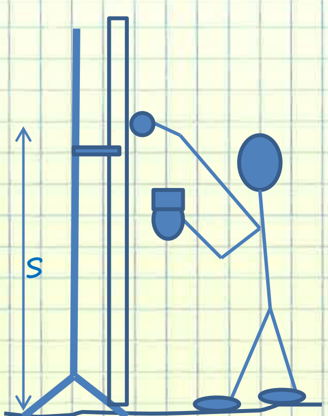
Appendix B: Example for Laboratory Notebook Entry

Lab 25: Experimental Estimate for Gravitational Acceleration at the Surface of the Earth

Thursday, September 25, 2014
Lab Partner: Michael Faraday

Purpose: Determine a value for gravitational acceleration "g" by measuring the time taken for a mass to fall a known distance and then using equation for distance fallen under constant acceleration ($S = \frac{1}{2} g t^2$) to determine a value for g.

Apparatus:



Equipment used:

- A two-meter ruler
- Stop watch
- Marble

The two-meter ruler is held vertically by a stand. The marble is held at the desired height S and then released while simultaneously starting the stop watch. Stop watch is stopped when marble hits the floor.

Data taken:

S = (meters)	2.00	1.80	1.60	1.40	1.20
	0.71	0.65	0.57	0.51	0.50
measured	0.61	0.63	0.63	0.61	0.51
fall times	0.70	0.55	0.62	0.49	0.48
t (sec)	0.59	0.61	0.59	0.53	0.47
	0.61	0.59	0.52	0.48	0.52
	0.62	0.58	0.56	0.58	0.47
	0.61	0.64	0.59	0.54	0.53
	0.63	0.57	0.59	0.56	0.39
	0.56	0.61	0.53	0.50	0.45
	0.59	0.65	0.57	0.57	0.51
	0.62	0.65	0.65	0.53	0.51
	0.72	0.64	0.54	0.59	0.56
mean	0.63	0.61	0.58	0.54	0.49
std	0.047143	0.031976	0.036795	0.038322	0.040351
stdmean	0.013609	0.009231	0.010622	0.011063	0.011648

TABLE I

Table I shows timing data for marble dropped from heights S = 2.0, 1.8, 1.6, 1.4, and 1.2 m. In each case 12 measurements were taken. Each measurement consists of releasing the marble and simultaneously starting the stop watch and then stopping the

28

stop watch when I hear the marble hit the floor.

Analysis of Data:

TABLE II

S = (meters)	2.00			1.40	1.20
	0.50			0.26	0.25
	0.37			0.37	0.26
square of	0.49			0.24	0.23
measured	0.35			0.28	0.22
fall times	0.37	0.35	0.27	0.23	0.27
t^2 (sec^2)	0.38	0.34	0.31	0.34	0.22
	0.37	0.41	0.35	0.29	0.28
	0.40	0.32	0.35	0.31	0.15
	0.31	0.37	0.28	0.25	0.20
	0.35	0.42	0.32	0.32	0.26
	0.38	0.42	0.42	0.28	0.26
	0.52	0.41	0.29	0.35	0.31
mean	0.40	0.38	0.34	0.29	0.24
std	0.06	0.04	0.04	0.04	0.04
stdmean	0.018378	0.011639	0.012907	0.012513	0.011527

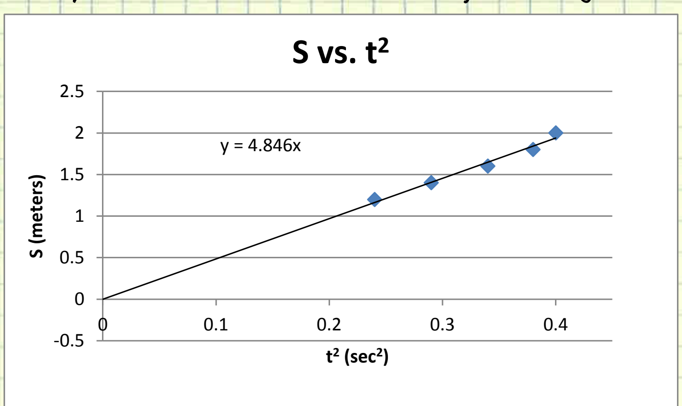
The individual time measurements from Table I are all squared and the mean value of the squared times is determined for each drop height S.

Table III gives summary of the drop heights and squared times:

TABLE III

t^2 (sec^2)	S (meters)
0.4	2
0.38	1.8
0.34	1.6
0.29	1.4
0.24	1.2

We next plot a graph of drop height vs. squared time and obtain the following:



We used the trend line and Linest functions in Excel to find the best fit straight line for the data.

TABLE IV

Slope → error →

4.767442	0.[illegible]26744
[illegible]25	0.140521
[illegible].97[illegible]26	0.054984
129.3077	3
0.39093	0.00907

TABLE IV

Slope → error →

4.846003	0
0.063918	#N/A
0.999305	0.047904
5748.087	4
13.19082	0.009179

We also used the Linest function in Excel to determine errors of best fit, summarized in Table IV (previous page). So the slope m and its uncertainty Δm are

$$m \pm \Delta m = \sout{4.7674 \pm 0.4192 \ m/s^2}$$
$$= 4.846 \pm 0.064 \ m/s^2.$$

Using the fact that $S = \frac{1}{2} g t^2$, the slope of the best fit line of S vs. t^2 should be ½ g.

$$g(m) = 2m = 2\,(4.846) = 9.692 \ m/s^2.$$

The uncertainty in g is determined by the method given in the lab manual (see Appendix):

$$\Delta g = g(m + \Delta m) - g(m)$$
$$= 2\,(4.846 + 0.064) - 2\,(4.846) = 0.128 \ m/s^2.$$

Using the rules in the lab manual for reporting a result, our final result is

$$g = 9.69 \pm 0.13 \ m/s^2.$$

Conclusion:

We were able to experimentally determine a value for the acceleration due to gravity at the Earth's surface, i.e. "g". Our measured value was

$$g = 9.69 \pm 0.13 \ m/s^2.$$

This value is consistent with values given in our text and the value of "g" given in the lab manual

$$g_{accepted} = 9.806\ 65 \ m/s^2.$$