

Appendix H Laboratory Record-Keeping

This appendix has been borrowed from “EE337- Electromagnetics Laboratory Experiments,” a laboratory manual by Mr. David Carey used for that class, and modified to be more generally applicable. It is an excellent guide for recordkeeping in the laboratory prior to actually writing the formal laboratory report, and includes some guidance for the lab report itself. A particular laboratory class may or may not have a requirement to keep a laboratory notebook. In some, only a record of data recorded in the laboratory is required. However, the material below reflects good practice even when not required. This advice should be helpful. In essence, a good laboratory notebook is a draft report, containing in preliminary form most of the material that will eventually be in the formal report, or at least that part that is performed in the laboratory. (Preliminary work using simulation should at least be summarized in the laboratory record.) From here on this is Dr. Carey’s work, with the more important editorial additions indicated with brackets.

Background:

A good laboratory notebook is a must for those engaged in any analysis and design work. Such a notebook provides the engineer with an accurate record of all that occurs during a project. Good record keeping helps track down errors, acts as a reminder of analysis or design methods undertaken during the project, and (as one's career progresses) provides accurate records to substantiate patents, copyrights, and other intellectual property documents.

A large ($\approx 8.5'' \times 11''$) bound notebook, such as the National 43-648 Engineering Computation Notebook, with paper that withstands occasional erasures, should be used. Coarse ($\approx \frac{1}{4}''$) cross-ruled pages are preferred since they are useful for entering sketches, and tabular and crude graphical data. Everything that is committed to paper should be put in the notebook, including hardcopy of computer analysis (tape or glue the print outs in the notebook). Avoid notes on loose pages: such scraps of paper are often lost. Avoid erasures whenever reasonable: errors should be corrected by crossing them out (what seems to be an error at first may not actually be an error). Write only on the right hand facing pages of an open notebook: the left pages are for afterthoughts and exploratory calculations and may be used in place of scratch paper.

I Guidelines for a good laboratory notebook

A. Heading of the experiment

Copy the laboratory number and the name of the experiment or laboratory exercise to the laboratory notebook. Write down the date of the laboratory exercise, the name of each member of your group, and the equipment used (Part Number, Serial Numbers and Name).

B. Original data in the notebook

The notebook is a record of all relevant designs, observations, hypotheses, and analyses that occurred during the course of the exercise: **the work should be reproducible solely from the notebook**. Careful descriptions of the procedure and the experimental "set-up", in the engineer's own words, are essential.

"Diagrammatic" sketches are often preferable to "pictorial" sketches. Original data must be recorded directly into the notebook as it is acquired. If errors are later found or if calibration measurements are used to correct data, these revised readings should also be recorded without deleting the original data. If multiple readings are taken and then averaged, record all of the data as well as the average value. The data should be arranged in tabular form when appropriate and each item or table should be properly labeled. Initial and date the lower right hand corner of the right hand facing page.

C. Housekeeping deletions

A notebook combining all work might become a mess, with a proliferation of erroneous and superseded material. Matters can be improved greatly with a little housekeeping work. Just draw a box around any erroneous or unnecessary material and hatch three or four lines across this box. This way the deleted material can be used in the future if the first idea was correct after all. Append a note to the margin of the box with an explanation of the error.

Keep notes current, from minute to minute, as the laboratory work progresses. While formal reports will be assigned, this notebook is the primary record of the laboratory work [for EE337 when this document originated and possibly in other courses].

D. Remarks and sketches

As stated previously, diagrammatic sketches are often the simplest and clearest way to define the various quantities indicated in a data table: **a phrase or sentence introducing each table or calculation is essential for making sense out of the notebook record.** When a useful result occurs at any stage, it should be described with at least a word or phrase. At the end of an experiment or other laboratory exercise, some sort of written comment, usually including a brief summary table of results, is needed.

E. Graphs

Hand-drawn graphs or computer output may be attached into the notebook with glue or transparent adhesive tape. Original data in graphic form should also be fastened directly into the notebook. The graphs must be properly labeled with a descriptive title in an unused portion of the graph. Appropriate scales must be indicated. Graphs must have abscissas and ordinates, which always require labeling. **Data should never be directly plotted on a graph without first entering the data in an accompanying data table.** [In the case of data dumped into a large file from a laboratory instrument, from which graphs are constructed in Excel, copying the entire file into the laboratory notebook, or even printing it to paper, may be impractical. At the very least, indicate the file name and the path that might be used to find it in your computer archives.]

F. Data and results

A neat summary of data and results will make the notebook more meaningful for both the experimenter and evaluator. Comparisons to theory or expectations are required. [In an experiment, you need to comment on whether the hypothesis is confirmed, denied, or remains unconfirmed but cannot be shown to be wrong.] Reasons for variations from theory and expectations must also be given whenever possible. Comments and conclusions should accompany any summary.

H. Partners and the work ethic

Limitations on equipment and space often require that two or more work together on a given experiment or project. Usually, a group of two produces an efficient work team in the instructional format. Additionally, it is often stimulating to be able to discuss the work as it progresses with a partner. **Each experimenter will perform completely independent calculations and keep a separate laboratory notebook [Applicable to EE337, check for other classes].** Mistakes in calculations are inevitable: the more independent the calculations are between partners, the more complete is the check against mistakes. Poor results on experiments are often the result of computational errors.

I. Completion of work [pertaining to EE337]

Calculations, graphing, and miscellaneous discussions should be completed before leaving the laboratory. The laboratory instructor will check the laboratory notebook every day before the experimenter is excused. The laboratory will be evaluated for a grade. Additionally written comments, suggestions, or questions will be entered by the instructor.

The same laboratory notebook standards will be used for those laboratory exercises requiring formal reports.

Seek the help of the laboratory instructor to deepen your understanding of the subject being investigated.

J. Formal Laboratory Reports [Specific instructions for EE337]

Engineers are often required to present experimental evidence to an outside evaluator. A formal report is often the medium for presentation. A report should be written so that the reader can easily follow it. It should clearly convey the reasoning which led to the experimental method used and the particular results obtained. The technical level of the report should be such that a peer can readily comprehend the results. While the format for the report can vary, all reports will contain the following information:

- Title of the experiment or exercise
- Purpose of the experiment or exercise
- Description of the experimental apparatus
- Identification of the individuals conducting the laboratory exercise
- Description of the exercise procedure
- Experimental results
 - Data summaries (tables, graphs, etc.)
 - Computations and analysis
- Conclusions including comparisons to theory and expectations
- Appendices with supporting material

It is particularly important to annotate the "Experimental results" section so that the reader can understand the significance of each table, graph, etc. Conclusions and comparisons to theory and expectations should be quantitative whenever possible. Variation expressed as a percentage

usually carries greater significance than absolute variation. Reasons for the variations must also be given whenever possible.

Reports should be typed on one side of standard 8.5" × 11" paper. Computer outputs and other supporting material may be included in appendices. The report need not be lengthy or elaborate. However, it must be neat and well organized. Use good grammar and correct spelling.