Table 2:-Experimental data for h_1=0.546m, h_2=1.003m

h_1 (m)	h_2 (m)	t_1 (s)	t_2 (s)	(t_2-t_1) (s)	g (m/s^2)
0.5465	1.0032	1.931346	2.050101	0.118755	9.778
0.5465	1.0032	3.880408	3.999252	0.118844	9.763
0.5465	1.0032	1.886512	2.005313	0.118801	9.770
0.5465	1.0032	1.546282	1.665096	0.118814	9.768
0.5465	1.0032	2.017973	2.136884	0.118911	9.752
0.5465	1.0032	2.870653	2.989529	0.118876	9.758
0.5465	1.0032	5.429775	5.548607	0.118832	9.765

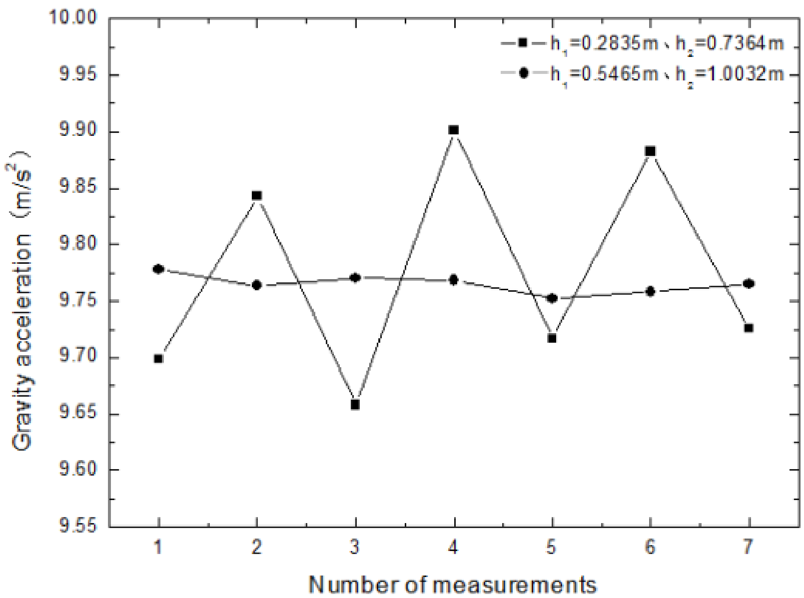


Figure 3:-Comparison of gravity acceleration values measured by the two groups

The gravity acceleration g values measured by the two sets of data are integrated into Fig. 3 for analysis and comparison: when h_1=0.2835m and h_2=0.7364m, the measured gravitational acceleration g value is between9.658m/s^2~9.901m/s^2 ,the fluctuation is larger; when h_1=0.5465m and h_2=1.0032m, the g value is between 9.752m/s^2 ~9.778m/s^2,the change is significantly smaller than the first group. The reason for the above results is as follows: when the ball falls 0.2835m through the first coil, because of the external factors such as the shorter distance and the action of the experimenter releasing the ball have a greater influence on the result, which causes the fluctuation of the g value measured by the first group to be larger; The falling distance of the ball increases, the speed when passing through the coil becomes larger, the increase of the distance causes the influence of the action of releasing the small ball to decrease. When h_1=0.5465m, h_2=1.0032m, the average gravity acceleration obtained is 9.765m/s^2, and the relative error of the local gravity acceleration theoretical value[7] of 9.974m/s^2 is 0.3%, which indicates that the method is completely feasible.

Summary

Based on the principle of electromagnetic induction, this paper introduces a method to measure the acceleration of gravity using Audacity audio processing software. Compared with the existing methods[2-5], the items except the computer are easy to obtain, no special experimental equipment is needed. The relative error between the experimental value measured by this method and the theoretical value of local gravity acceleration (9.794m/s^2) is 0.3%. The relative error of gravity acceleration measured by Yang Guoren et al.[4] using the improved free fall tester is 0.4%, it shows that our simple method is feasible. This method has a very positive effect and significance on stimulating students' learning interest, enhancing students' thinking and practical ability, and enriching the measurement method of gravity acceleration.

References:-

1. Yang Peng.A Brief Analysis of Several Methods for Measuring Gravity Acceleration g Value in the Laboratory[J].Physics Teachers,2014,35(03):33-34.
2. Zhang Buyang. Improvement of Free Fall Acceleration Experiment with Photoelectric Gate [J]. Physics Experiment, 2015, 30(12): 14-17
3. Han Chenxi. Improvement of the experimental device for measuring gravity acceleration by free fall method [J]. Physics Experiment, 2018, 38(05): 59-61.
4. Yang Guoren, Wang Guizhong, Yan Xiaoning. Improvement of free fall experiment instrument [J]. Physics Experiment, 2010, 30 (06): 34-36.
5. Ni Min, Chen Zhou. Comparative study on three kinds of dis experimental design methods for gravity acceleration[J].. Physics teacher, 2019, 40 (03): 60-63+66.
6. Sun Aming. Improvement of gravity acceleration experiment using single pendulum [J]. Physics teacher, 2018, 39 (08): 53-55.
7. Yu Fengjun. Earth's rotation, shape and acceleration of gravity with latitude [J]. University Physics, 2013, 32 (06): 14-17.