

Guidelines for a Physics Lab Report

A lab report has three main functions:

- 1) To provide a record of the experiments and raw data included in the report.
- 2) To provide sufficient information to reproduce or extend the data and
- 3) To analyze the data, present conclusions and make recommendations based on the experimental work.

General comments:

The single most important requirement for a laboratory report is clarity. Imagine that your audience is one of your classmates who missed that experiment.

Use spelling and grammar checkers. The grammar checker can be annoying because often technical sentences are wordy and complex, but it will help you avoid using too many passive sentences. In general, passive sentences are less understandable. Grammar check will not check clarity and it will ignore simple errors. What you want is a report that is readable.

Lab Report Structure:

- **Cover sheet:** This page has the class period, the title of the experiment, your name, your lab partners' names and the date the experiment was performed.
 - I. Background and Introduction:** Provides background information and relevant studies: "What knowledge already exists about this subject?" Outline scientific purpose(s) and/or objective(s): "What are the specific hypotheses and the experimental design for investigation?"
 - II. Materials and Methods:** List all of the materials and how they were used. Where and when was the work done?
 - a. Describe special pieces of equipment and the general theory of the analyses or assays used.
 - b. Provide enough detail for the reader to understand the experiment without overwhelming him/her. When procedures from a lab book or another report are followed exactly, simply cite the work and note that details can be found there.
 - c. Write this in paragraph form and be concise. Explain what you did in the lab. Write this procedure so anyone can follow it.
 - d. Provide a neatly labeled drawing of your apparatus.
 - III. Data and Calculations:** This section should include all the data collected from the experiment in tabular form.
 - a. Present all relevant observations you made, including any qualitative ones.
 - b. Make sure you obtain enough data points and trials to create a good graph.
 - c. Prepare **graphs and tables** that best display the results of the experiment and discuss them. For some experiments, you'll be acquiring a lot of data using the computer. Do not include these reams of raw numeric data in your lab report; present it in appropriate graphs and tables.
 - d. Indicate trends, analyze why they occur, and explain any significant features or differences from expected results.
 - e. The values that you record on your data sheet(s) must have:
 - i. Units (such as kg for kilograms)

- ii. Reasonable uncertainty estimates for given instruments and procedures.
- iii. All data tables and graphs appropriately labeled.
- f. **You MAY NOT use your lab partner's datasheet and then make a photocopy.**
- g. Please follow the appropriate format for making graphs. NOTE: Each graph should take up one (1) entire sheet of paper and should be appropriately labeled.
- h. White-out and similar covering agents are expressly forbidden. If there is a mistake, draw a single line through that value.
- i. Show calculations in a neat and orderly outline form. Include a brief description of the calculation, the equation, numbers from your data substituted and the result.
 - i. For calculations repeated many times, you only include one sample calculation. Answers should have the proper number of significant figures and units.
 - ii. It is not necessary to show a calculation for obtaining an average unless I specifically request that you do so.
- j. Typing the equation into the lab report is not required; it is easier and faster to print these calculations neatly by hand. If you wish to type this section, then use the equation editor in Microsoft Word. I can give you information on using the equation editor.

IV. **Results and Conclusions:** This is the most important section of the lab report; it is where you analyze your data.

- a. This is the section in which you state the main result(s) of the experiment and compare your result(s) to the accepted or theoretical value(s) (if available) by computing a percent discrepancy. State what you consider to be the most likely causes of these discrepancies. If possible discuss these potential reasons for error quantitatively by calculating (or estimating) how much effect each source of uncertainty may have on the final result. An example of this type of reasoning is shown in the sample lab report at
- b. Begin the discussion with the experimental purpose and briefly summarize the basic idea of the experiment with emphasis on the measurements you made.
- c. State only the key results. Your discussion should address questions such as:
 - i. What is the relationship between your measurements and your final results?
 - ii. What trends were observable?
 - iii. What can you conclude from the graphs that you made?
 - iv. How did the independent variables affect the dependent variables? (For example, did an increase in a given measured (independent) variable result in an increase or a decrease in the associated calculated (dependent) variable?)
 - v. Then describe how your experimental results agree with the theory. When comparison values are available, discuss the agreement using either uncertainty and/or percent differences.
 - vi. Sources of error.
 - 1. In your discussion of sources of error, you should discuss all of those things that affect your measurement, but which you can't do anything about given the time and equipment constraints.
 - 2. Included in this would be a description of sources of error in your measurement that bias your result (e.g. friction in pulleys that are assumed frictionless).

- vii. Your analysis should describe the qualitative effect of each source of error (e.g. slowed motion, causing a smaller value of acceleration to be measured) and where possible, provide an estimate of magnitude of the errors they could induce. NOTE: a tabulation of all possible sources of errors without any discussion of the effect will receive no credit.
- viii. You are not required to state a conclusion in this course, unless specifically asked to do so.

V. **Lab Questions:** Attach any lab questions to the end of the report.

NOTE:

1. No student should copy data from anyone who is not his or her lab partner.
2. You may discuss the experiment with your lab partner and other classmates, but the lab report you turn in must be your own work. Lab reports are subject to all the rules governing academic honesty.
3. Photocopies of any parts of the lab report are NOT permissible.

[EXAMPLE 1]

Assemble report using a staple in the upper left corner.

HOOKE'S LAW AND A SIMPLE SPRING

09 /24 /2010

Your name first, then your lab partners, all centered.

Include period and date lab was completed.

Joe Student

Ima Pigg

Hedda Lettuce

(Period 1)

A lab report should include a title page like this one with all of the appropriate information.

I. Background and Introduction

If a weight, $W = mg$, is hung from one end of an ordinary spring, causing it to stretch a distance x , then an equal and opposite force, F , is created in the spring which opposes the pull of the weight. If W is not so large as to permanently distort the spring, then this force, F , will restore the spring to its original length after the load is removed. The magnitude of this restoring force is directly proportional to the stretch,

$$F = -kx$$

The constant k is called the spring constant. In this form, it is apparent that if a plot of F as a function of Δl has a linear portion, this provides confirmation that the spring follows Hooke's Law and enables us to find k .

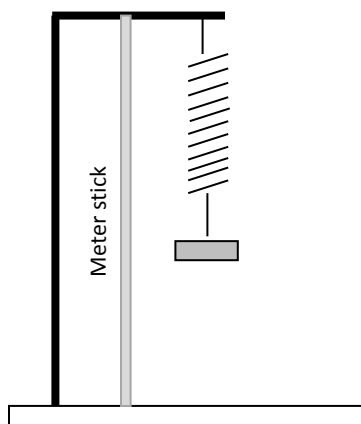
The purpose of this experiment was to measure and compare the spring constant of a steel spring. We investigated the relationship between the force applied to a spring and the displacement of the spring from its rest length. We hung various masses from the springs and measured the vertical displacement. We hypothesized that when a spring is subjected to loading, it will elongate within limits. We will find the spring constant using data derived from the loading and elongation of the spring.

II. Materials and Methods

Materials: Steel spring(s), masses, mass hangers, ring stand, metal rod, metric ruler.

Procedure:

1. Hang a spring from a horizontal metal rod.
2. Attach a mass hanger directly to the bottom of the hanging spring and record the position of the bottom of the mass hanger relative to a meter stick (rest position).
3. Add masses to the spring and record the position of the bottom of the mass hanger.
4. Repeat for additional masses.



Note: A simple illustration shows the basic setup.

Table 1:

Mass vs. Position of Hanger

Note units are at the head of the table and not in each box.

Position	Mass (g) ±1%	Location of the Mass Hanger Reference in cm ±0.05cm			
		Trial 1	Trial 2	Trial 3	Trial 4
Reference	0	69.55	69.50	69.50	69.50
1	1	69.27	69.19	69.18	69.17
2	3	68.61	68.50	68.53	68.52
3	5	67.95	67.87	68.88	68.86
4	10	66.42	66.20	66.21	66.20
5	20	62.90	62.89	62.90	62.93
6	40	56.32	56.22	56.30	56.23
7	60	49.65	49.60	49.61	49.6
8	80	42.97	42.97	42.95	42.95
9	100	36.32	36.30	36.32	36.32
10	120	29.63	29.70	29.72	29.72

If you drop that zero then it is 3 sig figs! This should have been 49.60

Table 2: Force vs. Displacement

Uncertainty can be calculated as a percentage.	Force (N)	Displacement (x 10 ⁻² m)					
	±1%	Trial 1	Trial 2	Trial 3	Trial 4	Average	Spring Constant
		± 0.07	± 0.07	± 0.07	± 0.07		(N/m)
	0.00981	-0.28	-0.36	-0.37	-0.38	-0.35 ± 0.02	2.8 ± 0.2
	0.0294	-0.94	-1.05	-1.02	-1.03	-1.01± 0.02	2.91± 0.08
	0.0491	-1.60	-1.68	-1.67	-1.69	-1.66± 0.02	2.96 ± 0.05
	0.0981	-3.13	-3.35	-3.34	-3.35	-3.29± 0.05	2.98± 0.05
	0.196	-6.65	-6.66	-6.365	-6.62	-6.65± 0.01	2.95± 0.03
	0.392	-13.23	-13.33	-13.25	-13.32	-13.28± 0.02	2.95± 0.03
	0.589	-19.90	-19.95	-19.94	-19.95	-19.94± 0.01	2.95± 0.03
0.785	-26.58	-26.58	-26.60	-26.60	-26.59± 0.01	2.95± 0.03	
0.981	-33.23	-33.25	-33.23	-33.23	-33.24± 0.01	2.95± 0.03	
1.18	-39.92	-39.85	-29.83	-39.83	-39.86± 0.02	2.95± 0.03	
1.37	-46.48	-46.50	-46.45	-46.43	-46.47± 0.02	2.96± 0.03	

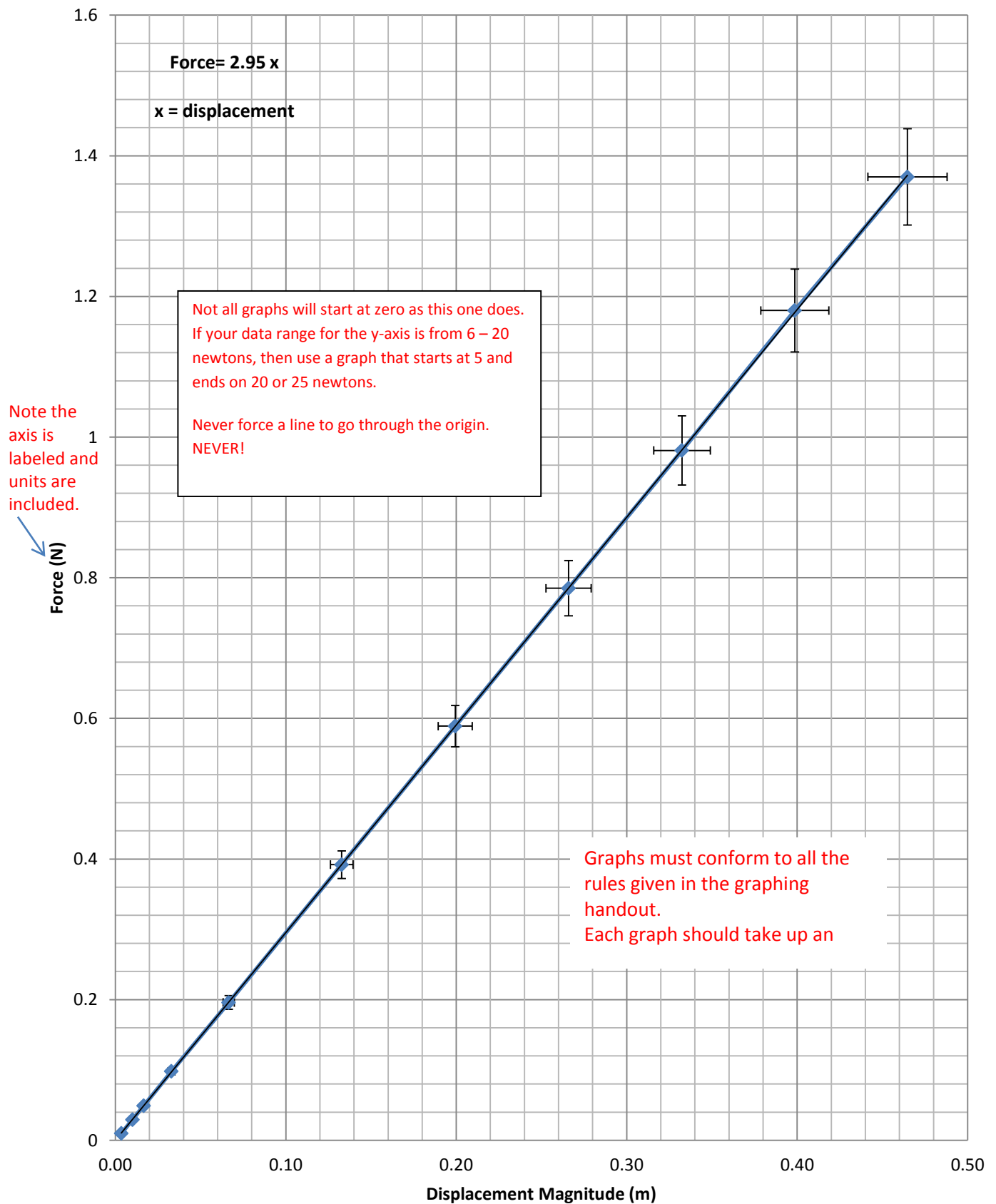
Uncertainty
can be
calculated as
a percentage.

Average Spring Constant ***k*** = 2.94± 0.01 N/m

Spring Constant ***k*** from Graph = 2.95 N/m

Restoring Force vs. Displacement Magnitude

Descriptive title
that is underlined



Sample Calculations

1. Displacement

X = displacement = location with mass 1 (0.010 kg) – reference location

$$x = 66.42 \times 10^{-2}m - 69.55 \times 10^{-2}m = -3.13 \times 10^{-2}m$$

2. Uncertainty of displacement (Δl): Propagation of error for addition and subtraction.

$$\Delta x = \sqrt{(\text{uncertainty in reference})^2 + (\text{uncertainty in location } l)^2}$$

$$\Delta x = \sqrt{(0.05 \times 10^{-2}m)^2 + (0.05 \times 10^{-2})^2}$$

$$\Delta x = 0.07 \times 10^{-2}m$$

3. Force on a spring from the hanging mass

$$F = mg$$

$$F = (10g) (1 \text{ kg}/1000g) (9.81 \text{ m/s}^2) = 0.0981 \text{ N}$$

4. Using Hooke's law ($F = -kx$)_ to find the spring constant.

$$k = -\frac{F}{x}$$

$$k = -\frac{0.0981}{-3.29 \times 10^{-2}}$$

$$= 2.98N/m$$

Discussion

The spring was hung vertically with a mass hanger attached to the lower end of the spring and masses from 1 g to 140 g were added. The downward location of the spring was measured once it came to rest. In this configuration, two equal and opposite forces acted on the hanging mass: gravity directed downward and the spring's elastic restoring force upward opposite the displacement. Using Hooke's Law ($F = -kx$) a spring constant was calculated for each measurement. The spring constants for each value of displacement are the same, within experimental uncertainty (Table 2) which verifies Hooke's law. The average spring constant is $2.94 \pm 0.01 \text{ N/m}$.

A graph of force versus the magnitude of displacement resulted in the expected straight line in the range of forces examined and is consistent with Hooke's law. The slope of this line, 2.95 N/m is the spring constant which agrees with value found by taking the average of the calculated spring constant ($2.94 \pm 0.01 \text{ N/m}$). The intercept for the best fit straight line intersects close to the origin, which is also consistent with Hooke's law.

The sources of error in this part of the experiment are due to the precision of the location measurement using the meter stick and the accuracy of the slotted masses. The meter stick was mounted vertically and behind the spring. The location was measured relative to the base of the mass hanger. Effort was made to sight the measurements directly; however, because of the location of the meter stick it was necessary to view the meter stick at a slight angle. However, this sighting was required for each measurement, and the displacement was the difference between the location and the reference. Thus, this systematic error due to parallax should be minimal. However the random error of measurement precision remains. For displacements 20 cm or more, the uncertainty of the displacement of the spring is 0.5% or less and has little impact on the uncertainty of k ; in those cases 1% uncertainty in the slotted masses has the greatest contribution to the uncertainty of k . However for small displacements the displacement uncertainty has the largest impact on the uncertainty in k . For example, the 1.0 g mass displaced the spring by $-0.0035 \pm 0.0002 \text{ m}$, a relative uncertainty of 6%. Using a motion sensor to measure distance would increase the precision for small displacements.

If there are any questions to answer, that page should be attached here.
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