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Using Android Mobile Device for Physics Experiments and Inquiry

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Abstract: This article proposes to use a smart phone as a data recording and acquisition device in some physics experiments. First, its camera can be used to capture the motion of a moving object and a student can record the time and displacement of the object. This idea was tested in experiments of projectile motion and slope motion. Second, the cell phone can be used as a data acquisition device measuring angular displacement in an experiment where the cell phone was the weight of a swinging pendulum. With the recorded data, students can explore and hypothesize a quantitative relationship between some variables, similar to what a scientist does in a real experiment. Instead of following prescribed steps in traditional physics experiment with completely predictable reults, students can now “rediscover” physical laws. With this training in scientific inquiry, students might develop better inductive skills in pattern finding, hypothesis generation and hypothesis testing.

Keywords: Physics experiment, scientific inquiry, inductive skills, mobile learning, Android

Introduction

Physics experiments play an important role in science education. The process of an experiment can make a deep impression on the students and increase their interest in learning science. The process of scientific inquiry can make the students think actively, make simplifying assumptions, construct hypotheses, explore various approaches, revise and verify their hypotheses. These skills can enhance students’ ability to solve problems (Chiappetta & Russell, 1982; Saunders & Shepardson, 1987) [1] [2].

In recent years, science education emphasizes more on encouraging students to explore and learn actively. Inquiry-based learning is a kind of teaching strategies of exploration activities that intend to help students construct and develop their own knowledge. Instead of giving direct answers to students, a teacher asks questions and provides information related to the subject so that the students can take the initiative to make hypotheses, explore, validate, summarize, explain and discuss their ideas. Some researchers have proposed inquiry-based learning environment for learning science. For example, Linn (1998) developed "WISE" (Web-Based Integrated Science Environment) and "TELS" (Technology Enhanced Learning in Science); de Jong (1996) developed "SimQuest" [3], and Pryor and Soloway (1997) developed “Science Ware” to explore science [4]. These studies focus more on encouraging students to develop self-directed solution to open-ended problems. In this study, more basic training is provided for students in designing effective experiments, doing effective reasoning, discovering rules, collecting data and interpretation of data plots.

1. Android Phone is Used in Physics Experiment in Two Ways

Android, acqired by Google in 2005, is a free and open operating system with a linux kernel for mobile devices such smart phones and tablet pc. In this study, a handheld device (Motorola Milestone) is used in several physics experiments. In some experiments, we use the embedded camera in the device to take video of the experiment. In another experiment, we make use of the acceleration sensor and the orientation sensor in the handheld device.

2. Experiment and results

There were two ways in which the smart phone was used in our experiments. The next two subsections describe two experiments where the phone played different roles.

2.1 Projectile Motion

This section describes an experiment in which the camera of a smart phone was used to record the experiment as a video. A scale handmade from cardboard was placed in the background of the object that was projected upward and then fell downward as free fall. The time (t) and displacement (s) data were then taken from the video with the background scale frame by frame. The data are plotted in Figure 1 and shown in the two leftmost columns of Table 1.

There are a couple of issues in working out the algebraic relation between t and s. After collecting the data and starting to find the relation, students would most likely start from the gravitational theory they remember learning in Physics 101. But this is precisely what we do not want the students to do. What the students should do is to do the experiment before learning about the theory. Then they can focus on the numerical data and ask what possible relation between the displacement and the time the data are trying to tell us [5].

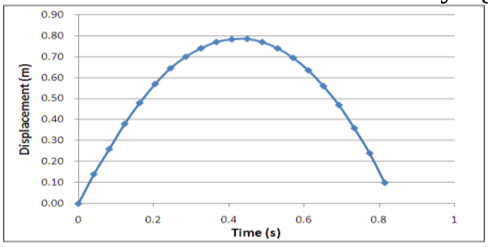

Fig. 1 Projectile motion plot

Consider the example in Figure 1 and Table 1. The figure shows that s is likely to be a quadratic function of t. Then the next question is where the vertex is located. The data show that both t=0.41 and t=0.45 can be a candidate, since s=0 at both instants. However, if either is chosen, the symmetry of the data about the chosen time is lost completely. So a better candidate is t=0.43, which is the middle of t=0.41 and t=0.45. Hence, a new term t-0.43 is generated. More terms are then generated: s/(t-0.43) and s/(t-0.43)^2. The latest term shows a more or less constant value in Table 1. Hence, we can claim that a relation has been discovered: s/(t-0.43)^2=4.64, meaning s = 4.64 * (t-0.43)^2.

Table 1 Pursuing to find a relation between t and s

Initial		Step1	Step2	Step3	
t	s	t-0.43	$\frac{s}{t-0.43}$	$\frac{s}{(t-0.43)^2}$	
0	0.79	-0.43	-1.84	4.29	
0.04	0.65	-0.39	-1.67	4.30	
0.08	0.53	-0.35	-1.52	4.35	
0.12	0.41	-0.31	-1.33	4.29	
0.16	0.31	-0.27	-1.15	4.28	
0.21	0.22	-0.22	-1.00	4.59	
0.25	0.14	-0.18	-0.78	4.37	
0.29	0.09	-0.14	-0.65	4.66	
0.33	0.05	-0.10	-0.51	5.10	
0.37	0.02	-0.06	-0.34	5.75	
0.41	0	-0.02	0.00	0.00	
0.45	0	0.02	0.00	0.00	
0.49	0.02	0.06	0.33	5.37	
0.53	0.05	0.10	0.50	4.90	
0.57	0.09	0.14	0.64	4.53	
0.61	0.15	0.18	0.83	4.58	
0.65	0.23	0.22	1.04	4.71	
0.69	0.32	0.26	1.23	4.70	
0.74	0.43	0.31	1.38	4.45	
0.78	0.55	0.35	1.57	4.46	
0.82	0.69	0.39	1.76	4.51	
0.86	0.86	0.43	2.00	4.63	
				Avg	4.64

2.2 Physical Pendulum

This section describes a second experiment in which the smart phone was the weight of a swinging physical pendulum. As the phone swings, it also records, as a data acquisition device, the angular displacement of the pendulum reported by a sensor embedded in the phone.

For one particular setting of an experiment at an initial angle of 15 degrees, the data of time and angular displacement are plotted in Figure 2. Clearly, the pendulum motion was periodic. The period for each wave was taken as the time elapsed between two peaks (or two troughs). Then the periods were averaged. The experiment was repeated for different lengths of the pendulum and the averaged period was computer for each trial. Table 2 shows that, after a number of terms were generated, the relation $T^5/L^2 = 14$, meaning $T^5 = 14*L^2$, was found.

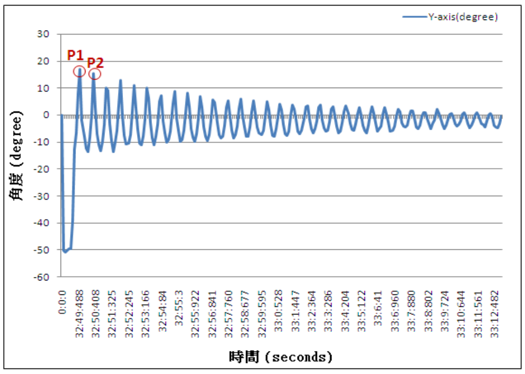

Fig. 2 Pendulum plot

Table 2 Find a relation between the period and length of a pendulum

Initial			Step1	Step2	Step3	Step4
Initial degree	L (m)	T (s)	$\frac{T}{L^2}$	$\frac{T^2}{L}$	$\frac{T^3}{L}$	$\frac{T^5}{L^2}$
15	0.12	0.72	51.64	4.28	3.15	13.80
	0.14	0.76	41.65	4.27	3.24	13.82
	0.15	0.80	34.67	4.22	3.38	14.27
	0.17	0.83	29.03	4.07	3.37	13.71
	0.19	0.87	25.15	4.07	3.54	14.41
						Avg 14

3. Conclusion

As smart phones become more popular, many applications have been developed. However, not many of them are made for the purpose of learning. This article proposes to use an Android smart phone in physics experiments so that students can enjoy an educational use of their smart phones.

In the first experiment of projectile motion, the relation $s = 4.6 * (t-4.30)^2$ was found. In the second experiment of physical pendulum, the relation $T^5 = 14*L^2$ was found. Comparing the displacement-time relation with theoretical results indicate that the relation is reasonable, considering the effects of other real-life factors. In summary, this article has shown an innovative way in which a smart phone can be used to enhance the learning of physics experiments for students.

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