OH NUTS! SPRING ENERGY LAB

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INTRODUCTION

INTRODUCTION

Purpose

- The purpose of this lab is to design and test an experiment using independent and dependent variables.

Researchable Question

- How will increasing the compression of a spring effect the maximum height of an object on a pendulum when the spring contacts the object?

Hypothesis/Proportionality Statement

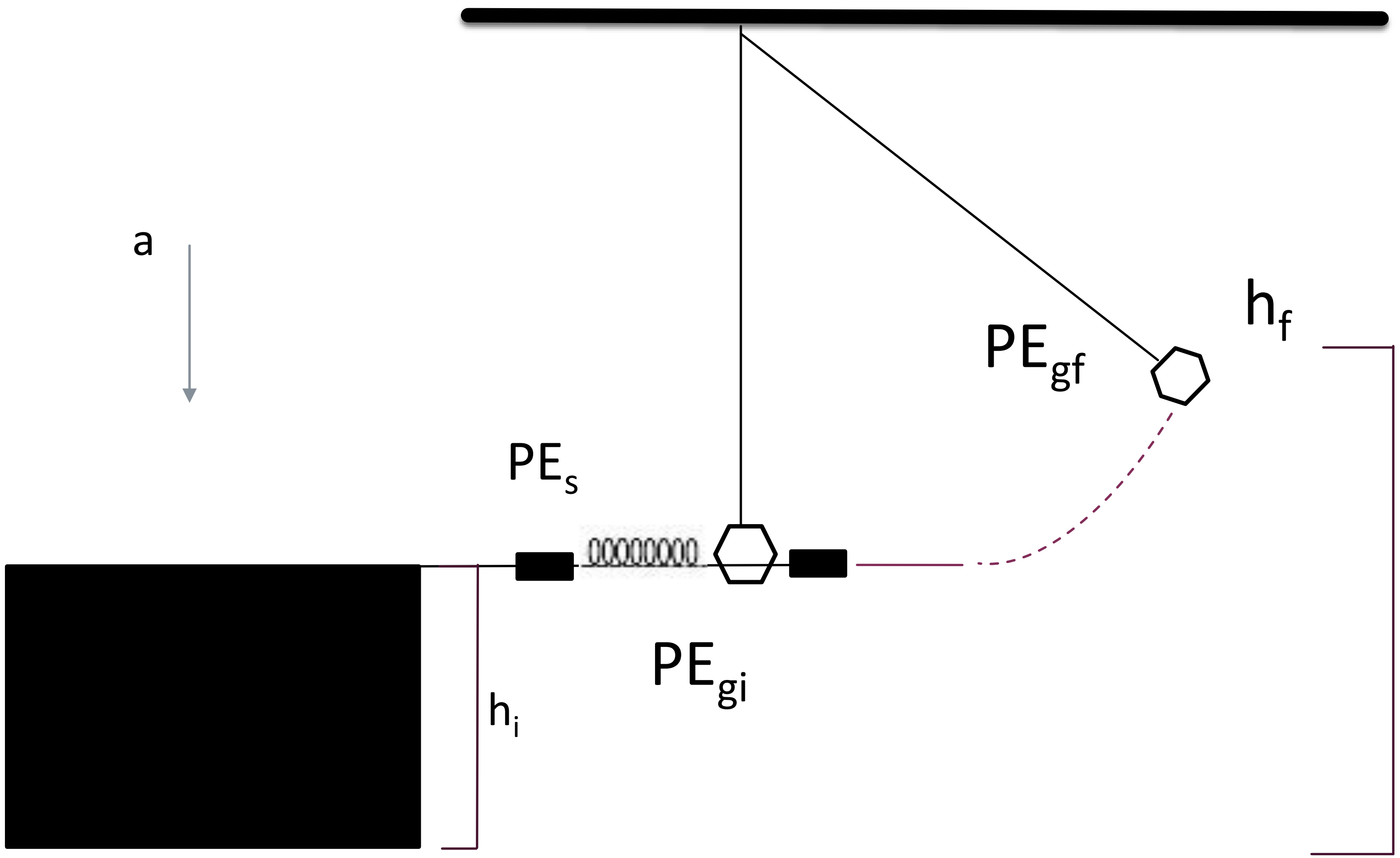
- The dependent variable is the maximum height at which the object reaches.
- The prediction is that maximum height will increase as the compression distance of the spring increases where $\Delta x \propto h_T$.

Variables

- The independent variable in this lab is the distance the spring is compressed.

METHODOLOGY

DIAGRAM



SETUP

METHODOLOGY

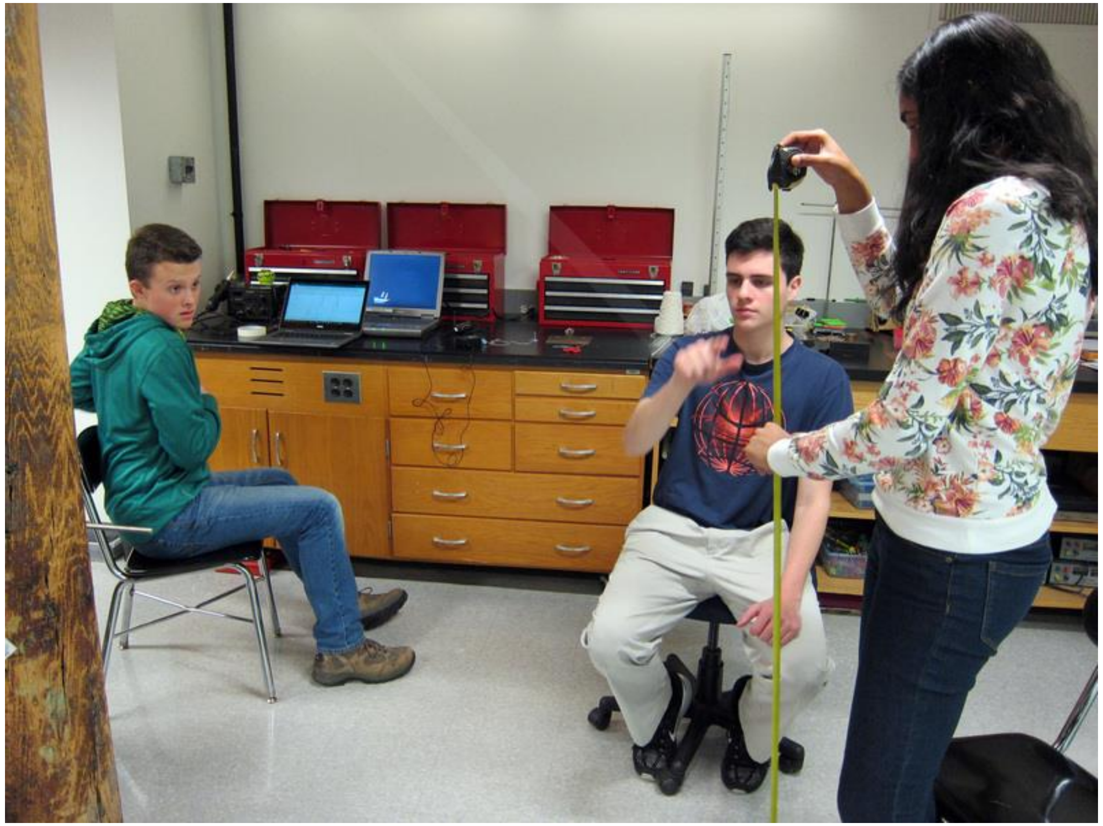
- The primary step of this lab was to setup the apparatus for the experiment.
- The pendulum was created by attaching a string that spanned from a pipe in the ceiling of the room to the edge of the table. The nut was attached to one end of the string and the other end was taped to the pipe.
- Next, one binder clip was attached to the metal dowel, followed by the spring. One end of the dowel was inserted through the nut.
- After, another binder clip was placed at the end of the dowel to compress and secure the components before it. Each of the five settings was marked on the dowel using a permanent marker.

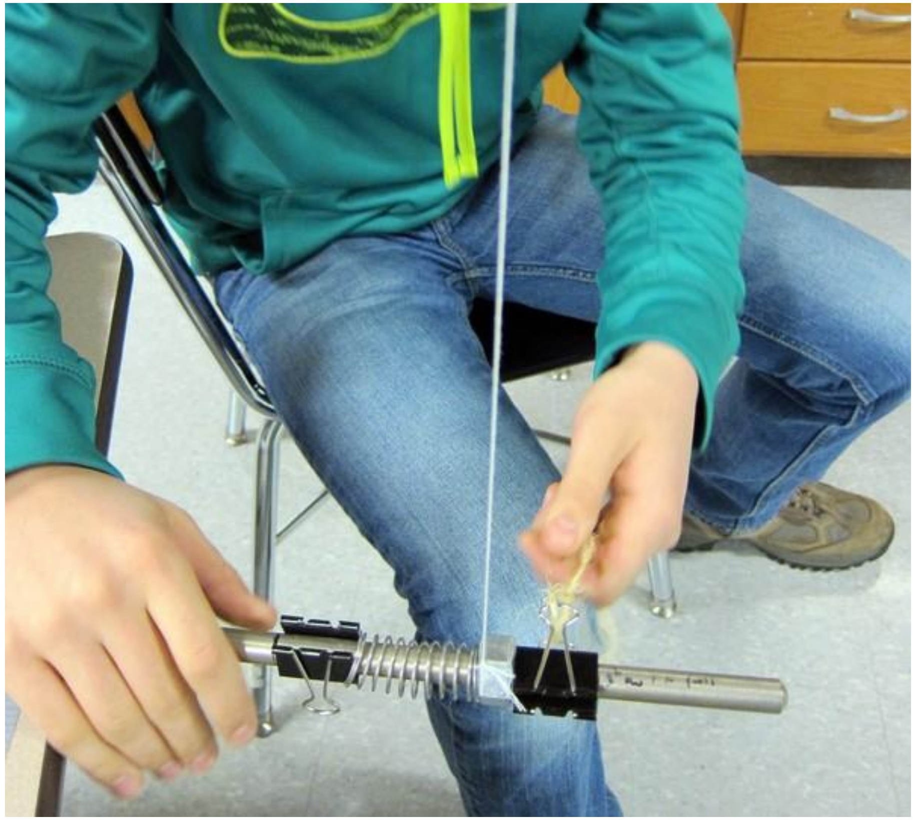
TESTING

METHODOLOGY

- The method of release consisted of pulling a string attached to the binder clip in front of the nut.
- Once Sean pulled the string, the nut reached its maximum height, to which Jack would place his finger.
- Manjusha used a measuring tape to measure the tip of Jack's finger as soon as it was positioned. The height was measured in centimeters and converted to meters.
- After every trial, the data was instantly recorded on a computer. 10 trials were conducted for each setting.

PHOTOGRAPHS





CONSTANTS

$m = 0.03196$ kg

$h_i = 0.7415$ m

$g = -9.8$ m/s^2

$k = 235.53$ N/m (Appendix A)

EQUATION

$$h_T[\Delta x] = \frac{\frac{1}{2}k\Delta x^2 + mgh_i}{mg}$$ (Appendix B)

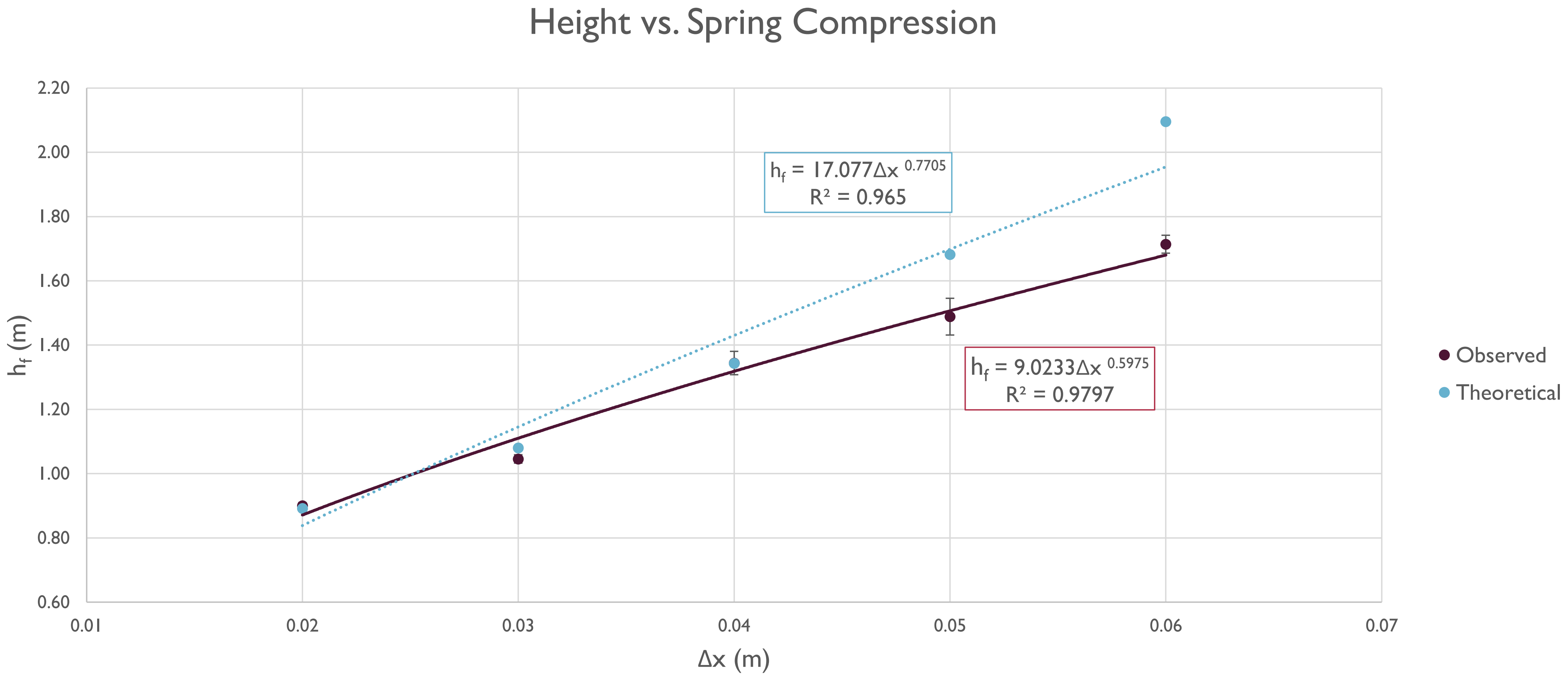
$$h_T[\Delta x] = \frac{\frac{1}{2}(235.53)\Delta x^2 + (0.03196)(9.8)(0.7415)}{(0.03196)(9.8)}$$

$$h_T[\Delta x] = \frac{\frac{1}{2}(117.76)\Delta x^2 + (0.232244)}{(0.313208)}$$

DATA TABLES

	Δx (m)	h_{avg} (m)	STDEV (m)	%RSD of t_{avg}	h_t (m)	|%err| of h	TEi (J)	TEf (J)	%E Change (J)
IV1	0.02	0.90	0.01	1.10	0.89	0.94	0.28	0.28	0.93
IV2	0.03	1.05	0.01	1.28	1.08	3.16	0.34	0.33	-3.26
IV3	0.04	1.34	0.04	2.72	1.34	0.08	0.42	0.42	0.08
IV4	0.05	1.49	0.06	3.83	1.68	11.47	0.53	0.47	-12.95
IV5	0.06	1.71	0.03	1.63	2.10	18.20	0.66	0.54	-22.26
			Avg	2.11	Avg	6.77			

CHART



Height vs. Spring Compression
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
h_f (m)
0.01
0.02
0.03
0.04
0.05
0.06
0.07
Δx (m)
$h_f = 17.077\Delta x^{0.7705}$
$R^2 = 0.965$
$h_f = 9.0233\Delta x^{0.5975}$
$R^2 = 0.9797$
Observed
Theoretical

ANALYSIS

- The data shows the height increase as the distance of spring compression increased by 0.01m.
- The average RSD of this experiment is 2.11% which is high precision compared to other experiments.
- The minimum height recorded was the third attempt at the spring compression of 0.02 m, which resulted in a maximum height of 0.89 m. The maximum height recorded was trial six when the spring compression was 0.06 m. The height measured at this trial was 1.76 m.
- Overall, the measured values were close to the theoretical values proving its accuracy and its precision. The accuracy is displayed by the R^2, which indicated that the data collected is 97.97% accurate compared to the theoretical height for each setting.
- The error of the observed data is 6.77%, indicating high accuracy. The data also proves that the energy was not conserved throughout the process of the experiment.
- The change in energy between TE_i and TE_f increases, which shows how the loss of energy increases as the distance the spring is compressed increases.

CONCLUSION

SUMMARY

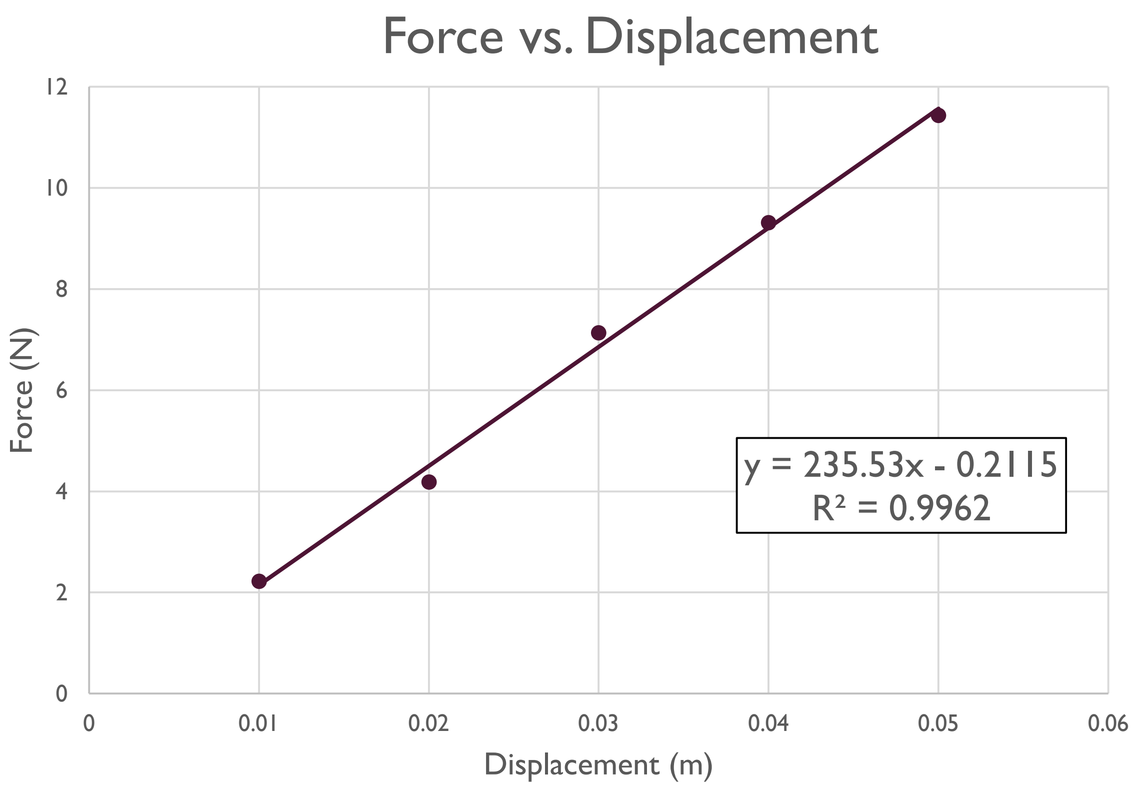
- It is determined that as the spring is compressed to greater distances, the maximum height of the object increases. This result matches with the prediction.
- A major source of error was due to the spring not staying on the dowel, which resulted in a loss of energy. which made the average time longer than the theoretical time for all the settings.
  - Other errors that could have affected the results include work done by air resistance, loss of thermal energy.
  - The approximation of measurements for the maximum height also resulted in slight disparities in the observed results compared to the theoretical.

FUTURE EXTENSIONS

- Future extensions of this lab could comprise of measuring the angle created between the initial position of the pendulum compared to the position at maximum height.
- Another possibility includes variations in the mass of the object, different launch mechanisms, and keeping the spring attached to the dowel.

APPENDIX A

SPRING CONSTANT



- The spring constant of the spring was to be calculated before using it in the experiment.
- The spring constant was found by pulling the spring a certain distance for a certain amount of time.
- This process was repeated five times and the data collected was used to find the slope, which resulted in the spring constant.

Spring Constant	
(m)	(N)
0.01	2.219
0.02	4.181
0.03	7.13
0.04	9.312
0.05	11.43

- The table used to create the spring constant graph.

APPENDIX B

DERIVATION

$$PEs + PEg_i = PEg_f$$

$$\frac{1}{2}k\Delta x^2 + mgh_i = mgh_f$$

$$\frac{\frac{1}{2}k\Delta x^2 + mgh_i}{mg} = h_f$$

$$\boxed{h_T[\Delta x] = \frac{\frac{1}{2}k\Delta x^2 + mgh_i}{mg}} \rightarrow \boxed{h_T[\Delta x] = \frac{\frac{1}{2}(235.53)\Delta x^2 + (0.03196)(9.8)(0.7415)}{(0.03196)(9.8)}}$$

APPENDIX C

ORIGINAL DATA TABLE

	Δx	h_1	h_2	h_3	h_4	h_5	h_6	h_7	h_8	h_9	h_{10}	h_{avg}	STDEV	%RSD	h_t	|%err|	TE_i	TE_f	%E Change
	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	of h_{avg}	(m)	of h	(J)	(J)	(J)
IV1	0.02	0.905	0.897	0.887	0.904	0.913	0.885	0.916	0.899	0.901	0.896	0.900	0.01	1.10	0.892	0.94	0.28	0.28	0.93
IV2	0.03	1.032	1.043	1.039	1.024	1.036	1.063	1.048	1.064	1.057	1.052	1.046	0.01	1.28	1.080	3.16	0.34	0.33	-3.26
IV3	0.04	1.326	1.386	1.383	1.265	1.339	1.342	1.337	1.324	1.357	1.383	1.344	0.04	2.72	1.343	0.08	0.42	0.42	0.08
IV4	0.05	1.571	1.459	1.536	1.476	1.443	1.567	1.433	1.511	1.403	1.488	1.489	0.06	3.83	1.681	11.47	0.53	0.47	-12.95
IV5	0.06	1.734	1.681	1.719	1.697	1.679	1.763	1.746	1.702	1.695	1.721	1.714	0.03	1.63	2.095	18.20	0.66	0.54	-22.26
													Avg	2.11	Avg	6.77			