Experiment logbooks – the essential record of your investigation

For experimental work, it is essential that you keep a record of your progress as you work through your experiment and then analysing your results. Scientists often need to refer back to work that was done in the past for many reasons, and having a complete and understandable record of what was done in the experiment, and a record of the analysis of the results is essential.
Memory of what you did is unreliable. Research has shown that even recalling events can lead to recollections becoming corrupted. The best way of keeping your hard-won data and the record of the analysis process safe is to write it all down as you do it, in one place. Writing a proper experiment logbook is regarded an essential part of the laboratory experience.

What should be in the logbook?

The logbook should contain all these elements, and in the order listed.

1. Title

A short title identifying the experiment is given. Include the date and the name of any partner investigator.
This is essential for identification of the experiment. Generally, research laboratory logbooks are hundreds of pages long and quick indexing is important.

2. Aim

This is the next thing to list under your experiment. Once again it is an identifier of what the experiment was about, this time in a more detail. Here you should list the important things you are trying to investigate in your experiment. For completeness, write this as a paragraph rather than simple dot points.

3. Theory

Before you start your experiment you should have read through the laboratory script in its entirety. Some aspects are bound to be unclear and ideally you should look into these matters before you come into the laboratory to do your experiment – you don’t want to lose excessive time researching things when you are running your experiment.

The theory section is where you should briefly outline the theory that you are going to test. Many scripts outline the steps leading to equation that you will use to fit your results. In this case, there is no need to reproduce the steps, just explain what the final equation represents (and what all the parameters are) and reference the origin to the laboratory script. If you need to refer to any information that’s not in the script, make sure you correctly reference this material (see 8. References, later).
Some scripts (such as holography) are not about demonstrating the validity of a mathematical description. Here you should demonstrate that you understand the physics behind your obtained results (such as how holograms are actually an interference pattern). Equations may be appropriate, and some research beyond what is listed in the script may be required to clarify matters.

Many of the laboratory scripts require you to do essentially several separate experiments.
While it is ideal that you research your experiment beforehand (and a pre-completed theory section is good evidence for this), if you are working through the script on the day, it may be sensible to have a separate theory section for each separate experiment, immediately followed by a

results/analysis/discussion section for this part of the script. This is fine. You are not required to have only a single theory (or other) section for the whole investigation. The important thing is to progress through the steps in the process listed here.

4. Experimental Record

For any laboratory work, researchers are required to undertake a risk assessment of the procedures and equipment they are using.

In the Level 3 Laboratory, the technical staff have evaluated the risks associated with performing an experiment and have entered these into the Monash University OHS system (known as SARAH). For each experiment, these risk assessments have been provided on Moodle. **It is a requirement of the Laboratory that you read the risk assessments before starting work on your experiment.**

At the beginning of your experimental record section, you must write down any important identified risks along with the control measures that are recommended. This is evidence that you have read and understood the risks. An example would be using the laser for the holography experiment. The dangers are potential retina damage due to the high intensity if the laser beam enters the eye. The control measures would be to wear laser safety glasses when aligning the unmodified beam, and not attempt to align optics by sighting when the laser is on.

The experimental record section is where you write down all the steps you do in your experiment. Don't write "performed as per the script" or similar. You do not need detailed sentences – point form is fine as long as it clearly shows what you did. The important aspect is to be complete - someone reviewing your experiment should be able to work out what you did in your experiment from this record. When results don't come out as expected, this record is important for working out what went wrong. (e.g. are the results right, but the analysis is flawed?)

You are required to record all your data as you collect it in your logbook (if not computer generated). Many experiments have automated data collection and data records may be thousands of lines long. In these cases, include a table of the first 10 or so lines of data (with appropriate column headings). This will allow reviewers to verify that the data is probably correct, based on the initial data entries, and that the correct parameters have been recorded.

For manual data collection, you should plot your data as you go in your logbook. This is vital to check that you are recording useful information, and that you are resolving any interesting behaviour that your data has as you scan parameters. Experience has shown that students viewing data for the first time once out of the lab often get a (nasty) surprise.

You can produce a final formatted graph later on in your analysis section.

5. Analysis

In this section you should show all your calculations and analysis. Don't do this on a separate piece of paper and put a neat transcription in your logbook! Do it here, and don't worry about any untidiness/mistakes – it's best to have all your thinking done in one place so that you can come back to it later.

This is one area in which a paper-based logbook has an advantage – you can easily write down mathematical expressions without the issues that come with typesetting.

Make sure you do a full uncertainty analysis – it's expected, and you will be assessed on this. Also insert/paste any graphs you generate here. Make sure labels and error bars (if appropriate) are present. Graphs should have either a fit generated by a model, or an appropriate trend-line.

6. Discussion

It's important to compare your results to what you should expect, based on values given in the lab script or in the scientific literature. You should always compare your values to a reference.

Often results deviate from expectations, and you are expected to reflect on why this may be the case. Most physical models only approximate the observed behaviour, often excluding the influence of some contributing effects. Non-ideal measuring apparatus can also lead to divergent results. Consideration on whether the uncertainty bounds on your reported parameters are correct is also appropriate, particularly the possibility of systematic errors.

A detailed discussion shows that you have reflected on the possible reasons for discrepancy.

7. Conclusion

Here you succinctly summarise your important results in a paragraph or two. In some ways, this is the most important part of the experiment – the answer to the aims of the experiment.

In a research laboratory logbook, this is important as it is the distillation of what you found. Typically in an actual research laboratory situation, you will need to go through your logbook and find the experiment you were interested in, and then go to the conclusions to see what was found - all summarised in a tidy way.

When you write a report or a scientific journal article, the aim and the conclusion are juxtaposed together to give you the abstract – the succinct summary of the investigation you made. When journal articles are indexed for searching, only the abstract is shown, and so this has to contain the essential results of your investigation.

8. References

You are required to reference any sources of information that you use. Ideally, these are scientific texts, journal articles, or information from national standards organisations (like NIST), but increasingly resources are being accessed are from websites. Be discriminating on what sources of information you use. The order of "trust-ability" for internet sources would be: national standards websites (such as NIST); Wikipedia; established university course content (MIT, Caltech, etc), commercial websites, online "institutes", forums.

In many cases, it's appropriate to simply reference the laboratory script.

The format used for referencing isn't important, but do be consistent in the format you choose.

Important considerations for the logbook record

Make sure you actually fill out the logbook out as you go!

You should fill out your logbook with sections in the order listed here, i.e., don't leave space in your logbook to fill in the theory section after you have done the experiment. Also, don't be tempted to record your data and analysis on separate pieces of paper (or whatever you use) and then neatly transcribe these into the logbook later. The logbook is where you record all this as it is happening. The assessment criteria is for completeness of the record, not neatness, or attractive formatting. Just make it legible!

With electronic logbooks in particular, it is tempting to go back and edit information that you recorded in your experiment (e.g. settings of equipment, individual readings) once inconsistencies from the analysis appear to indicate an obvious “mistake”. Doing so is dangerous (e.g. what happens when you realise that it is the analysis that is actually incorrect?). Instead, note that there is an issue, and the rationale for using a different value in your analysis.

Electronic logbooks
You can choose to record your logbook on an electronic device, which does offer some advantages over a hard copy. You are free to choose whatever format you wish: Word, Powerpoint, OneNote (template on the lab site), etc.

Advantages:

- Easy to prepare the final submission (which must be a single PDF file, uploaded to the Laboratory Moodle site).
- Highly legible (your assessor will appreciate this, definitely).
- Easy to incorporate tables, graphs, etc in a seamless way.

Disadvantages

- Discourages writing mathematics, particularly derivations.
- Discourages quickly recording information (like rough graphs, experiment parameters, etc) in the logbook.
- Encourages the “rewriting of history”, where the logbook is edited after the event to yield an apparently smooth narrative which doesn’t confirm to the reality of the experiment.
- Loss of document due to various issues (overwriting, corruption – watch the use of memory sticks).

Hardcopy logbooks
These are still used by most scientists and have some advantages (and disadvantages) over electronic recording:

Advantages:

- Straightforward and fast to record a variety of information (written text, sketches, rough graphs).
- Forces recording the true chronology of the experiment and analysis (assuming that you only record work in your logbook)

Disadvantages:

- Need to scan logbook for submission (can be done on any Monash photocopier, many accessible by students are in the School of Physics and Astronomy corridors).
- Handwriting legibility often an issue for assessors.
- Need to glue/tape in graphs, tables, other printouts.
- Can be confusing if a strict structure isn’t followed.
- Student angst over the potential loss of marks due to poor presentation (generally unfounded).