UNIVERSITY OF CAMBRIDGE

DEPARTMENT OF ENGINEERING

Guide to Report Writing

for the Engineering Tripos
and the Manufacturing Engineering Tripos

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Summary

This Guide provides practical advice on all aspects of technical report writing throughout the Engineering / Manufacturing Engineering Tripos (MET). Report writing is a key transferable skill that needs to be learnt and practised during the course. It is central to life as a practising engineer (and in most professions) to write reports, papers, or technical memoranda. Well-written reports are read, enjoyed, remembered, cited, and are potentially career-advancing; poorly written reports are not.

Report Writing is introduced in Part IA Exposition in the first term, and evolves through laboratory reports, project reports, and coursework and examination essays, until the Part IIB Final Project Reports. Reports will therefore range from a few pages written to a prescribed format, through to a 10,000 word final project report, designed and written entirely by you. But most principles of good technical writing are common to all that you write – so this Guide serves as a single resource for the whole course. The modular structure and indexed Web format are designed to enable the Guide to be accessed repeatedly during the course, as your writing tasks become progressively more advanced.

Contents

Acknowledgements

1   Report writing in the Engineering Tripos

The Table below summarises the main technical writing activities in the Engineering Tripos. MET has its own program in Part IIA and IIB – for more details see the MET Website.

Specific instructions on each task may be found in the relevant handouts and by following the hyperlinks.

PART IA

Activity	Term	Writing Task
Exposition	Michaelmas	Report on Statics experiment
Engineer in Society	Christmas vacation	Report (see CamTools)
Structural Design Course	Michaelmas or Lent	Report (see SDC Handout)
Integrated Electrical Project	Lent	Report (see IEP Handout)
Laboratory Experiments	Lent and Easter	Long Lab Reports (+ see Lab Handouts)

PART IB

Activity	Term	Writing Task
Integrated Design Project (IDP)	Michaelmas or Lent	IDP final report
Integrated Coursework	Michaelmas or Lent	4 page report (extended exercise)
Laboratory Experiments	Michaelmas and Lent	Long Lab Reports (+ see Lab Handouts)

PART IIA

Activity	Term	Writing Task
Module experiments	Michaelmas and Lent	1 x laboratory report per module
Module experiments (FTR)	Michaelmas and Lent	1 x "Full Technical Report" per term
3Ex module coursework	Michaelmas and Lent	1 x coursework essay per module
IIA Projects (x 2)	Easter	Interim and Final Reports

PART IIB

Activity	Term	Writing Task
Module coursework	Michaelmas and Lent	1 or more reports per module
IIB Project: Interim Report	Christmas vacation	Technical Milestone Report
IIB Project: Final Report	Easter	Final Project Report

2   Introduction to technical writing

Purpose of technical writing

The purpose of writing any report is to convey information clearly and to persuade your reader of your arguments. No matter how hard you have worked in preparing the material, lack of effort in presenting the work will diminish its impact. Whenever you set out to write a report, whatever its length, there are two key things to do first: (a) think who the readers are and what you want them to learn from the report; (b) plan the structure and contents, before you write anything.

Know your audience

Technical reports could be read by several people with different levels of knowledge of the subject, and different pressures on their time. For example, an industrial project report may be read by your immediate supervisor, who is familiar with the problem, and who expects you to display detailed knowledge of the report material. It could also be read by a new colleague, and your report is needed to bring them up to speed quickly. On the other hand, it may be read by a senior manager, who has little time to study the detail, and is only concerned with your summary, conclusions and recommendations. Managing the length, structure and style depend directly on a sound assessment of the intended readers. For example, a common device is to use appendices to record details that will be of interest only to a very specific reader, such as someone who perhaps is going to repeat your work. But equally, no reader wants irrelevant content – details of how standard equipment works, or basic theory that all intended readers can be assumed to know. Much can be absorbed from your own reading of other people's writing – if you found a report to be a good, clear read, think about their structure and style: why was it effective? Or if it was a dreadful experience: what would you have done differently?

The writing process

The writing process resembles the design process – it breaks down into stages (planning, drafting, and revising), with iterations between these stages as the report is filled out and refined. Remember the golden rule in design: time spent in the early stages pays dividends later. A short report may be written in one complete draft, but will still benefit from some advance planning, and a read-through. For long reports, planning and iteration are essential. This takes time – you will be a much more effective critic of your own writing if you come back to it after a break of at least one day, preferably longer.

The message then is to *start early*, allowing time for critical self-editing (and proof-reading by friends or colleagues), while hitting your deadline. The plan itself is somewhat fluid, as sometimes it is only by writing a few sections that you realise that things are not in the right

order, and that there are omissions or unnecessary content. Allowing time will also help you to develop good style. Reading through and improving a draft of one section of a report will enable the lessons learnt to be applied in the remainder of the report. You can also re-visit sections of this (and other) writing guides, at the time when they are directly relevant to you.

Planning, drafting and good style are addressed in later sections. First though, all writers must understand the importance of these concepts: integrity, record-keeping, plagiarism and referencing.

Integrity, record-keeping, plagiarism and referencing

Integrity

Professional engineering requires integrity in conducting and reporting all technical work. The physical records of the work are therefore central to maintaining, and being able to prove, your integrity. The records include the notes and results taken during the work itself, which nobody else might read at the time, and the subsequent distilled reports and papers written for the benefit of others. Engineers must therefore maintain detailed, honest, laboratory notebooks (or the electronic equivalent in software documentation), and this takes practice to become a routine habit. Technical reports and dissertations do not provide the full historical record of how some new concept was developed, though they may make some reference to ideas that were explored and proved unsuccessful. Journal and conference papers are even more compact, and are written to summarise an investigation with the author's best current interpretation of the results. This brings us to the second aspect of maintaining professional integrity: recognising that all of your technical work builds on the work of others. The confidence which a reader has in a technical report or paper is based on trusting the authors. Part of building that trust is through the authors demonstrating how they have built on the work of others and given full credit for previous contributions. Note that this does not only mean work that you read about in the literature or on the Web – it applies just as much to the contribution of others to work conducted in collaboration or as a team. In both instances it is essential when writing up your work to acknowledge and to reference the contributions of others. Any attempt to pass off the work of other people as your own is plagiarism.

Record-keeping: Laboratory Notebooks and Software Documentation

In Part I, you will be provided with Laboratory Notebooks; in Part II you mostly provide your own. But the aim of having them is the same: you use them in the laboratory, and afterwards when working on the analysis and report, to record *everything*: your measurements, hand calculations, draft graphs, sketches of equipment, draft designs etc. For ongoing research or design work (e.g. Part IB IDP, or Part II and MET projects) it can also serve to record notes from meetings with supervisors, industrial sponsors, or members

of your group in a team project – it is then a good idea to date every entry: meeting notes, experimental records, notes from phone calls etc.

Developing best practice in keeping records is an important part of the laboratory and project work in the Engineering and Manufacturing Engineering Tripos. It is required professional practice in all research and development laboratories. Your work may be inspected and signed off at regular intervals by a supervisor, but even more importantly your lab notebook can form the essential evidence of originality and intellectual property when making a patent application. Your creative imagination is what your employers are paying you for and so it is only reasonable that they expect you to provide the evidence on which the company can survive commercially. In the Department we expect bound notebooks, with any additional pages fastened in – loose pieces of paper are easily damaged or lost.

Similar principles apply to the development of software, though in this case the records may be primarily electronic. An electronic logbook follows the same pattern as a hard copy logbook, but software provides two additional challenges: version control, and commenting code. Keeping track of different versions of evolving code requires rigour in recording and dating (in hard copy or your electronic log) how each version differs in its functionality, with careful choice of systematic file names and directories for archiving. Commenting within the code itself is essential best practice in software development – one of those slightly dull tasks that nearly everyone is tempted to shortcut, but which pays dividends in the long run (either when you need to go back over your own code, or when you pass it on to someone else to develop and run). For most code it pays to write a "user guide" as you go along, even for your own exclusive use – it is safe to assume that you will forget small but important details about data format, or sequence, or software compatibilities.

Plagiarism

Collaboration is central to professional practice: modern engineering is frequently complex and multi-disciplinary, so collaboration and teamwork make sense in terms of splitting up large, difficult tasks into smaller parts. It can also be an efficient and enjoyable method of generating and implementing new projects. Learning how to manage and work within a collaborating team therefore forms an important part of your training as an engineer, including writing reports. In professional reports and papers that describe collaborative work, the input of all the contributors is recognised by including them as co-authors. In undergraduate work submitted individually for assessment and examination credit, it is important to identify unambiguously the parts of any collaborative work which are the student's own, original contribution.

Whether your reports are based on collaborative work or your own individual effort, the key point is that integrity is maintained: at no point should you attempt to present the work of others as your own. This deception is known as *plagiarism*, defined as *"the action or practice of taking and using as one's own the thoughts, writings or inventions of another"*

(Shorter Oxford English Dictionary, 1964). Forms of plagiarism include copying someone else's language and/or ideas as if they are your own by, for example, quoting verbatim, paraphrasing, cutting and pasting from the internet, and applies to *all* types of sources and media, whether published or not. Plagiarism is both poor scholarship and a breach of academic and professional integrity. Resorting to unfair means is taken very seriously within the Department, and more generally in all University academic matters. Such behaviour is a form of cheating, and any incident in work assessed for examination credit will be reported to the relevant Chair of Examiners, who may refer to the University Proctors.

So remember, the guiding principle is that the Examiners and others who may read your work must be in no doubt as to which parts of your work are your own original work and which parts are the work of others, or have been produced by you in collaboration with others.

Referencing

The mechanism for maintaining the integrity of your technical writing is *referencing*, to give recognition to other people's work (published or otherwise). Wherever you use sources of information or data such as books, journal articles, internal company sources, personal interviews, web-sites or other internet resources you should ensure that they are fully referenced, so that the reader can locate the source and if necessary make an independent judgement of the quality of the information. You should include text which you have not generated yourself only if it is clearly marked as a quotation (e.g. by placing it in quotation marks with a full reference to its source). In some instances, standard facts and ideas are so well-known that no reference appears necessary. But if in any doubt about whether the reader might misinterpret the extent of your own contribution, it does no harm to refer explicitly to sources of previous work (which may be textbooks for well-established material). A subsidiary benefit of referencing is that it also provides a historical 'audit trail' for how the current cumulative state of knowledge has been reached, allowing the entire track record of a particular topic to be re-visited and re-interpreted as techniques and understanding evolve.

For examples of the approved ways to reference sources of material, see *References* in the section *Guidance on Technical Writing*.

Further guidance can be found in the statement of the University's Policy on Plagiarism at www.admin.cam.ac.uk/univ/plagiarism. If you are ever uncertain about plagiarism or the interpretation of these guidelines, seek advice from the appropriate coursework leader and supervisors will be glad to provide advice.

3   Planning a technical report

Introduction: planning, drafting and revising

Planning

Before you start any report you need to gather your information and plan the form of your document. Even the shortest lab report will benefit from some preliminary jottings; a 50 page final year project report requires correspondingly more planning. Before committing time to actual writing, planning allows you to:

- check any requirements for layout/presentation style. Are there specific instructions to observe (font size, line spacing, page limits, required house-style used by your employer etc?). If the report is going to be published: camera-ready, or type-set by a publisher? What are their presentation rules and requirements?

- check that you have included everything that you consider relevant, and have the relevant data and results prepared (or in hand, if computations or experiments are continuing in parallel to the writing).

- check you're not including unnecessary stuff – e.g. have you read the lab handout, which may give specific guidance on what is not expected, or should be included as an Appendix?

- play around with the sequence: for larger reports, it is not necessarily self-evident in which order some things should appear, and you might change your mind as you write – but it is helpful to have thought about it, and at least to have a plan in place for the first draft.

Planning needs something to be mapped out and written down, for you to refer back to and revise as you go along. Thinking about what to write often throws up bits and pieces that you decide are important, and don't want to forget to incorporate. Having a written outline also allows you to 'braindump' notes to yourself: key references to remember for the introduction, a particular figure or two that you produced earlier and capture the key results, an inspired idea you had to plot two sets of data in a novel, revealing way, and so on.

There are various formats for a written plan, and it is largely a matter of personal preference. Two are discussed in later sections: a concept sheet, and an extended Table of Contents.

Drafting

In the drafting stage, the main goal is to get the bulk of the report written down, without worrying too much about style and artistic impression. In the final report, appearance *is* important, but much of the tidying up can wait until the content is done (good layout, clear headings, breaks in sensible places etc). Clearly the better the style and use of English in the first draft, the better for you in the long run, but this comes with practice and you can

only give this your full attention once the content has been committed to paper. Reports don't have to be drafted sequentially – do it in any order you wish. Your overall plan will keep you on track, and will remind you what will have been said by this point, even if you haven't said it yet! In fact it is often easier to write introductory material when you've already written about the content towards which it is heading. The Abstract or Summary should wait until last – just leave a suitable space. For now, get the scientific facts and technical ideas down, graphs and figures planned and drawn, calculations developed, reference lists assembled. If good ways of expressing particular ideas occur to you now, write them down and work out how they fit later.

One thing worth developing in near-final form from the outset is figure style. Figure clarity is particularly important and should not be left until the end.   Figures are usually plotted electronically from a template, which is copied and edited repeatedly. Developing the template on one or two early figures allows this to be propagated through the whole report, saving endless repeated revisions later. So experiment with the graph aspect ratio, the size and line weight for the axes, background grid (if used), symbols, and curves, and choose a suitable font and size for the axis labels. For work to be published for a conference or journal, or for internal use in a company, there are often required styles in both text layout and figures – make sure you adopt the right templates at the outset.

Revising

Finally comes the crafting, iterating (like a good designer) to improve the clarity, balance, and readability. Read the report through, both to correct the more obvious mistakes of spelling and grammar, but also to improve your style – anything that helps to make the meaning clearer. The section *Guidance on Technical Writing* deals with good English and good style.

Ideally, a final draft should be left for a week and then be re-read. It is amazing how many omissions and errors are then obvious, but are not noticed if you try and proof-read your own writing after only one day. For Part II reports, get a friend to read your draft and make helpful comments – though this must not go as far as copying from your peers (remind yourself of the expectations concerning integrity and plagiarism).

Planning I: concept sheet   *(online)*

Planning II: draft table of contents   *(online)*

Typical report structure   *(online)*

4   Guidance on technical writing

Introduction: developing good writing style

Writing good English is not easy – it evolves with practice, and it is impossible to summarise all aspects here. Concise but fairly comprehensive advice is provided in the sections below; *Further Reading* lists other sources of advice.

Your Part IA Exposition leaders will start the process, and they (and later, project supervisors) will have plenty to say, in their own personal fashion, about your writing style and how to develop it. By way of initial pointers (e.g. for Exposition in the first term), there are some simple things to take on board:

- write in short, succinct sentences (G.B. Shaw once apologised for writing a long letter because he didn't have time to write a short one!). The result should not just be a series of staccato phrases but should retain a flow and continuity of expression.

- avoid slang and unnecessary jargon, and define specialist terms (including new abbreviations) the first time you use them.

- use standard SI symbols and abbreviations, which are listed in your *Guide to Units* booklet (CUED databooks).

- standard English grammar and standard English spelling are important. See *Guidance on technical writing*; a good general reference is: Gowers I., *The Complete Plain Words* (Penguin books, London, 1975).

- avoid the use of the 'first person' (I, we, my, us, etc.) in technical writing.

- be aware of, and avoid, sexist language (to which engineering is particularly prone), e.g. always using 'he' when there is also 'she' (which can largely be overcome by careful drafting and the use of plurals: 'they'). And be aware that gender bias easily slips in unnoticed, e.g. using male-oriented examples to illustrate a technical idea: engineering is not all about cars!

Grammar   *(online)*

Spelling   *(online)*

Punctuation   *(online)*

Good writing style   *(online)*

Figures

The role of Figures and their prominence in planning a report are discussed in *Planning a technical report (Drafting,* and *Typical report structure)*. Here are some tips on formatting Figures for reports.

Size, shape, title and captions

Many figures are generated in a software package (Excel, Matlab etc) with default settings for the shape of the graph (and many other formatting details). So make sure you consider the final size and location on the page of the figures in print, before committing yourself to a figure style. This may require experimentation – often figures can look too bold in the original package, but are then fine when pasted into the report and reduced in size.

There is no need to give a title on the figure itself in addition to an informative caption (below the figure) – use the same space to make the figure larger. Figure captions should be numbered sequentially, Figure 1, 2.... (or alternatively, Figure 1.1, 1.2.... if numbered by chapter or section – the advantage being that new figures inserted later do not disrupt later sections). Use "Figure ...", not Graph, Illustration etc. Figure captions should provide enough detail to interpret the figure, but should not include discussion points (which should be in the body of the text).

Scales and Axes

In general, it is best to use a true axis, but if the graph is meant to show a trend over a range that is relatively small compared to the absolute magnitude of the data (e.g. between 210 and 220), then a 'false origin2 is clearer – e.g. starting at 200 means that the data can span the whole graph and trend lines will rise or fall at 45°. If a false origin *is* used, it should be clearly identified. Note that a false axis will emphasise variations in data when compared visually to a graph with true axes, and can lead to over-interpretation of what is simply experimental scatter.

Choose scales that are easy to read. Remember that semi-log and log-log plots may be appropriate to reveal possible mathematical relationships that are not evident on linear axes (or they can spread the data more meaningfully when the data range spans more than an order of magnitude). The axes should extend *beyond* the end data points, which otherwise tend to be overlooked. Frame the graph with a solid line, rather than having only x and y axes. Use a sensible number of ticks along each axis, with ranges that subdivide into sensible round numbers, e.g. data spanning 1 – 17 are best shown on an axis from 0 – 20, with ticks at intervals of 5, rather than 0 – 18, with ticks every 3. It is a common failing of using graph plotting software that the axis ranges are determined automatically from the data ranges, and need to be reset manually. Ticks inside are better than outside – the graph frame is larger for the same area on the page. Gridlines and background shading are hardly ever useful – Excel in particular includes these as a default: remove them.

Make sure that the axes are properly labelled, including units, and choose a font style and size that are clear in the final figure size. Use a clear legend to differentiate between sets of

data or curves. Colour is good for this differentiation, and gives a more pleasing appearance – but bear in mind that copies may be made in black-and-white: contrast will be lost, and pale colours can disappear altogether! And your printing costs will be greater.

Accuracy and Errors

Datapoints with a trend line drawn through them give an initial indication of experimental scatter, and suggest the likely uncertainty in your results without elaborate calculation. Plotting results as you go is a standard technique of the good experimentalist – your appreciation of the trend and the scatter build up as you go, and you can refine the number of measurements taken at the time: much better than finding out later that the data are insufficient, when the equipment may no longer be available.

Given sufficient data, including repeated measurements, there are of course formal statistical ways to estimate the errors in your results. Generally the controlled stimulus or 'input' is plotted along the abscissa (x axis) and the error is predominantly in the response or 'output', along the ordinate (y axis). Error bars are then shown as a vertical line conventionally drawn as one standard deviation above and below the datum (though errors can be shown both ways, if both axes are measured variables of significant uncertainty).

Cleaning-up Data

It has been known for lazy or indeed unscrupulous scientists to 'doctor' their data. It is one thing to query an outlier, a data point so far from the trend as to suggest it might be the result of a gross error in procedure; it is quite another simply to remove the outlier as an embarrassment. Progressive degrees of adjustment, removal of points, cleaning up or incorrect reporting of results can lead to corrupted and incorrect conclusions. So what should be done with stray data? Standard advice is to repeat any case which gives such stray points and to take additional points close by. If three such repetitions show the original point is not reproducible, then it can be discarded. Strictly speaking even this lacks rigour – one should really test *all* the data points and not query only those that look out of line. Great experimentalists, like Cambridge's Lord Rutherford, showed that apparent outliers can be genuine and lead to new discoveries.

References   *(online)*

5 Further reading   *(online)*

Appendix: Examples of effective writing   *(online)*