M Eng Materials Science Teaching Laboratory – A Brief Guide

Prelims and Part I

Pete Nellist, October 2022

This document aims to be an informal introduction to the teaching laboratories and to give a science basis for the way teaching and assessment occurs in the laboratory. The Course Handbook for your year gives more details on policies and processes, and the definitive guide to assessment is given in the Examinations Regulations appropriate for your year.

1. Purpose of teaching laboratories

Materials Science is predominantly an applied science and much of the research in Materials Science is experimental in nature. It is therefore important that you learn appropriate experimental skills as part of your degree. This involves not only practical skills in handling samples and equipment in the laboratory, but also associated skills such as reading and assimilating briefing documents, effective time management, working in groups and ability to meet deadlines in writing and submitting reports.

We also hope that you will find the teaching laboratory experiments to be interesting and enjoyable, and that they help reinforce your learning in other parts of the degree course.

2. Attendance and timing

The marks arising from teaching laboratory assessments form part of the overall year marks and are examinable coursework. In Prelims (Year 1) this means that the laboratory marks form part of your overall Prelims mark. Second-year marks count towards the overall Part I mark and thus the overall degree classification. Because the practical marks are part of the Prelims or overall degree assessment, **attendance at all practicals is compulsory along with submission of all required laboratory notebooks and practical reports. You need to sign in and out of the teaching laboratory on each afternoon of attendance. You must attend the briefing by the Senior Demonstrator. You must get your laboratory notebook time and date stamped at the beginning and end of each practical and not start the practical until the you have received the briefing and had your laboratory notebook stamped.** It is expected that you attend labs for each full afternoon the practical is scheduled and you will need to secure permission if you need to leave early.

It is recognised that sometimes ill-health or other personal circumstances may cause a difficulty in attending a specific laboratory session. If you are in the first week of a particular experiment, it may be possible to accommodate you in the following week. If you miss a scheduled session in the teaching laboratory your tutor will be informed. A valid reason for absence can be presented following the process described in the Course Handbook (Section 10.3).

In each of Michaelmas term and Hilary term, you will attend 4 practicals spaced over the term normally on a 2 week cycle. For Prelims, each practical takes two afternoons and are on the Thursday and Friday afternoon of a particular week. Part I (Year 2) practicals are longer and are conducted on the Monday, Tuesday and Wednesday of a particular week. You will normally work in groups of 3, with several groups doing the experimental in parallel. In Prelims Michaelmas term, there are practical sessions for all students in weeks 1 and 2. In Trinity term, the need for specialist equipment leads to a more complicated schedule.

The list of practicals for each term and your allocation to a particular week and group can be found on the department website. Reading briefing documents is a common and necessary activity for scientists and we strongly recommend that you read through the instruction sheets in advance of the practical (they are all available on the website at www.materials.ox.ac.uk/teaching/ug/ugpracticals.html). It is your responsibility make sure that by a combination of the briefing and the instruction sheets you understand what is required for each specific experiment. If you have any doubts, please ask the SD when s/he is present during the practical.

There is a **compulsory** introductory meeting on normally the Monday of the first week of each term where groups are arranged and details of the timetable explained.

3. Staff involved with teaching laboratory

Each practical is led by a Senior Demonstrator who will provide an initial briefing about the practical. This briefing will cover the theory and practice of the experiment. They will discuss any specific safety issues associated with the experiment. They will discuss any particular requirements associated with the laboratory notebook or longer report. They will also provide the assessment of your work (see Section 5). Following the briefing, the Senior Demonstrator will be present at times during the practical to answer questions, provide advice and may choose to assess your laboratory notebook towards the end of the practical or may assess it after the practical.

Also present throughout the practical will be Practical Class Technician (PCT) and a Teaching Assistant (TA). The PCT (Diana Passmore) has a lot of experience regarding the instruments in the laboratory and can provide advice. The TA will be an early-career researcher (usually a post-graduate research student) who will have experience of conducting laboratory research.

The overall academic lead for the teaching laboratories is the Practical Class Organiser (PCO), Pete Nellist.

4. Conduct

One of the aims of the Materials Science degree is to teach you to be a professional scientist. The teaching laboratory is a professional space, and we expect an appropriate conduct in the laboratory. Here are some DOs and DON'Ts. It should be obvious why these are important in the laboratory, but talk to the PCT or PCO if you are not sure about any of them.

DOs

DO pay attention to the PCT and demonstrators

DO read and follow safety instructions

DO concentrate on what you are doing to avoid mistakes

DO familiarise yourself with fire escape routes

DO keep fire doors closed and escape routes clear

DO wear appropriate eye and hand protection

DO wash hands after working with chemicals

DO work in a fume cupboard with etchants and solvents

DO use minimum quantities of flammable liquids

DO keep the labs clean

DO speak in English at all times in the labs

DO keep long hair tied back at all times

DON'Ts

DON'T eat, drink or put on make-up in the labs

DON'T use your mobile phone

DON'T mouth-pipette or lick things

- this includes sucking your pen!

and a couple of "obvious" ones:

DON'T mess around

- if you do, you'll be required to leave

DON'T wear inappropriate clothing and shoes

- e.g. sandals, short skirts, long scarves
- you'll be asked to modify your dress or leave

Note: it is important that the only language spoken in the Teaching Labs is English - whether that be student-to-student or demonstrator-to-student - such that if incorrect (and potentially unsafe) instructions are given, there is a better chance someone overhearing them will realise and be able to act.

5. Assessment through laboratory notebooks and full reports

As a professional research scientist, it is necessary for you to learn to keep an accurate laboratory notebook as you are performing an experiment and to subsequently be able to write a longer report or scientific paper. Both the laboratory notebooks and the longer reports are marked as part of your examinable coursework. Your laboratory notebook will be marked for **every** practical (except 1P1 and 1P2 at the start of Michaelmas Term for Prelims). You are required to write long reports for **three** of the practicals in an academic year. For Prelims, the first long report assessment is formative (the marks do not as examinable coursework) so that you will have received some feedback before writing the two that do count.

For each practical, your laboratory notebook will be awarded an integer mark out of 3. It is expected that most notebooks will receive a mark of 2 presuming they show an ability to accurately record the experiment. Notebooks that show some innovative thinking may receive a mark of 3. Unsatisfactory notebooks will receive a mark of 1. See Appendix A below for guidance on keeping a good laboratory notebook.

The longer reports will be written in the form of a scientific paper. These will be marked out of 13. Guidelines for writing a good paper can be found in Appendix B. A report must be typed or word-processed and converted to a pdf file prior to submission via the assignment tools on Canvas.

For both the laboratory notebooks and the longer reports you will receive feedback but not the mark because these are still subject to moderation by the examiners before being finalised. This is also realistic of research science where submission of a paper will lead to feedback from independent peer reviews, but you don't receive a mark.

For Prelims, the 8 laboratory book assessments and 2 long reports add up to a total of 50 marks out of a total of 500 marks for the total of coursework and examination papers for the year. Thus each laboratory mark counts 0.2% to your final mark.

For Part I, 7 practicals have the laboratory notebook marked, and 3 practical require submission of the paper-style report, leading to a total of 60 marks out of 800 total for coursework and examination papers for the year, so each practical mark is worth 0.125% of your Part I mark and 0.083% of your overall degree mark.

6. Requirement to pass the practicals part of the course and penalties for late submission

Because experimental capabilities are an important part of learning to be a Materials Scientist, all candidates are required to pass the practical class part of the course for both Prelims and Part I in order to progress on course. Details of the requirements can be found in the Examination Regulations.

All scientists have to work to deadlines and follow ethical principles, this is also expected in your laboratory work. Penalties deducting marks will be applied for late work. Plagiarism is also taken very seriously by the university. See the Course Handbook for more details.

7. And finally

Remember, the more you put in, the more you will get out of the practical classes. Hands-on experience can be a great way to learn. Also remember to ask if you have any questions. Asking good questions is what drives science!

Appendix A

Keeping a good lab notebook: some advice

Sergio Lozano-Perez [amended by Pete Nellist October 2022]

Recording research data is as important as the experiment itself. If your lab notebook is well maintained and contains an accurate record of the research protocols used and the results obtained, it will be the basis to reproduce the experiment in the future (if needed) and to write scientific papers and reports. It will also be an invaluable source of information if you want to claim a discovery or an invention, to prove that you have adhered to standards of good practice (e.g. in case of an accident in the lab) and that you have acted with academic and ethical integrity.

What is a lab notebook?

It is a record of your activities in the lab: what you did, how you did it, why you did it and what you observed as a result. This includes mistakes and difficulties, which will often teach you more as you try to overcome them. The procedures and method you use might be standard or documented elsewhere. In that case, you should refer to them and there is no need to copy them again the notebook. However, if you are modifying them, you should include enough details so that other researchers could check/repeat your experiments. In some cases, they will be a legal document to prove patents/inventions and defend your results and actions from accusations of fraud or bad practice. The lab book is also your scientific legacy in the lab. When keeping a lab notebook, the question to ask yourselves is have I recorded enough information that I could still write a report or scientific paper on this work many years later.

The lab notebook doesn't have to look perfect. It should reflect, in a practical and efficient way, your experiences in the lab. A key scientific skill is to learn to keep notes in the lab book while you are performing the experiment. Do not be tempted to use a "draft" lab notebook, for example on loose paper, and then write up something more polished at the end of the practical. This is not realistic of a working lab environment and it won't bring you any extra marks. If the lab notebook is legible and shows the right content, it's served its purpose.

There are different types of lab notebooks: bound/stitched, loose leaf/ring binder or electronic. They all have advantages and disadvantages:

-The bound notebook won't allow you to change the order of your annotations or add extra data to an old experiment. However, it will keep its pages more reliably and it's legally stronger. This is the format you'll be normally using in the lab.

-The loose leaf notebook can be organized and sorted more flexibly, with all related data together, in the order you choose, but it can lose pages easily and it is harder to authenticate.

- The electronic notebook makes searches easier, can be read/edited in multiple devices and it is easy to share. However, the required electronic security might be hard to implement/guarantee, files can corrupt and data format might present compatibility issues in the future.

The bound lab notebook you have been given belongs to the Department and must be handed back to the Lab technician at the end of each practical. For the practicals that require writing a report, you can photocopy any relevant pages before the practical finishes (time it accordingly to avoid photocopier “overbooking”). You are not allowed to remove pages from it, just void them if not needed.

Why do you need a lab notebook?

Each research environment will have different requirements for the lab notebook, some will be flexible and others very strict. However, all of them will benefit from a detailed and consistent lab notebook. When experiments take several days/months/years to complete, they might involve more than one researcher. It is therefore important that all critical details are recorded with enough level of detail for a different person to interpret or reproduce your results. Your Prelims Practical Course might offer you your first opportunity to use a lab notebook efficiently, hence we will try to ensure that you develop good practice.

Using a lab notebook

A pen (‘permanent’ ink, ideally black) should be used to write on the notebook, since pencil can be erased (and generate authenticity issues). Your writing should be legible and clear. The notebook should contain:

- A reference name so that it can be distinguished from other notebooks you use (E.g. Teaching Labs Practicals).

- In the cover page: Your name, year and email address.

- Numbered pages.

- Date/time for each experimental session.

- All the experimental entries from your practicals.

- Clear headings and subheadings for all relevant sections, including the title of the practical. Ideally, new practicals should start in a new empty page.

- A table of contents, with enough space to be expanded as needed (particularly when you use a bound notebook), and including all the experiments you describe in your lab notebook and where to find them (with a page number for cross-referencing). You should leave several pages blank at the beginning or the end of the notebook for this purpose.

What should be recorded in a lab notebook?

A lab notebook should not contain long paragraphs of text. It is not a report and you won’t have time to write extended text while doing the experiments. Keeping your notes to a minimum is a key skill.

At the beginning of the session, write the name of the experiment, the date and the time. If the pages are not numbered, number them. No pages should come out of the notebook and you shouldn’t skip pages. Write an appropriate heading for each of your entries

It is good practice to very briefly note the key scientific questions that the experiments are seeking to answer at the start of the notes for a particular practical. That can help keep the experiments focused on the main goals.

The experiments that form a practical should then be described in chronological order, whether they worked or not (good lab ethics). Entries should be sufficiently detailed, clear and legible for someone else to reproduce your procedure using your notebook and any materials you refer to such as the briefing document for that practical. There is no need to reproduce details that are in the briefing document, but you should note all your activities, stating if you are follow a written procedure. If you need to change the procedure/protocol or decide between alternative ones, write down your reasons. If you make a mistake, cross it out with a neat line such that it remains legible and write the corrected information next to it. Don't erase or use white correction fluids (e.g. Tipp-Ex). If you need to add extra material (e.g. plots, photocopies, printouts,…) don't leave them loose inside the notebook, always staple or glue them to the pages.

If you are making manual measurements, for example from a gauge, then these should be recorded neatly in a table in your lab book. Some experiments are automated and the data is recorded directly into a computer. In this case, the filenames and locations of the data should be recorded in your lab book.

You may be expected to perform some initial processing of your data to get a numerical result. You may be using a software package such as Excel which is being used to convert, for example, forces to stresses. There is no need to show every step of the processing in your lab book – you should just summarise what was done in a few sentences. You just need to demonstrate the experiment is working (eg by getting an expected straight-line plot which you should include in your lab book) and to record any final numerical results.

For some experiments, it may be useful to perform some prelimiary error analysis. Often one particular measurement is the dominant source of error, and you may choose to repeat that measurement more than others to try and reduce the error.

Finally you might make some quick comments interpreting the results. Do they make sense? Do you think the experiment has delivered useful results

As much as the lab notebook needs to be up to certain standards, it is not more important than the experiment itself. Try to get the balance right between the time spent on both. Don't spend time on extra details or finishing touches that are only required on the final practical report

At the end of the practical, review your notes. Are you confident you could write a full report or scientific paper based on your notes? Is there anything else that needs to be noted down?

Appendix B

Writing a scientific report

Sergio Lozano-Perez [updated Pete Nellist]

Introduction

Writing scientific reports that can be shared, evaluated (often critically) and followed-up is a very important part of any scientific activity. In order to increase the impact of your findings and to ensure they reach as many peers as possible, publishing in a scientific journal is one of the most popular ways of sharing your research work. Published papers have high standards of quality and should be clear, accurate and concise. It can be useful to think of a scientific report or paper as an opportunity for you to "teach" others about what you have learnt in your experiments. Your aim is to maximise the amount they "learn" so keep the report clear and easy to follow. For your laboratory report, we expect a report in the format of a journal paper, using the journal *Acta Materialia* as the format to use. Look at some article in this journal to see how they are formatted.

Structure

When you organize your report as a scientific paper, it is important to get the order of the sections right. Although there are no strict rules, there are some recommendations to follow. First, you think of a title that represents well the results and conclusions you are presenting. Next, you could write the abstract (although some people prefer to leave this for the end, once the whole article is ready). The abstract is a very brief summary of the report. It should state the scientific question the work was trying to answer, include an outline of how your experiment was conducted and the methodology you used. Include, if relevant, some details about the samples used and methods for analysis, and the results or outcomes from the work. We are limiting the length of your abstract to a maximum of 400 words. After that, you can start working on the main body of the manuscript. Elsevier, the publishing company responsible for Acta Materialia, suggests the following format, known as IMRAD (Introduction, Methods, Results and Discussion) + Conclusions:

- Introduction: Where you introduce the topic, clarify the motivation for the work presented and explain the content of the next sections. It is expected that you briefly review some of the relevant background literature (describing what others have done before you), using citations to help the reader follow up. Introduce the important scientific concepts involved in the work at this stage so your reader is sufficiently informed to cope with the rest of the paper.

- Methods: This section provides enough detail and information for others to reproduce your experiments. It should contain information about your samples (or software) and the methodology used, including what hardware/instruments and how.

- Results: This section contains your results, described objectively. It is also acceptable that you incorporate your discussion (see next point) to the results and use instead a "Results and discussion" section. Where appropriate, error analysis should be performed here so that the results can be interpreted in a meaningful way.

- Discussion: This section contains your interpretation of the results, explaining the reader what they mean. Some speculation is acceptable, although it should be clearly stated when not enough evidence exists to back them up.

- Conclusions: This final section presents the outcome of the work by summarizing the findings in a more concise way, typically in the form of bullet points. The findings are often related to the motivation stated in the introduction section. Suggestions of potential future work can also be stated here.

Although **Appendices** are permitted in Acta Materialia manuscripts, we don't think they are necessary for your reports and are **not** allowed.

Working on your report

Once you have finished your experiments and have all your data ready and analysed, it is time to report your results. Even with a tentative structure, as explained in the previous section, writing the whole report might appear as a daunting task. For this reason, it might be easier to start from the sections that just require an objective description and then work on the discussion and conclusions. We have imposed a **3000 word limit for your manuscript** (excluding references and figure captions), this will help you focus on what is essential and prevent lengthy introductions and discussions. Elsevier [1] describes this approach, which is used by many scientists, and suggests the following order:

- Start by preparing the figures and tables you are going to include in your report. You'll have to decide how to present your data. While tables provide numerical values they are not that common in scientific papers, figures/plots are more useful for comparison between experiments. Remember to add errors and error bars, describe the contents concisely in the caption and reference them in the text. Check that your labels or any text in the figures are legible and bear in mind **you shouldn't use more than 10 figures**.

- Write the Methods section. This section contains information about how you performed the experiment. It should be detailed enough to allow another researcher to reproduce it. You should describe the samples, chemicals and instrumentation used.

- Write the Results. Here you will objectively describe what results you obtained from your experiments. Try to present them in an order that facilitates the story you are telling and makes them easy to understand. Present an error analysis, if appropriate, to allow your results to be interpreted in a meaningful way.

- Write the Discussion. Here you will explain what your results mean. Although you are allowed to speculate, you should always try to support your ideas with data or references.

- Write the Conclusions. Summarize your findings and their relevance. You can also use this section to suggest future work.

- Write the Introduction. Here you should introduce the topic, explain why it is relevant, what has been learnt in the past, its limitations and what you are trying to achieve. Introduce the main concepts that will be used later in the paper. Most of your citations/references are in this section. Make sure this section is balanced and does not become the main body of your report. The Introduction can also explain the structure of the paper to help signpost the reader.

- Write the abstract. The abstract summarizes what you did, what the important findings are and will play an important role in determining how many potential readers will find your report interesting. You can give away key results here but without many experimental details. A very short snapshot of the conclusions can be added as a last sentence. **Do not use more than 400 words for the abstract**.

- Choose the title

- Write up the Acknowledgements and References

Details of how to submit your long report can be found in the Course Handbook

Assessment of your report

Your long report will be marked out of a total of 13. For Year 1 students your first report will be marked, but the mark for this first report is formative and does not count to your overall Prelims year mark. The subsequent two reports will count towards your overall Prelims year mark. For Year 2 students, 3 long reports count towards your Part I mark.

You will receive feedback on your report but the mark is finalised by the Prelims Moderators or the Part I Examiners and not released prior to their moderation.

The allocation of marks is as follows:

Title, abstract and Introduction – 2 marks

Description of methods used including methods of data processing and analysis – 3 marks

Presentation of results including the appropriateness of figures and data presented, and the use of errors where appropriate – 4 marks

Discussion and interpretation of results – 3 marks

Conclusions – 1 mark

Reference

[1] https://www.elsevier.com/connect/11-steps-to-structuring-a-science-paper-editors-will-take-seriously