

# Laboratory Notebook Guidelines

PHY4803L

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## References

These guidelines were taken with modifications from those of the [MIT Junior Laboratory](#).

## Notebook

1. The notebook should have numbered  $8.5 \times 11$  pages and a cloth binding. The composition-size notebooks are too small. Don't get the kind with duplicate pages or spiral bindings.
2. Put your name, address, email address, and phone number at the top of the first page and label an area below for a table of contents (TOC). This notebook TOC should simply list the experiment name followed by the notebook page where entries begin. Continue sequentially from there. Do not leave empty pages to be filled in at a later date.
3. Don't ever erase, use white-out, or tear out pages of a lab notebook. Indicate "mistakes" by simply drawing a single, neat line through the item. These may prove not so incorrect as initially thought and will very often be useful as a guide to how the experiment was done and provide clues on how to better execute the experiment next time.
4. At the beginning of each experiment label the first two pages for a table of contents for the experiment. The experiment TOC should list the exercises, procedures, comprehension questions, etc., and the page numbers where they start. (The notebook and experiment TOCs are the only pages where entries are not made in chronological order.) Use entries like "Spectrometer alignment," "Spectrometer calibration using helium and neon spectrum tubes," etc. These sorts of descriptive headings will prove enormously useful later on when reviewing your notebooks.
5. All comprehension questions with solutions should be in your lab notebook. Be sure to include each question in the TOC using a descriptive entry like 'Comprehension Question 2: Discussion of crossover resonances.'
6. Exercises should be written up in the notebook and photocopied to turn in for grading. They can also be written up on separate sheets and copied or taped into the notebook at the appropriate place.
7. One of the first sections called 'Experimental overview' should include a discus-

sion of the essential physics of the experiment in your own words. List the experimental objectives and how they relate to the essential physics. In particular, explain the physical system under study, the main experimental variables and the measuring equipment that will be used.

**8. Put a date at the top of each page.**

Don't cram the notebook. Start a new page for each new day or new procedure. Put headings on these pages (which are then copied to the experiment TOC) and then describe what you are doing. An example procedural heading might be: 'Measurement of susceptometer's primary coil inductance.' Give a description of how the work relates to the experimental objectives. For example: 'The current in the primary determines the amplitude of the  $B$  field around the sample and can affect its superconducting behavior. The drive frequency affects the rate of change of flux through the secondary coil and thus the amplitude of the induced emf.'

9. The details of the procedure would come next. Describe the variables involved giving their shorthand names (for use in tables and graphs) and how they were measured. Give predicted relations between variables and, when appropriate, derivations or explanations for those relations. Provide all appropriate circuits, diagrams, formulas, data tables, graphs and results. Also include sources of error, both random and systematic, and explain how they were assessed. Don't forget to write down the controlled variables—those that might affect the data but are not purposely varied during the procedure. Examples might be equipment settings such as amplifier gain, function gen-

erator amplitude, or ambient temperature. Remember to also give an estimate of their uncertainty or variability during the data acquisition. For example, this part might start: 'The current amplitude will be determined using a TDS210 oscilloscope measuring the ac voltage across a resistor in series with the coil. Figure 2 (below) is a circuit schematic showing the function generator including its  $50\ \Omega$  output impedance, the coil (as an ideal inductor  $L$  and a series resistor  $R_L$ ), and the current-measuring resistor  $R_I$ . Thus the current  $i(t)$  can be predicted from an ac circuit analysis ...'

10. Loose pages are never acceptable within a lab notebook. Graphics or tables generated by computer must be neatly taped into the notebook. Remember to annotate these types of graphics with as much information as possible about how they were created.
11. When tabulating data into columns, each column header should give the variable name, its measurement units and estimated uncertainty. If each entry has a different uncertainty, list them in a separate column. Computer data files should adhere to these rules as well and when they are small enough to print on a page or two, you should do so and tape the printout in the notebook. When they are too large, a graph or other summary of the data can be placed in the notebook along with a reference to the filename where the complete data set can be found. Be sure the notebook includes all relevant information associated with each computer data file. Don't try to put this information into the filename. 'Table 2 (below) gives the peak-to-peak amplitude of the voltage across the current-

measuring resistor  $R_I$  as the frequency was varied. The amplitude determinations from the TDS210 oscilloscope “Measure” tools are estimated to be good to about 3%.  $R_I = 100\ \Omega$  was from a substitution box with an estimated 2% uncertainty.’

12. In general, graphs should show data points with error bars, but without connected lines between points. Theory or fitting results should be displayed as a smooth curve without individual points. A main purpose of the graph is to illustrate the agreement (or disagreement) between the data and the fit relative to the measurement uncertainties.
13. The chi-square test is another way to assess the agreement between the data and the fit. Equally weighted fits to experimental data should give the resulting sample standard deviation  $s_y$ , which is typically calculated from

$$s_y^2 = \frac{1}{N - M} \sum_{i=1}^N (y_i - y_i^{\text{fit}})^2$$

The value of  $s_y$  should then be compared with the expected standard deviation  $\sigma_y$  based on experimental uncertainties. If you are sufficiently confident of the  $\sigma_y$ , then the reduced chi-square  $\chi_\nu^2 = s_y^2/\sigma_y^2$  should be calculated and a statement regarding its probability should be provided.

For fits where the  $y_i$  have varying standard deviations  $\sigma_i$ , provide the reduced chi-square calculated from

$$\chi_\nu^2 = \frac{1}{N - M} \sum_{i=1}^N \frac{(y_i - y_i^{\text{fit}})^2}{\sigma_i^2}$$

and include a statement regarding its probability.

14. Don’t wait until after the session has ended to determine the quality of your data. Plot and analyze data as they are acquired, not later. These initial plots and analyses can be in rough form, but should be good enough to ascertain that the data are reasonable and suggestive of the behavior you expect. **The importance of making preliminary plots and analyses as the data is acquired cannot be overstated.**
15. Your notebook should contain diagrams, narratives, tables of raw data, formulas, computations, reduced data, error analysis and conclusions in a neat and detailed arrangement.

Instructors grading your notebook will be specifically checking for the following details:

1. The table of contents (TOC) is complete and located at the beginning.
2. There are no loose pages.
3. A description is provided for each experimental procedure and, where appropriate, includes a sketch of the apparatus/circuits. Where appropriate in the sketch, components and variables appearing in the description are labeled.
4. Data tables include table number. Entries include units and uncertainties. A description should discuss how uncertainties were determined.
5. All graphs include figure number, title and axis labels with units as well as a description or discussion of the contents.
6. Graphed data points are shown as symbols with error bars. Fits are shown as superimposed solid lines.
7. When a best fit curve is produced, the sample standard deviation  $s_y^2$  and/or the reduced chi-square  $\chi_\nu^2$  are provided and discussed in relation to expected experimental uncertainties. Uncertainties on relevant fit parameters are determined.
8. Description of analysis procedures are provided including equations and calculations, data tables and graphs.
9. Light cross outs of irrelevant sections are used to facilitate understanding and clarity.
10. Sections of work are delineated with headings and boxes and coordinated with page numbers in TOC.
11. Analysis, data tables, and graphs are cross referenced properly with page numbers, table numbers and figure numbers.
12. Significant digits are properly used.
13. Answers to comprehension questions are set off on separate pages and referenced in TOC.
14. Conclusions are included and flow logically from the work performed.