PHY2811 (Group A) Jason
Experiment 1 Sept. 15, 2006
Free fall and measurement of *g* Setup 1

Objective:

To study the properties of free fall and measure the acceleration due to gravity *g* by the time elapsed in free fall.

Method: The experimental setup is shown in Fig. 1.

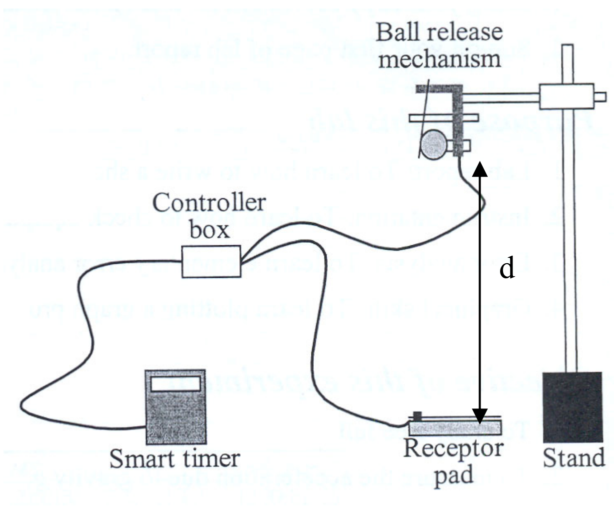

Fig. 1 Setup for free fall experiment

The distance *d* between the bottom of the steel ball and the top of the receptor pad is related to the falling time *t* recorded by the smart timer:

$$d = \frac{1}{2}gt^2 \qquad [1]$$

In Part 1, the distribution of the time *t* can be obtained by repeating measurements with the same *d.*

In Part 2, by varying the distance *d*, different falling times are recorded. From Eq [1], the acceleration due to gravity *g* is determined by plotting *d* against t^2.

Measurements:

<u>Part 1: Distribution</u>

The falling height, *d* was set at 1.095 ± 0.001 m.
The falling time *t* was measured 40 times as tabulated in Appendix 1.

<u>Part 2: Verification of free fall equation</u>

For each distance *d* ranging from about 0.39 m to 1.10 m, the falling time was recorded. The data are tabulated in Appendix 1.

Data Analysis:

Part 1: Distribution

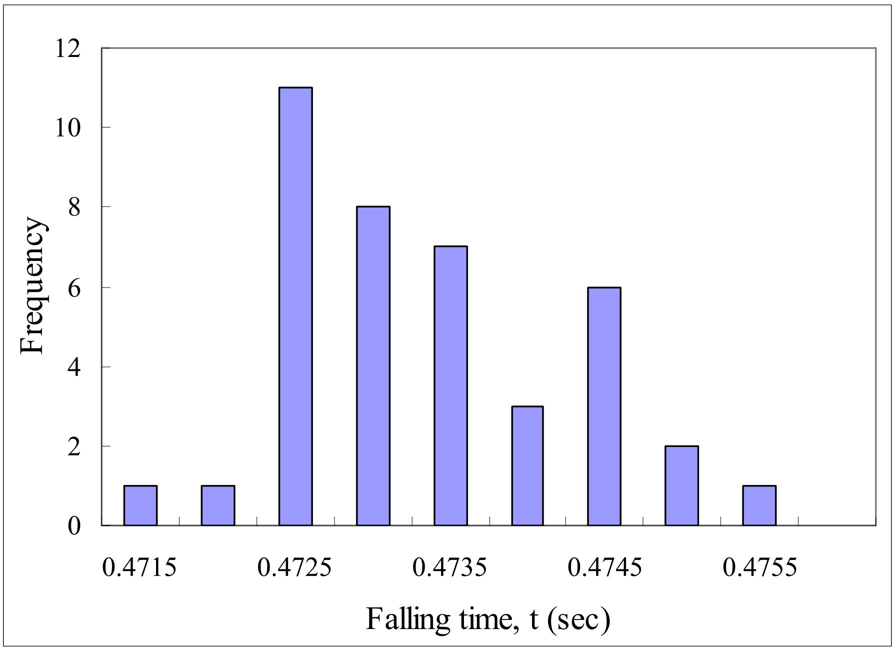

Fig. 2 Distribution of falling time for a fixed distance d =1.095 ± 0.001 m

A histogram of the falling time is shown in Fig 2. The data were analyzed by Excel. The average value of t was 0.4731 sec and the standard error was 0.001 sec.

Part 2: Verification of free fall equation

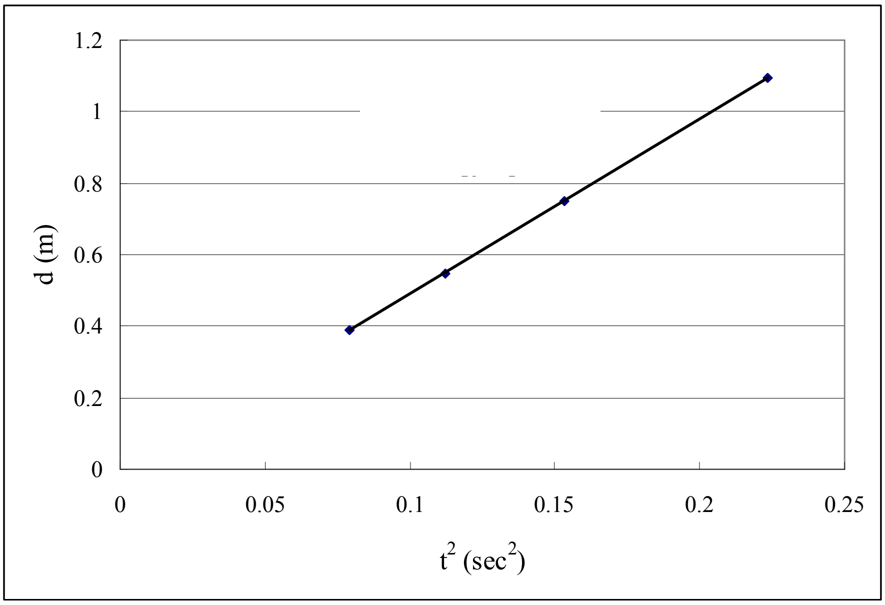

Fig. 3 Verification of free fall equation

The free fall data (shown in Appendix 1) are plotted in Fig. 3. The line is obtained by linear least square fit. The slope obtained is 4.90 ± 0.01 m s^{-2}. Therefore, the acceleration due to gravity *g* is 9.80 ± 0.02 m s^{-2}. Compared with the standard value of *g* = 9.8 m s^{-2}, the discrepancy is only 2.0%.

Discussion:

For more accurate determination of *g*, air resistance should be considered, especially for large *d*. For achieving more accurate values of *g*, more data points should be recorded and larger range of *d* should be used.

Plotting *d* against t^2 is better than plotting *t* against $\sqrt{d}$ because there might be systematic error in measurement of *d*.

Conclusion

For the same distance *d* = 1.097 m, the falling time can have a statistical distribution, but it does not look like a normal distribution. The average value of *t* was 0.4731± 0.002 sec. We also verified the free fall equation (Eq. [1]) and obtained the acceleration due to gravity *g* = 9.80 ± 0.02 m s^{-2} which is only 2.0% from the standard value.

Appendix 1: Data sheet

Table 1. Distribution of free fall time *t*

0.4723 ± 0.0002 s	0.4741	0.4732	0.4741	0.4734
0.4730	0.4740	0.4726	0.4723	0.4743
0.4745	0.4723	0.4739	0.4724	0.4747
0.4727	0.4734	0.4742	0.4751	0.4721
0.4726	0.4727	0.4739	0.4735	0.4722
0.4727	0.4734	0.4744	0.4716	0.4731
0.4723	0.4728	0.4723	0.4723	0.4728
0.4711	0.4733	0.4724	0.4747	0.4723

Table 2. Free Fall time *t* as a function of *d*

d	*t*		average *t*
(m)	(sec)		(sec)
1.095 ± 0.001	0.4723 ± 0.0002	0.4727	0.4725
0.751	0.3916	0.3918	0.3917
0.548	0.3346	0.3350	0.3348
0.389	0.2815	0.2817	0.2816