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1 Introduction

There are many different and equally valid views on how best to define the aims of laboratory teaching. These aims are sufficiently varied and numerous to make it virtually impossible to cover in a single laboratory course all the possibilities which seem desirable. In the undergraduate engineering laboratories the principle objectives are:

- To illuminate topics covered in lectures by demonstrating practical applications.
- To teach the use and limitations of instruments.
- To convey some idea of orders of magnitude.
- To teach communication
  - with oneself by keeping laboratory diaries, and
  - with others by writing formal reports of experiments.
- To teach experimental techniques.
- To develop ability to interpret and assess critically experimental results. (This is often best achieved by setting experiments on topics not covered in lectures).

2 Experimental Logbook or Laboratory Diaries

After leaving the University, engineers involved in practical work will find it necessary to learn how to make clear concise notes about experiments together with records of results as they are taken. These notes and results are often needed to form the basis of a report after some considerable time has elapsed since the notes were taken, so that it is not possible to rely on memory to provide all the details which may be required. It is hoped that the keeping of experimental logbooks or laboratory diaries will give students practice and instruction in how to do this.

It is recommended that students should use for experimental logbooks A4 sized books with graph paper on one side of the page and ruled lines on the others. Each logbook should have an index. Logbooks should contain notes about each experiment, recorded following the pattern below:

1. Record the date.
2. State the objective of experiment.
3. List the apparatus available and make notes about how it is used, what preliminary setting up is necessary, (e.g. zeroing instruments), and about any difficulties experienced during the course of the experiment.

4. Tabulate the readings taken, noting the units of measurement.

5. Record all the information needed to determine the overall experimental error.

6. Derive sufficient results for the success of the experiment to be assessed e.g. plot any graphs needed and estimate the experimental error.

7. Record your comments on the experiment and discuss the results.

In general (and there may be some exceptions depending on the nature of individual experiments) experimental logbooks should be handed in at the end of each laboratory period, thus limiting to 2 hours the time spent on any one experiment. After grading, the logbooks will be returned the following week at the beginning of the next laboratory period.

3 Formal and Short Laboratory Reports

At the end of week 8 each student will be allocated one of the experiments he has done in that laboratory as a subject of a formal report. These formal reports should be on A4 size paper and bound in the Faculty Student Report covers. The following description is intended to give some guidance as to the structure and content of a typical formal report.

1. **Title**  The title of the report should indicate exactly what the report is about. The reader should know not only the general topic, but also the aspect of the topic contained in the report. Compare the following pairs of titles:

   (a) *Compressor Analysis* versus *Analysis of Turbocharger Compressors for Truck Engines*

   (b) *Project 1* versus *Project 1: CFD Computation of Hull Resistance in Oblique Flow*

2. **Summary**  This should be summary of the whole report, including the principal result and conclusions. It is usually placed immediately after the title, but it should not be written until the rest of the report is complete. It is difficult to summarise something which does not yet exist.

3. **Introduction**  This is the first section of the report proper and it serves to set the scene, to explain the purpose of the experiment and, if appropriate, to relate it to previous work.
4. **Theory**  If you think that you can predict the outcome of the experiment in advance, the relevant theory (mathematical or qualitative) should be developed here. Don’t forget that theories are by their very nature speculative. We don’t carry out experiments to ‘confirm’ things which are beyond doubt. However, it is helpful to distinguish between the assumptions of the theory (which must be questioned if the predictions are not confirmed by experiment) and the deductions from them which should be rigorous.

For some experiments a theoretical treatment is not appropriate or is not possible, in which case this section should be omitted. We often investigate a system without preconceptions as to how it will behave.

5. **Experimental Procedure and Results**  This is the purely descriptive aspect of the report. You must describe those features of the experimental method and apparatus which might affect the result and give a suitable presentation of the results obtained. The following points should be noticed:

(a) There is no need to describe a standard piece of laboratory or workshop equipment which any engineer would recognize from the name alone.

(b) Try to avoid lists and tables as these are difficult for the reader to assimilate. For example, rather than give a list of apparatus, it is preferable to give a prose description of the experimental system and the way it is used.

(c) Graphs are much easier to interpret than tables of results and contain the same information. The tables are therefore best omitted in most cases.

(d) It is often necessary to calculate new quantities from the ‘raw’ data of the experiment—e.g., results may have to be averaged or a non-dimensional parameter involving several variables may have to be calculated. Such calculations should be ruthlessly excluded from the report their place is in the lab. Diary. The reader is not concerned to check the accuracy of your arithmetic which must be beyond question.

You should ask yourself whether the raw data has any intrinsic interest other than that derived from its effect on the calculated quantity. If so, two graphs can be presented: one of the results as obtained and one of the quantities calculated from them.

(e) Never present a graph without some verbal description of the trends which it displays.

(f) A quantitative experimental result is incomplete unless it is accompanied by an indication of the range of experimental error to which it is subject. The degree of sophistication in the assessment of possible error should be commensurate with the accuracy which is claimed.
6. **Discussion** In the previous section, the results have been merely described. Now they are to be discussed and if possible interpreted and explained in the light of any relevant theories. In this section, you have to make scientific judgements on the basis of the evidence of your results and the ability to do this is of primary importance to a career in engineering. The discussion may only represent 20% of the report in the length, but it is disproportionately important in the assessment.

7. **Conclusions** This is a brief recapitulation of the principal facts discovered by the experiment and the judgements made upon them.

8. **References and Bibliography: How are they different?** References or bibliography usually come at the end of your report.

   - *References* should contain only those works cited within your report.
   - *A Bibliography* is a list of references at the end of a report, cited or otherwise. It includes works you made use of, not only works you referred to in your report, but your own additional background reading, and any other articles you think your reader might need as background reading.

9. **Appendices (if required)** Information that is not essential to explain your findings, but that supports your analysis (especially repetitive or lengthy information), validates your conclusions or pursues a related point should be placed in an appendix (plural appendices).

   Items that could be included in an appendix include:

   - *Raw data.* Most readers of a report will not need your raw data, but the person who picks up your project after you leave it will be very interested in the raw data. Also, you may wish to have an archive of your raw data, and including it in the appendix of a report is a good way of organizing such an archive.
   - *Equipment instructions.* A report typically gives a general description of methods used and also detailed discussions and interpretations of the results. It is not necessary in a report to give step-by-step instructions on how to operate a particular piece of equipment. Having such a step-by-step instructions would, however, be very useful for your own records in case you need to go back to that equipment, and it would be quite useful to the person who takes up the work after you. It may be helpful to include such instructions in an appendix.
   - *Derivations.* A technical report should be as short as possible. In the service of this goal, detailed derivations are often not included in the body of the report. In preparing the report you may have spent a great deal of effort in tracking down a particular derivation, however, and you may wish to be sure that you can find and comprehend the derivation some time in the future. You can make sure that you (and your readers) have access to such derivations if you
include them in the appendix. If the derivation is easily accessed in a published source, however, it is better to cite the derivation rather than repeat it.

There is no prescribed length for a formal report as this will be determined by the content. Mere length may indicate application, but it is no measure of quality and there is the additional hazard of inducing boredom in the assessor. If the total length of a full report including graphs exceeds 15 pages, or that of a short report 7 pages, it is probable that the report writer has not been sufficiently concise, particularly in the purely descriptive passages, or have introduced irrelevant material.

It must be emphasized that different types of experiment require different types of report (Engineering Experimentation: Planning, Execution, Reporting; Experimental Methods for Engineers, 7ed.). A short report might reasonably consist of sections 5, 6, 7 alone, carefully pruned of all but the most essential description of apparatus and methods and prefaced by a concise statement of the objective of the experiment.

4 Assessment

Performance in each laboratory will be assessed on the basis of experimental logbooks and formal reports, and also on attendance, e.g., no marks will normally be awarded for an account in the laboratory diary of an experiment carried out when the student concerned was absent. The assessment will be continuous in that both laboratory diaries and full reports will be marked soon after they are handed in. Reports which are acceptable will be awarded some combination of A, B, C, D and plus or minus signs. Any report which is awarded an E is unacceptable and this bad performance must be compensated by a good performance subsequently, so that the average score is at least D which is the lowest acceptable mark.

Students scoring so many D’s that compensation by better subsequent performance is impossible can expect to be given an oral examination and also, possibly, some extra work.
Bibliography


