UNIVERSITY OF BRISTOL

DEPARTMENT OF AEROSPACE ENGINEERING

NOTES ON TECHNICAL WRITING

By

C.M.HEMPSELL

Issue 4

August 2006

NOTES ON TECHNICAL WRITING

CONTENTS

List of Tables

List of Figures

THIS PAGE IS INTENTIONALLY BLANK

NOTES ON TECHNICAL WRITING

C.M.Hempsell

Department of Aerospace Engineering
University of Bristol

Issue 4 - August 2006

1. INTRODUCTION

1.1. Background

Throughout your time at University and your working life thereafter you will be expected to write technical documents that report work you have done or give instruction to other people. It is important to your success in both arenas that you acquire the skills involved in writing such documents. For, no matter how good your abilities to do a job are, if you cannot successfully communicate what you have done you may as well have not done it.

The importance of this was emphasised by the Department's Industrial Advisory Board. When asked what skills, outside basic engineering, that they wished graduates to acquire before coming to them, every Board member put the use of English at the top of the list. By this they did not mean punctilious attention to grammar, such as have you correctly gerunded a verb, or even your elegance and style, such as the use or otherwise of split infinitives [1]. What concerned them was the ability to put together a readable document that fully and accurately communicates the required information.

The Board members went further, pointing out that in their view the standard of basic English displayed by graduates was very poor - an opinion shared by most members of the Academic staff. There has been a lowering of the standard over time as the correct forms are not taught in most secondary schools as they were even twenty years ago. It is also true that standards have always been low. For example this author had the first report he produced in industry (after obtaining his degree) completely rejected because of its poor English. However the most significant factor in pressing for improvement of undergraduate English is that its importance in the workplace has grown. Everybody is now expected to have good communication skills and without them your career will suffer.

You probably feel you are already good at English - yet, on the basis of past student performance, the chances of this are low. Even if you do have a good grasp of technical communication it is almost certain it could be improved. Therefore you are recommended to put time and effort into improving your English writing abilities during your undergraduate studies both to get the best possible degree and for the benefit of your future career.

1.2. Scope

This document gives general advice on the preparation of technical documents. It outlines the types of technical document you will encounter during your degree programme and in

later working life, it explains what their purpose is, and the common factors that you need to consider whenever writing such documents. There are also a series of appendices, which cover the specific requirements and advice that you should observe when preparing the assessed work required by your degree programme.

You should bear in mind that in the assessment of reports a large part of the marks are awarded on the quality of the report as a piece of technical English. To get first class (or even upper second) marks will require not only good quality work, but also good quality reporting of that work. Failure to incorporate the advice given in this note can (and in many cases will) result in a considerable lowering of your marks.

Final Year students are particularly at risk in this regard. Your Research Project report not only accounts for a considerable percentage of the final year marks, but also is seen as your "masterpiece" in the original meaning of the word. A masterpiece was the piece of work an apprentice produced at the end of his training to show he had the skills of a master of his trade. Your Research Project report is the key piece of work the University and external examiners use to assess both individual merit and the general standard of the degree programme. It is therefore of particular importance that you produce a report to the highest standard, as good use of English is part of those skills you are expected to have.

You are expected to read through and understand this note. You may wish to make up a "check list" of points to consider when writing and checking though your submitted work. However, this note is not intended to be a complete guide and you may wish to consider reading other works on the use of English to improve your writing skills.

1.3. Technical Documents

We need to be clear about what we mean by technical document. A technical document is one intended to convey scientific or technical engineering information. The rules relating to these documents are similar to those for other academic documents (that is documents purporting to enhance human knowledge) and of course are also governed by principles of good clear English. But there are also some special factors in engineering documents that you will need to know about.

In engineering, technical documents can be of two types.

i) The first type are those reporting results of work to convey what has been found to other people and also make a permanent record of it. In essence the way a reporting document is produced is the same in engineering as other disciplines.

ii) The second type of document is an instructional document and this form of document is almost unique to engineering. It is a document that conveys information that the reader needs to act on and follow – in short it gives instructions.

1.3.1. Reporting Documents

Almost all the documents you produce at university will be reporting work you have done. That is the purpose of the document is to tell someone else some information be it facts or opinion. They will include:

Lab reports – reporting the results of experiments
Design reports – reporting your designs
Essays – a short informal piece of prose exploring a subject
Research project report – probably the largest document you need to produce

As your career progresses you will probably find reporting documents still dominate your working output. If you pursue an academic career you will be expected to produce published papers, research reports and books. If your career is in industry or finance then reports of all kinds are likely to be your main output.

1.3.2. Instructional Documents

With reporting documents the communication of information and opinion is the sole purpose of the document and no further action is required by the reader. An instructional document contains information that the reader is expected to use in some way. Examples of instructional documents are:

- engineering drawings,
- requirement specifications,
- procedures (and guidelines).

Because these documents normally have greater consequence than reports they normally have greater control by the organisation issuing them.

Generally the same good writing considerations apply when producing instruction documents, as for a reporting document. Good writing is always about achieving successful communication. The main differences that can apply in some cases to instructional documents are:

- there is no need to draw conclusions at the end,
- the wording many have to follow a more legal form,
- there will not normally be explanatory material or opinions.

Exercise. *Consider this note – is it a reporting or an instructional document?*

1.4 Special Instructions

Almost always you will be writing reports in circumstances where there are special instructions that you need to follow. University coursework will have instructions and advice, employers normally have procedures and house styles, publishers of both journals and books will have "advice to authors" (these days normally on their websites). You should always seek out and follow this advice, and if it conflicts with this note clearly it takes precedence. However mostly you will find this special advice will be consistent with this note, but this note will give more detail and explanation behind the instructions.

2. GENERAL ADVICE

2.1. Considering the Reader

The purpose of writing is always to communicate to other people. Whenever and whatever you are writing you should always be considering the reader. That means you must keep your intended readership in mind while writing. Many great writers have a few specific people in mind while working even if they intend to publish the work for a wider audience. Jane Austen aimed her novels at “her family and friends” [2]; many childrens books were first written for the author’s own children, and even one of the earliest complete pieces of literature we have (Hesiod’s “Works and Days” [3]) although written to be performed at public poetry recitals was clearly written for Hesiod’s brother. You are going to have to find your own way of bringing the reader into your creative processes – but you must do it in some way or other. As a guide we expect coursework to be written at a level appropriate to a graduate in the subject you are studying.

Remember it is primarily the writer’s responsibility to ensure that the communication is successful. In this context you should have a very precise idea about who the reader is and then consider.

- Have you started the document from a point within the reader's knowledge?

- Are you using terms and concepts the reader will understand? If not, the first choice should always be to rewrite in terms he or she will understand, when this is not practical the second choice is to clearly explain new terms or concepts when they are first used.

- Is the reader going to maintain attention? Only a very few (very sad) people read technical documents for fun. Reading technical documents is a chore and it is your job as the author to make them as short and easy to read as possible. In particular consider work you have submitted as part of an assessment. Here the assessors are likely to have up to a hundred similar works to get through, they are likely to be bored out of their minds and can think of thousands of things they would rather be doing than reading your report. A clear short report wins every time in these circumstances.

- Has the document been attractively laid out? If you are preparing a document on a computer there is considerable scope to alter fonts and page layout - use this flexibility with care. There is no excuse for small unreadable fonts covering the page top to bottom, edge to edge. In particular the use of small fonts (or minuscule handwriting) and reduced margins to meet page limits on assessed work will be taken into account when marks are awarded.

A further courtesy to the reader is to stick to the purpose of the document. Be ruthless about removing any material that is in any way irrelevant to the function of the document. The inclusion of peripheral issues and opinions is a particularly common fault among young people some of whom treat each document as their last chance to encapsulate their entire life experience. One piece of advice (attributed to Dr. Johnson) worth considering is to review the document after writing it and decide which paragraph you are most proud of - then delete it. In this paragraph you have almost certainly ended up pontificating on a "hobby horse" which is unlikely to be strictly relevant to what the document is about.

2.2. Document Structure

One of the commonest problems with student written work is the "mind dump". The report includes all the material the student has available on the topic (and anything else even vaguely related), but in no particular order. Of course such a report is very difficult to read, and also does not demonstrate any understanding of the facts presented.

All written work needs to be structured. That is, the material in it should be presented in a way that the reader can easily follow. Looked at another way the document needs to tell a story with the arguments and facts presented in an order and a manner that;

- enables the reader to comprehend them,
- makes clear to the reader why they are included,
- highlights the links between them,
- presents an overall case supporting the purpose of the document.

Any piece of writing (not only technical documents) should always start with an **introduction**, which should always discuss the:

Scope – that is explain the subject, the purpose of the document and the authority under which it is produced.

And, if helpful, it should discuss;

Background - that is take the readers from what they know to where the document main argument starts, for example some history of the subject;

Structure – where the document is large and the arguments complex it is sometimes useful to provide a guide as to the document's structure. But note this applies only when the large and the arguments complex.

After the introduction comes the main discussion or **exposition**; this is where all the new material is presented. The order in which the material is presented should be guided by the fundamental principle of presenting the material in the order that is most easily comprehensible to the reader. One point should lead to another in a continuous path through the material you wish to present. Finding the best path is often difficult and takes time and planning, particularly as you will often be working within a word limit that restricts how much of your total material supply you can put in.

In the case of work that is being assessed the structure is very important. It is the way you structure the work and link the facts and arguments that demonstrate if you understand what you are talking about. "Mind dumps", or reciting material in the order presented in the lectures, does not show you understand the knowledge or can use it intelligently.

One common mistake – particularly in the research project report – is to present material in the chronological order as the author came across it. In research you are very unlikely to reach the end result by a rational common sense path. You will have started at the wrong point, gone up many blind alleys, made mistakes, played hunches a few of which helped move you forward. But this history is not important. For the purpose of the report you should rearrange the important and relevant matter into an optimum order for

understanding, which will probably bear no resemblance whatsoever to the way you learnt it.

Another common problem is presenting material, which requires understanding of concepts the report has not yet covered. Very occasionally it may prove necessary to use the phrase "…as will be shown later in section…." but it should be avoided unless there is no way to introduce all the material in a linear way without forward referencing.

Once the material has been presented the document should be finished off (except some instructional documents) with a **conclusion**. This should leave the reader with a clear understanding of the importance and consequence of the facts and arguments that have been presented. Ideally the **introduction** should be asking a question either explicitly or that the **conclusion** should answer.

This basic form applies to all written work. Even in literature only the most avant-garde novels break from this form (e.g. [4]), more typically a novel will follow this general sequence. Take a typical detective novel; in the early stages it will introduce the characters, the location and background story leading to the murder (which implicitly asks the classic question "who dun it?"). The author then presents us with all the evidence required to answer that question – of course in this case the author is deliberately obscuring what is really important and adding irrelevant material, neither of which tactics are appropriate to a technical document. When all the clues have been presented the novel reaches the conclusion - typically by bringing all the suspects together allowing the detective to answer the implied question and reveal the murderer.

So the form

Introduction – Exposition – Conclusion

should always be used no matter how short or long the piece, or on what subject. Now that we have established the overall requirements for structure in any piece of written work, we can look at the more specific requirements for what should be in technical documents.

3. CONTENTS OF A TECHNICAL DOCUMENT

3.1. Contents

There is a British Standard (BS 4821) [5], on the presentation of theses and dissertations; and this includes a guide contents; which is:

(not numbered)

Title Page (used as the front cover)
Correction sheet (this is a blank page for later corrections)

(use lower case Roman - e.g. iv)

Abstract/Summary
List of contents (chapter and sections with page numbers)
List of tables (if tables are treated separately from figures)
List of figures (no pagination unless figures are enclosed within the text pages)
List of accompanying material
List of notation (entitled "Notation", starts on a new page)
Acknowledgements
Declaration

(use normal Arabic numbering – e.g 4)

Main Text (divided into chapters, first page of chapter 1 is numbered as page 1)
Appendices
Glossary (used if the subject requires special vocabulary)
List of references (entitled References)
Tables (if treated separately from figures and not in body of text)
Figures (if not included in the Main Text)
Accompanying material.

Note the front section is separately numbered from the rest of the document. As an example the page numbering of this note shows how it is done.

This should be seen as guidance rather than a rigid requirement, and you will see many minor variations on it. Many publishers and organisations have their own “house style”. You will certainly not need all these items and as discussed below there are acceptable alternatives on the handling of tables and figures. However if you do include an item, it is advisable that it appear in this order.

3.2. Summary

Some reporting documents may require an abstract or summary. Where they are used their purpose is provide a short but complete description of the contents of the report so potential readers do not have to read the complete document to find out what it says. For example academic papers will always have an abstract, which tells other researchers whether it is relevant to their work and therefore whether they need to read the whole paper. Abstracts are also published separately so researchers can quickly scan whole subject areas for relevant work. Different publications and conferences have different guidelines for abstracts but typically they will ask for a single paragraph of no more than 300 words.

As the purpose of a summary or abstract is to be read independently of the main work they should be self contained and should not contain specific references to the main text or

other publications. Another consequence of the separate life of a summary or abstract is that they do not feature in section numbering of the main document, or in the contents list

A more recent development in industry and commerce is the "executive summary", which has a slightly different purpose. Rather than acting as an advert to attract readers to read the report or paper, it is supposed to replace reading the report. Reports that are complete often have supporting material and detail not needed by persons at an executive level and which make the report too long for busy executives to properly read. The "executive summary" aims to get the report's main conclusions across to these executives without them having to read the report itself. An executive summary gives the report writer a more controllable route to getting the report's message into the higher management levels, as opposed to the executive skim reading the report or relying on what other people say about it. These summaries are typically are longer than paper abstracts but still less than four pages.

It is important to realise that not all documents have summaries or abstracts. For example summaries are never used on instructional documents, as they do not have arguments and conclusions that can be summarised. Also if someone is expected to read them because they need the instructions as part of their job then they clearly should read the whole thing. When you submit course work the marker will need to read the whole report anyway so there is little purpose to a summary. Where they are required you will be given a clear instruction to provide one. You are recommended not to waste time producing summaries when they are not asked for.

3.3. Contents and Other Lists

The guidance contents list in BS 4821 indicates several lists at the start of document and then also a glossary and a reference list at the back. We will treat references later, here we deal with the other lists. The first important point is that a document does not need to have all these lists. Your first aim should be to keep the document as simple as possible. So a 2000 word essay needs none of the lists discussed here (it will need references of course), only a major book or thesis is likely to need them all and even then it is a good idea to carefully consider their use.

The overall contents should list everything in the document down to all subtitles. It should include numbers, titles and page numbers. An example of a contents list can be found at the front of this note.

The lists of tables and figures are self explanatory again should include numbers and titles and, if they are in the body of text, page numbers (see Section 5.4 for different ways to incorporate figures and tables). Page numbers are not required if tables and figures are collected at the back as shown in BS 4821. An example of a figures list can be found at the front of this note

Typically accompanying material would be annexes and attachments; that is they are separate documents, which you feel form such an important part of the exposition that they need to be available to the reader. For example, in a legal document discussing a contract it would be usual for that contract to be attached. In practice it is very unlikely this will arise in your university work.

The last list at the front is notation. This is needed when the text includes mathematical formulae and helps remind the reader what the letters etc mean. They are introduced in alphabetical order Latin letters first, Greek next, and weirdoes last. An example of a Notation list is shown in figure 3.1. The addition of a units column is optional but can be useful.

NOTATION AND UNITS

		UNITS
a	local speed of sound	m/s
c_{tip}	propeller tip chord	m
D	propeller diameter	m
n	propeller rotational speed	rev/s
P	power supplied	kW
T	propeller-only thrust	N
V	true airspeed	m/s
V_R	resultant propeller tip speed	m/s
ρ	density of air	kg/m^3
μ	dynamic viscosity of air	kg/ms

Figure 3.1: An Example of a Notation List

All these letters should still be introduced in the text when first used, but if there is a notation list there is no need to explain terminology during each algebraic section. If there is no notation list (which is quite acceptable if there is not too much maths) then terms should be explained in each mathematical argument when they are first introduced. This is normally done as follows:

$$F = m.a$$

where: F = force (in Newtons)
m = mass (in kg)
a = acceleration (in metres seconds^{-2})

The Glossary is a list of words and acronyms used in the text that may be unfamiliar to the reader. All these should be explained when first introduced in the text but in long documents a "dictionary" can help the reader. Its basic purpose is therefore similar to the notation list, but unlike the notation list it is placed after the main text – for no apparent logical reason.

3.4. Acknowledgements and Declarations

Acknowledgements are entirely at the discretion of the author and are a chance to record special thanks and anything (well almost anything) can be placed here. This is probably only something you will want to consider on your research project report. The only point to be made here is do not feel you are obliged to acknowledge your project advisor – he or she is just doing their job – and will not be offended if they are not on your list of special people.

Declarations include assertions of intellectual property (such as copyright statements), or declarations of originality. In your University undergraduate work this is only needed on your research project report.

3.5. Main Text

3.5.1. Introduction

We have already seen in general terms what should be in an introduction. The common problem for the inexperienced is to confuse the introduction and the summary.

You should write the introduction as if the summary does not exist. The danger then is that you may end up with very similar text - and this is wrong. The function of the summary and introduction are different and this should be reflected in what is in them. A summary encapsulates the whole report, whereas the introduction sets the reader up for the main exposition. To highlight this, consider a detective novel. A summary of the novel should definitely tell you that the butler did it, the introductory part of the novel definitely should not tell you the butler did it.

One job of an introduction to a major technical document covering academic research is a discussion of past work leading up to the new work being presented. This can be extensive and is often given a separate chapter, typically entitled Literature Review. However in function it is still part of the introduction.

3.5.2. Main Body

As we have already discussed in the general advice this needs to be carefully structured to present the material in an easily followed manner.

In the case of presenting experimental results there is an established order, which you should follow if the document is reporting an experiment.

i) An exposition of the theory being tested by the experiment;
this should be sufficient to make the purpose and rationale of the experiment clear.

ii) An outline of the equipment and the method of using it;
this should enable the reader to fully comprehend it and ideally should enable them to duplicate it to test the results. This can be divided up into “apparatus” and “procedure” sections if it is likely to be long..

iii) A presentation of the results obtained.

iv) A discussion of the results;
this should include an evaluation of the errors in the results

This structure is important to follow for laboratory reports and sections of the research project report that cover experimental work.

3.5.3. Conclusions

In a technical document the conclusions should succinctly answer the question asked in the introduction. The conclusions should be obvious by the time the reader has finished the

main exposition and conclusions may only be a summary of points already made. There should certainly be no new arguments or material in the conclusion.

Limitations, caveats and provisos should be included to highlight the strength of the conclusions that have been reached. This should be more general than the detailed discussion of errors that should be in the main body of the text.

Given that almost all academic work ends up with some areas of uncertainty, or opens up new questions it is very common for the conclusions to discuss what further work should be undertaken to explore these issues.

In the general advice it was stated that all written work should have a conclusion. There is an exception in that some instructional documents do not need a conclusion since the instructions do not lead to any specific end point.

3.6. Appendices

Appendices are a way of including material that is relevant and important but which is not essential to the main discussion. Their use should be considered when:

- The material is long and complex (for example a major mathematical proof) and is not essential for the flow of the overall argument.

- The material will only be of interest to some readers and is not essential for the flow of the overall argument. (This is the logic behind the appendix in this document).

- The material needs to be recorded (for example: computer code, stress calculations, raw data, or drawings) but is not essential for the flow of the overall argument.

There is a tendency for students to over use appendices. You are advised to use them with great caution and if in doubt then leave it out. The most common mistake is to try and use appendices to overcome word or page constraints. This never works as most markers will not read appendices and will deduct marks for their inappropriate inclusion. This is particularly true of the final year Research Project where appendices often simply lose marks; always consult with your Project Tutor before including an appendix.

An important point to remember when preparing appendices is that they should be written to be read, and thus have the same standards of English as the main text. Appendices should be treated as documents in their own right with a similar structure. They should have text with a readable discussion even if that only serves as an introduction to something like a computer listing. There is an example of an appendix in this Note showing how they should be handled. Not treating each appendix as a document in its own right is another very common reason Research Project reports are marked down.

In the worst cases inappropriate appendices have been used by students for figures and tables, which should be included in the main text. To repeat the advice above, if you are at all uncertain about appendices leave them out and discuss any appendix ideas with your tutor before including it.

Appendices should not be confused with accompanying material such as Attachments. Appendices are a part of the document and written at the same time, Attachments are other documents (probably not even written by the author) that are included because of their close relation to the document you are writing. As already discussed in Section 3.1, these are placed at the very end of the report.

3.7. Indexes

You will find that academic and text books are laid out in a very similar manner to BS 4821 (with allowances for different "house styles") but normally have an index after all the other material. An index is unique to books and is not used on reports – even theses.

The purpose of an index is to enable the reader to reach the discussion on a particular subject quickly, and as such it is of course very useful. However, they are difficult and time consuming to produce, and publishers use specialist employees to produce indexes (note that it is not normally done by the author). It is because of the time and the special skills needed to produce them that indexes are not expected on any other type of document.

4. FORMS OF ARGUMENT

4.1. Principles

In this section we will look in more detail at the way to make arguments and present information in a technical report.

A key principle in all reporting documents is that the reader should at all times have a clear understanding of the basis for every statement of fact made within it. The foundations of statements of fact can be one of four basic types.

1 - Your personal belief.
2 - A logical argument (which includes mathematical proof).
3 - Observation (ideally in experimental conditions).
4 - Because somebody else has supported the statement – i.e. referencing.

With regard to personal belief: when you are an emeritus professor, Nobel laureate, a peer of the realm and scented flowers spring from your footsteps as you walk, then people may be interested in your personal views as the basis of sound knowledge. As an undergraduate it is best to steer clear of this route as a basis of knowledge - which does not prevent you expressing opinions about knowledge supported by one of the other three rationales if the document calls for it.

4.2. Logical Argument

4.2.1. What is Logic?

Thanks to the Vulcans in Star Trek many people have an incorrect notion as to what logical means – it is not a synonym for "reasonable". Logic is the method of argument that uses formal deductive or inductive reasoning.

A logical argument starts with a premise and therefore if this premise is nonsense then so will any argument that follows, regardless of how faultless the logic. In science the premise should ultimately be based on experimental observation (although a testable hypothesise may also be used as a premise) – that is the most basic definition of science (or "natural philosophy" as it was originally called). Not surprisingly engineering normally follows this line, but not always; in engineering the premise could be based on ethical, aesthetic, financial or legal considerations.

Although you are unlikely to have training in formal classical logic, for the purposes of technical documents this is unlikely to be an issue. Your arguments should either be very obvious or you should use the method in which you have been trained – and that is mathematics.

At the start of the twentieth century Russell [6] showed that mathematics and logic are identical. That is mathematics is simply a refined language to present logical arguments. So it turns out you have been trained in the most powerful form of logic after all and when using algebra and other mathematical forms in a report you are making a logical argument

and, assuming your maths is correct, your logic should be impeccable – just do not forget to ensure your premise is also impeccable.

4.2.2. Presenting Maths

As you will be aware from personal experience that following mathematical proofs is often difficult, so an author should take special care when presenting them. How often have you met this sort of thing?

> Clearly
>
> $$E_\tau = \frac{v^2}{2} - \frac{\mu}{r}, \qquad (3.1)$$
>
> from which it can be shown
>
> $$E_\tau = -\frac{\mu}{2a}. \qquad (3.2)$$

It may be clear to the author, but what about the reader? And yes it can be shown but why make the reader do the proof again when you have already done the work? (How this proof could be handled is shown in the guidance example below).

The reader should be given some guidance as to the steps, and phrases like "clearly", "hence", "it can be shown" and their like should only be used when the step is blindingly simple and obvious, and even then it is still better to just say what you have done. As a general rule remember you are presenting a proof and you need to explain each step so the reader can follow it easily.

The actual level of explanation will depend upon the target readership but it is normally better to over explain (which can never hurt) rather than risk the reader not being able to follow what you are saying.

4.2.3. Equation numbering

When presenting proofs of any length it is normally necessary to refer to previous equations and this can be done by numbering them. You do not need to number every equation, only those to which you are going to later refer.

Equations are best referred to as Equation (n.m) (or Eqn. (n.m), but be consistent) where n is the chapter number and m the sequential number of the equation counted from the beginning of the chapter. The equation number appears on the same line as the equation, in parentheses and aligned with the right hand margin (see the example below, for quotations in text when the equation is in the middle of a sentence or paragraph, or at the end of a paragraph.). Some of the word processing packages are not good for equations, matrices etc., so it may be better to leave a space and write some of the mathematics neatly by hand (or in another package).

An example of using equations in text

> The energy of a satellite in an orbit, E_τ, is made up of 2 components, the kinetic energy and the potential energy, and is given by

$$\mathrm{E}_{\tau} = \frac{v^2}{2} - \frac{\mu}{r}, \qquad (3.1)$$

where v is the velocity of the satellite at a particular distance r from the centre of attraction of a body with a gravity potential μ. However, v can be described by the force equation

$$v^2 = \mu\left[\frac{2}{r} - \frac{1}{a}\right]. \qquad (3.2)$$

Thus we are able to combine Equations 3.1 and 3.2 to give

$$\mathrm{E}_{\tau} = -\frac{\mu}{2a}. \qquad (3.3)$$

4.3 Observations

As mentioned above in the discussion on logical proofs (Section 4.1) the foundation of science is that the premise upon which statements about the universe are made should be based on observation of the universe - a philosophical premise known as "empiricism". Any observation is valid, but because of the control and repeatability it entails more weight is given to formal laboratory experiments – but some branches of science, for example astronomy, still mainly rely on chance observations by necessity. Whatever the circumstances of the observation care must be taken when reporting them as they represent the foundation upon which scientific knowledge is based.

We have already covered the way to lay out a report of a laboratory experiment in section 3.5.2 and this should always be followed.

The main problem in writing up experiments is to get the level of detail right. It is best to bear in mind that it should be possible for the reader to set up the same experiment and get the same results, so you need to include all relevant factors.

For example a report that says

> "The temperature of the water was raised until bubbling was observed. The temperature at which this occurred was found to be 98 ^{o}C."

leaves out critical information like how pure was the water and what was the ambient pressure, both being critical factors to successfully repeating the experiment. The method of measuring temperature would also be an important factor in discussion of the accuracy of the result. However details of the container and heating method are not essential, as the same result should be obtained if the water is in a glass beaker or in a copper retort, and if it were heated by a Bunsen burner or by an electric coil.

That said; in less trivial experiments more detail than the bare minimum would normally be given. In reporting an experiment you are trying to convince the reader of the validity of your conclusions so the apparatus and method description should be at a level that helps the reader to;

a) understand what you have done;

b) have confidence you have done a good job.

Precisely what level is needed to achieve this will depend upon the circumstances.

In a first and second year laboratory the equipment is very well known to the reader, so what you are doing in describing it is showing you understand it. In your Research Project the experimental equipment and the way you have used it will be new to the reader (who may well have doubts) so a fuller description is appropriate. Illustrations and even photographs of the apparatus are to be encouraged in these circumstances.

4.4. Referencing

4.4.1. Definitions

Other documents can be called up within a technical document for two reasons, for reference and for application. From this there are three ways other documents can be included in your work.

i - Applicable Document
An applicable document applies to instructional documents only and is when the document that is called up forms part of the instructions. It follows that an applicable document should also be an instructional document. You will meet these very rarely.

ii - Reference Document
A reference document shows the source or authority for a statement so the reader knows where material or opinion comes from. These will be discussed in more detail in the next section. This is the way you will introduce other work in all your University reports.

iii - Background Documents (Bibliographies)
Background reading lists are rare in technical documents but still acceptable. These documents are works that are not directly referenced and therefore do not form part of the argument the author is making, but are related to the subject, and the author recommends them if the reader is interested in further reading. These are not normally applicable to any of your University work.

Note that Applicable Documents and Reference Documents must be mentioned in the text, while items in a Bibliography are not (unless they are separately mentioned as a reference document). A surprisingly common mistake is to have works in the reference list that are not actually referred to in the text.

Note that referencing other documents is not an exercise in showing how widely read you are (well not officially). Of course in a major academic work the authors will wish to show they have fully researched the background to the subject, but references should never be gratuitously included. If you reference another document it should be because it is a logical part of the argument you are making and needs to be there.

4.4.2. When to Reference

All facts and opinions that are not due to your own thoughts, analysis or observation should be clearly referenced to indicate where they come from. It follows good technical writing should have a lot of references.

For example in the first paragraph of Section 2, I supported my argument that many successful authors have a specific audience in mind by saying "

"Jane Austen aimed her novels at 'her family and friends' [2];"

That is I am using David Cecil's biography of Jane Austen (reference 2) as the basis for that statement.

There are times when you will wish to use the references words rather than your own. When you do this as a minimum you should enclose the quoted text in inverted commas, but, because inverted commas can have other uses, many publishers also change the typeface as well (such as italics, or smaller typeface). The reference number or author (depending on referencing method) is placed straight after the quote such as in this example

"Many authors start writing in order to relieve their private feelings; Jane Austen began in order to contribute to family entertainment." [2]

This is a direct quote from David Cecil's biography of Jane Austen. Direct quotes are normally used when text is to be analysed, but can also be used when another author's phrasing is particularly apt. It is of more use in arts and humanities work than science and engineering.

However make sure you never use another author's words without clearly identifying them as a referenced quote. Copying text without clearly showing what your are doing has very severe consequences as it subverts the core activity of academic life.

Just as with quotes, you should also reference where figures and tables come from if you have not produced them yourself.

4.4.3 What to Reference

The first point is that the strength of the support a reference gives depends upon how strong the document is as evidence. The best references to support statements of fact are refereed papers in archived journals (most such journals are on the Science Citation List). Every paper in such a journal has been anonymously reviewed by at least one expert on the subject and judged to be correct, of a professional standard and making a contribution to the subject. Archived means the journal is intended to be kept as a permanent record, as opposed to magazines and newspapers, which are intended to be read and then disposed of.

Below archived journals in the spectrum of technical literature, but still valid, are conference papers. These are normally refereed on the Abstract only, not on the complete paper so the checking is far less rigorous.

Another source of facts are books - but not all books. The best books are academic books (from academic publishers), which are refereed and thus the equivalent to journal papers. Such books are less common in engineering and sciences where journal papers predominate, than in the arts and humanities where books are more highly regarded. Note that academic books are not the same as text books. Text books are also checked but are written as a summary of established knowledge and learning aid for a subject and thus they are not normally intended to be the primary source of knowledge. It is important to reference the original work where new knowledge is presented and recorded, both to give proper credit to the creators of that knowledge and to present it in its most reliable form.

The main problem with books from academic publishers is that the same publisher will publish a range of different types of book, such as

- Textbook/Lecture Notes – *a book that contains detailed information about a subject for people who are studying that subject.*
- Monograph – *a long article or a short book on a particular subject*
- Handbook – *a book which contains instructions or advice about how to do something or the most important and useful information about a subject.*
- Review Volume – *a book where you consider something in order to make changes to it, give an opinion on it or study it.*
- Reprint Volume – *a collection of published papers on a particular topic or contributor.*
- Study guide/Self help – *a book containing notes and information about a particular course or topic, often used by students or those who do not have the time to read the text itself.*
- Proceedings – *a collection of papers from a conference.*
- Popular – *a book that appeals to a wide audience.*

And it is not always made clear what sort of work a specific book is. You have to use your common sense as to what weight a specific book can be given to support an argument.

From this it follows that you will be expected to concentrate on using technical papers as sources of fact to support your arguments. This particularly applies to research projects and essays in the final year.

Sources such as popular books, magazines, and especially internet sites should not be used as the basis of fact - or if it is necessary to use them, their weakness as sources considered and acknowledged. However, they can be used as the basis of statements related to somebody's opinion. For example the statement:

"in the past alien beings visited Earth, interbred with humans and helped the Egyptians build the pyramids [Von Daniken 1969]":

is not supported by the given reference as a statement of fact. The book by Von Daniken [7] is not refereed, and many believe it contains errors and misleading statements [8]. It

may also be pertinent that Von Daniken was in prison for fraud when he wrote his second book.

Exercise. *Consider the above paragraph. Is there anything wrong with the supportabilty of the statements within it?*

However the statement:

"Von Danieken [7] believed that in the past alien beings had visited Earth, interbred with humans and helped the Egyptians build the pyramids";

is supported by the given reference as a statement of fact. Whether or not Von Daniken did really believe this or thought that a book that claimed this would sell well and make a lot of money is a moot point. In this context, if somebody has published anything that purports to be their opinion then you are entitled to use that publication as evidence of their opinion or belief.

4.4.3. How to Reference

All the references used in a work should be listed in full at the back of the report in a way that means readers could easily trace them if they so desire. There are a number of variations on the exact way to list them (including a British Standard [9]). A typical order is; Author(s), then Title, then Publication Details as in this example of a journal publication:

Smith, A.B. and Jones, C.D. "The Big Break". *J. Material Science* 10, pp. 472-480, 1990.

(Note: Journal is often abbreviated to J, the 10 is the volume number the pp. 472-480 are the pages and then the date)

and this example of a book publication:

Timoshenko, S.P. and Goodier, J.N. "*Theory of Elasticity (Third Edition)"*. McGraw-Hill, New York: 1982.

(Note: the city of the publishing house is traditionally given, although of little value these days)

The authorship, title details and publication details are to be differentiated by choice of punctuation and changes of typeface within the reference statement. One common scheme is: authorship in normal type. Title also in normal type (perhaps enclosed in quotation marks), or italics if a book title. Journal name in italics, volume number in boldface, publication year and pagination in normal type. The publisher should be given for books.

There are two schemes that can be used to reference published work; either by author's name or by number. Journals and publishers have their house method and you should make sure to use their method when submitting manuscripts. For normal university course work you can use either method but make sure you use it correctly and consistently.

Reference by Author's Name

When using the author as the identifier each item is referred to in the text by its authors (surnames only, unless initials are required for distinction if you have two Smiths for example) and the year date that also appears in the formal reference list at the end of the work. The reference list is ordered alphabetically by first author's name. The main advantage with this scheme for the author is that late insertions/deletions in the text cause little trouble.

In the text a work is referred to in the following manner (Note the use of square brackets when the reference is silent, that is it would not be said if read out):-

".. as reported previously [Atkins (1973)], further work ..",

or

".. as reported by Atkins [1973], further work…"

An example of the reference list using this format is given below:

REFERENCES

Alexander, H. and Haasen, P (1967)a. "Dislocation distribution in deformed Ge." *Canadian Journal of Physics,* **45**, pp. 1209-1212.

Alexander, H. and Haasen, P. (1967)b. "Dislocations and plastic flow in the diamond structure." *Solid State Physics,* **22**, pp. 1-531.

Atkins, A.G. (1973). "High temperature hardness and creep." *Science of Hardness Testing and Its Research Applications,* edited by Westbrook, J.H. and Conrad, H. Ohio: American Society for Metals, pp. 174-186.

Middleton, D.B., Srivatsan, R. and Person, L.H., Jr. (1988). "Simulator evaluation of a display for a takeoff performance monitoring system." *NASA TP-2908.*.

In the text these would be referred to as [Alexander and Haasen (1967)a.], [Alexander and Haasen (1967)b.], [Atkins (1973)], [Middleton *et al* (1988)] respectively. These examples show how to handle the same author(s) publishing more than one referenced paper in one year and how to handle a long list of authors (*et al* is from the Latin for "and others").

This method is sometimes called the "Harvard" scheme.

Reference by Number

References that follow this style are numbered sequentially at appropriate points throughout the text. The reference list for this scheme is then ordered by number, which must strictly follow the order in which the references appear in the text. The problem with this scheme is that it does not allow for easy insertion or deletion of items late in the process of writing.

In the text a work is referred to in this manner (Note as before that the use of brackets in the method of referring to an item within the text depends on whether or not you would actually say the phrase or number used):

".. as reported in a recent paper [1], further work ..",

or

"… as reported in a recent paper by Smith and Jones [1], further work …"

or

"…as reported in Reference 1, further work…".

And in the formal reference list it would look like this:

1. Smith, A.B. and Jones, C.D. "The Big Break". *J. Material Science* **10**, pp. 472-480, 1990.

Another advantage of the numbering system is that references can be intermingled with notes and comments[1] as has been done in this note. Not all publishers allow this so check advice to authors before doing this. An example of how a reference list should look using this method is given at the end of this note.

The most common mistake when using this method is not numbering the references in the order they first appear.

4.4.5 A Special Note on Websites

We have already argued because websites are uncontrolled and ephemeral they are generally not suitable as sources of fact. However because the Web is rapidly becoming the main means of communication it can no longer just be ignored.

Copying chunks of text from the web is plagiarism and treated in the same way as any other form of copying. The software in the University used to check submitted work is getting very good at spotting this so be very careful to put things into your own words unless you want to explicitly quote the site.

If, despite the problem with the use of websites, you feel you are justified in using a website then the reference, normally to the site's homepage, should be in form:

4. www.siteaddress.com accessed 23rd May 2005

Note it is important to give the date the site when the site was active with that information.

One new feature of the Web is "electronic journals" where technical papers can be accessed from the web, and some journals have even abandoned hardcopy publishing. Such papers are as good as other refereed papers and are handled in exactly the same way as papers from as printed journals. The reference gives the journal's name, the volume and page numbers and the date, it does not give the website address.

1. The alternative way to add notes and references is to use footnotes, like this one. They should appear at the foot of the page to which they are they are referred and as such can present a difficult formatting problem. Never mix numbered notes at the end of a document with footnotes – it is only done here for illustration. This method is rather out of fashion and you are not recommended to use it.

5. WRITING STYLE AND FORMAT

5.1. Tense

Reports should always be written in the past tense, for the obvious reason that you are reporting on something that has happened. Sometimes in a report it is appropriate to move to the present tense for discussion of results and conclusions, particularly is these lead to recommendations for further action. But if in doubt use the past tense throughout the report, as it can never be wrong.

Instructional documents can have a more complex tense requirement. Formal instructional documents which have a legal form (such as requirement specifications) are written in the future tense but always using “shall”, never “will”, “should” or any other form. As an example the range of a civil aircraft in its requirement specification shall be worded like this:

> “The range with full payload shall exceed 9000 km.”

Therefore:

> “The range with full payload will exceed 9000 km.” – IS WRONG
> “The range with full payload should exceed 9000 km.” – IS EVEN WORSE

Even when full legal language is not required an instructional document should always be clear and concise to minimise the chance of mis-reading.

5.2. Construction

Traditionally all technical documents are written using a "passive" (or double passive) construction [10]. This is an impersonal form, which avoids direct reference to the initiator of an action. The main consequence is that the word "I" should never be used. The word "we" can be used when referring to the writer and the reader, but must never be used to refer to a group of writers alone as in “..we found that..”. Here are some other examples of good and bad practice.

> "The manometer was connected to Pitot 1" - IS CORRECT
> "I connected the manometer to Pitot 1" - IS WRONG
> "We connected the manometer to Pitot 1"- IS ALSO WRONG

Another example

> "It was seen that the pressure dropped" - IS CORRECT
> “The pressure dropped” – IS BETTER
> "I saw the pressure drop" - IS WRONG
> "We saw the pressure drop" - IS ALSO WRONG

This style evolved with the rise of modern experimental science from the seventeenth century: probably for three reasons.

i - Fashion. The formal style tended to be used on reports of the higher quality work based on formal experimentation, while more informal styles tended to be used for

reports and hypotheses based on more informal observations or hearsay evidence. Therefore as time progressed writing that had pretensions to seriousness tended to use the more formal style.

ii - Neutrality. The formal style removes personality from the report. Some of the debates within institutions like the Royal Society could be highly acrimonious and personal and the formal impersonal style of the written reports was a means to reduce the tension in these arguments.

iii - Philosophical. The principle behind the scientific method was that anybody making the observations recorded would observe the same thing and reach the same findings. Therefore the reporting style that removes direct reference to the author was seen as the most correct in the circumstances.

In recent years this has become a controversial issue as some see the use of this construction as against the principles of good plain clear English. Microsoft Word will actually highlight the "Passive" construction as a potential problem. Some schools now teach use of direct constructions in reports, and there are some Faculty members who also believe that abandoning the traditional form is desirable. There are two factors that should be considered in this context.

i - The use of the passive construction does not preclude its being good clear English. Any construction can be used to produce good clear (or poor unreadable) writing. If you have trouble producing clear readable text then you probably need a bit of practice - and your time at university is a good time to get that practice. If your work remains unclear then the chances are your writing in other constructions is also unclear.

ii - Not using the passive construction can appear very unprofessional in many circumstances. The current circumstances are that the use of the passive is never wrong, whereas not using it can be detrimental to the reception of your written work particularly when that work is all the reader has. This point cannot be over emphasised - many selection committees and review panels would reject a work solely on the basis of not using the passive form.

Therefore <u>you are strongly advised to use the passive construction in all written work</u> during your degree. If you feel strongly about this and wish to use another form check with the assessor of the work - the majority of Faculty academic staff will heavily penalise work not using the traditional construction and in these cases you should stick to the formal style.

The passive means the word “you” should also be avoided. If the passive is used then the above paragraph would be worded

> “Therefore <u>it is strongly advised that the passive construction is used in all written work</u> prepared as part of an engineering degree. If it is strongly felt this is incorrect and another form is preferred then this should be checked with the assessor of the work as the majority of Faculty academic staff will heavily penalise work not using the traditional construction and in these cases the formal style should be adhered to.”

You will have noted that this note has not followed use of the passive – although it purports to be an example of a well written technical document. This is because it is intended to teach important points and the use of "you" is intended to increase the impact by emphasising that all these points do apply to YOU.

5.3. Layout and Headings

You may feel you know how to do this, but the number of reports that are incorrectly laid out is a constant surprise particularly since all students are supposed to have GCSE English to grade C or equivalent. It may be that students have forgotten their English teaching or that they feel what they were taught was not relevant to technical work. Either way such poor ability to layout a document gives the impression of poor general education, and hence presents a poor impression of you. The need to layout a document to make it attractive to read has already been discussed above (in Section 3.1) this section gives more specific advice

5.3.1. Paragraphing

The paragraph has been defined as follows [11], *"The division of discourse next above the sentence is the paragraph. It is a collection, or series of sentences with unity of purpose"*

Paragraphs are the most import factor in the overall construction and layout of a document. Each paragraph should contain a complete thought or argument. They should, as a general rule, be neither too long nor too short, but it is a good idea to vary the paragraph length. Single sentence paragraphs are fine for (very) occasional use but if you use too many the purposes of paragraphs is lost and the document gets difficult to follow.

Paragraphs can be separated by a line space (as is the practice in this note), or by an indentation of the first line, or even by both. But make sure you use one of these options – it is amazing how much written course work is submitted that has nothing to indicate the start of a new paragraph.

5.3.2. Use of Lists

Lists of points, either numbered or using "bullet points", can be very effective at presenting information and, when appropriate, their use is encouraged. However many students do not use or present lists properly. The four most common faults in coursework are given in the list below.

i) - Using too many lists at the expense of the prose discussion.

ii) - Using lists when not appropriate (normally combined with i):

iii) - Having sections of the document with only a list in it. Every list should be preceded by text introducing and explaining it.

iv) - Laying out the list in an unclear manner. There should be some distinct format (like indenting used here) to distinguish a list from the main body of text.

5.3.3. Section Subtitling and Numbering

The use of subtitles has become popular in recent years, and is good way to improve the visual attractiveness of the document and make its structure clearer. They should be used to distinguish subjects as a level of separation above paragraph but take care not to over use them or their purpose is lost. They should also only be used on longer work.

Subtitles should be short, three or four words as maximum. They can be highlighted using capitals, bold, and italics as exemplified by the subtitles in this note. Underlining is not normally used in professional work but this only a matter of style.

One common fault is to assume the subtitle is part of the text as in this example

> ***5.3.3. Section Subtitling and Numbering***
>
> has become popular in recent years….. THIS IS WRONG

As an extension to subsection numbering, it has become the practice in some organisations (including the British civil service) to number (but not title) every paragraph as in this example

> ***5.3.3. Section Subtitling and Numbering***
>
> 5.3.3.1. The use of subtitles has become popular in recent years, and is good way to improve the visual attractiveness of the document and make its structure clearer. They should be used to distinguish subjects as a level of separation above paragraph but take care not to over use them or their purpose is lost. They should also only be used on longer work.
>
> 5.3.3.2. Subtitles should be short three or four words as maximum. They can be highlighted using capitals, bold, and italics as exemplified by the subtitles in this note. Underlining is not normally used in professional work but this only a style matter.

The main value of this is for documents that are going to be discussed and referred to in detail (either verbally at meetings or through written discussion) as it helps people get to the part under discussion quicker. It is not recommended for the work you produce at University except the Systems Engineering project requirement specification where it is specifically asked for.

The style recommended by the Department is: Chapter headings should be in full capitals and centred (without the word "chapter"), whilst section headings should be in lowercase text with initial capitals - see Example 5. The sections and sub-sections should be numbered using the format 1., 1.1., 1.1.1. It is strongly recommended that you do not use more than three sub-divisions, i.e. no 1.1.1.1 .

It is good practice to emphasise headings by printing in bold (underlining can also be used but is less professional – how often do you see it used in published work?), another distinguishing feature can be the use of italics. Each new chapter (but not section) should begin on a new page. This note provides an example of how chapter and subsection titling can be implemented.

5.3.4 Fonts

Technical documents are generally conservative pieces of writing in a conservative environment. There is a temptation to use some of the many exciting fonts our good friends at Microsoft have put into their software. People who do this often have the quite laudable aim to make the document more interesting – more likely to get noticed and remembered. The same effect can be achieved by wearing a clown costume to a job interview, you will get noticed and remembered (I guarantee it), but you will not get the job (unless it is a clown's job of course). And the primary objective of a job interview is to get the job.

So flash fonts should be saved for party invitations, and posters. They make the wrong impression in the business world. In the past students who have used them have had adverse comments and in some cases marks have been deducted. A further problem is that software is less consistent with the exotic fonts so electronically transmitted documents might not appear to the reader as you intended.

The safest font is Times New Roman (used in this document) or a close variant of this, at 12 point. It was designed as a compact font that was easy to read which is why it is so widely used. Times Roman is the recommended font of the Department.

In some circumstances you can get away with Arial (or something close to it like Gothic), which can be reduced to 11 or 10 point more successfully than Times Roman (this is 11 point). But this does not actually help get more words on the page as it is a less compact font. Its most common use is in illustrations and their titles to make them more easily distinguishable from Times New Roman text.

Most fonts have different lengths for different letters, so an “i” takes up less line length than an “m”. If you are laying out a table this can make aligning numbers etc. difficult. If you are not skilled at tables in the word processing software you are using then the use of Courier font can help. Courier is based on the fonts used in typewriters, tele-printers etc. Due to their mechanical nature they required all letters to take up the same line space. It is not very neat, not very compact and not generally recommended, but it could be better than unaligned tables. But only use it in tables.

Leave every other font alone for technical documents unless the organisation you are writing for specifically directs you to use something else in their special instructions.

5.4 Illustrations and Tables

5.4.1 Purpose

"A picture is worth a thousand words" is sometimes true; but the cliché also highlights that in the context of a report a picture or other illustration is part of the communication process and is there to support what is being said within the text.

It is therefore very important that any illustration (figure or table) in a report is referenced within the text. Never place an illustration in a document without discussing its content and context so that he reader can understand why it is there and what its message is. The exception is a frontispiece where an illustration is included at the front of a document for decoration.

5.4.2 Numbering and Titling

It follows that if every figure and table must be referred to in text it must have a number and a title. In the text they are referred to by number only can be referred to as “Figure 3”, or “Fig. 3”, or for a table “Table 3”. There are two main options for the numbering system itself:

i) The simplest is to number them in sequence throughout the report e.g. Figure 5 for the fifth picture to appear in the report. Whilst this is the easiest for the reader in a large report that is prepared in a hurry this can be difficult to manage.

ii) Number figures within a chapter e.g. Figure 2.3 for the third picture in the second chapter (this is the system used in these notes).

Tables can be numbered separately from figures, but if there are only one or two they can be considered as another figure; either form is correct. When tables are treated as figures for numbering purposes they should be referred to as figures.

5.4.3 Location

Before computers with word processors, the text for documents was typically typed (by a typist) from the author's handwritten manuscript. Further, before photocopiers reproduction of documents was normally by a process requiring the original to be typed on a special waxed paper. Thus once a document was typed it was very difficult to alter. Illustrations were produced separately by a more complex (and more expensive) process and of course could not be on the same page as the text. These problems made the introduction of illustrations into documents difficult and expensive. Certainly it was almost an impossible task to successfully combine illustrations and text together. Therefore the practice was to include illustrations and tables after the text at the end of document.

While this format (not the production technique) is still the practice with some organisations, it is really anachronistic in an age of multimedia computers, laser printers and high quality photocopiers. It is clearly preferable to have illustrations at the point in the text where they are discussed.

However, if you are producing work in a hurry it may be better to resort back to placing all the illustrations at the end, rather than risk making a mess of a poorly organised and formatted document. The practice is still quite acceptable. The only thing you must never do is mix the two formats with some illustrations within the text and others at the back.

All tables and figures are to be mounted in the report such that they read from the front (portrait format) or from the right-hand side (landscape format). Tables should be numbered and titled at the top of the table, with further caption material beneath, as shown

in Figure 5.1., For figures, the title should come after the figure number, beneath the figure; see Figure 5.2.

Table 5.1: An Example Table - B-747 Spoiler Displacements and Normal Operating Rates.

Spoiler Panel	Maximum Displacement (deg.)	Operating Rate (deg. s^{-1})
1, 2, 3, 4, 9, 10, 11, 12	45	75
5, 8	20	75
6, 7	20	25

5.5 Symbols, Numerals and Abbreviations

The nature of engineering means that technical documents are full of symbols, numbers and abbreviations. This section covers how to handle them in the text.

A point, which applies to all of them, is never start a sentence with a number, or a symbol or an abbreviation. It should always be possible to either rearrange the sentence (or leave the offending number etc. out).

5.5.1 Symbols

We have already covered the use of symbols in equations in Section 4.2 and the requirement that if a large number are being used a Notation list should be included (Section 2.5). In the body of the text symbols should be used in exactly the form they are used in the equations including any changes of font and use of italics. Thus if the equation has been written

$$F = m.a$$

then you should use m when the symbol is used in the text.

5.5.2 Numbers

There is no fixed rule as to whether you should use Arabic numerals or write numbers out in words – it is mostly a matter of judgement and common sense. But it is an important point to keep consistency. If the text includes a combination of long and short numbers then always use figures. If only short numbers are involved then use words.

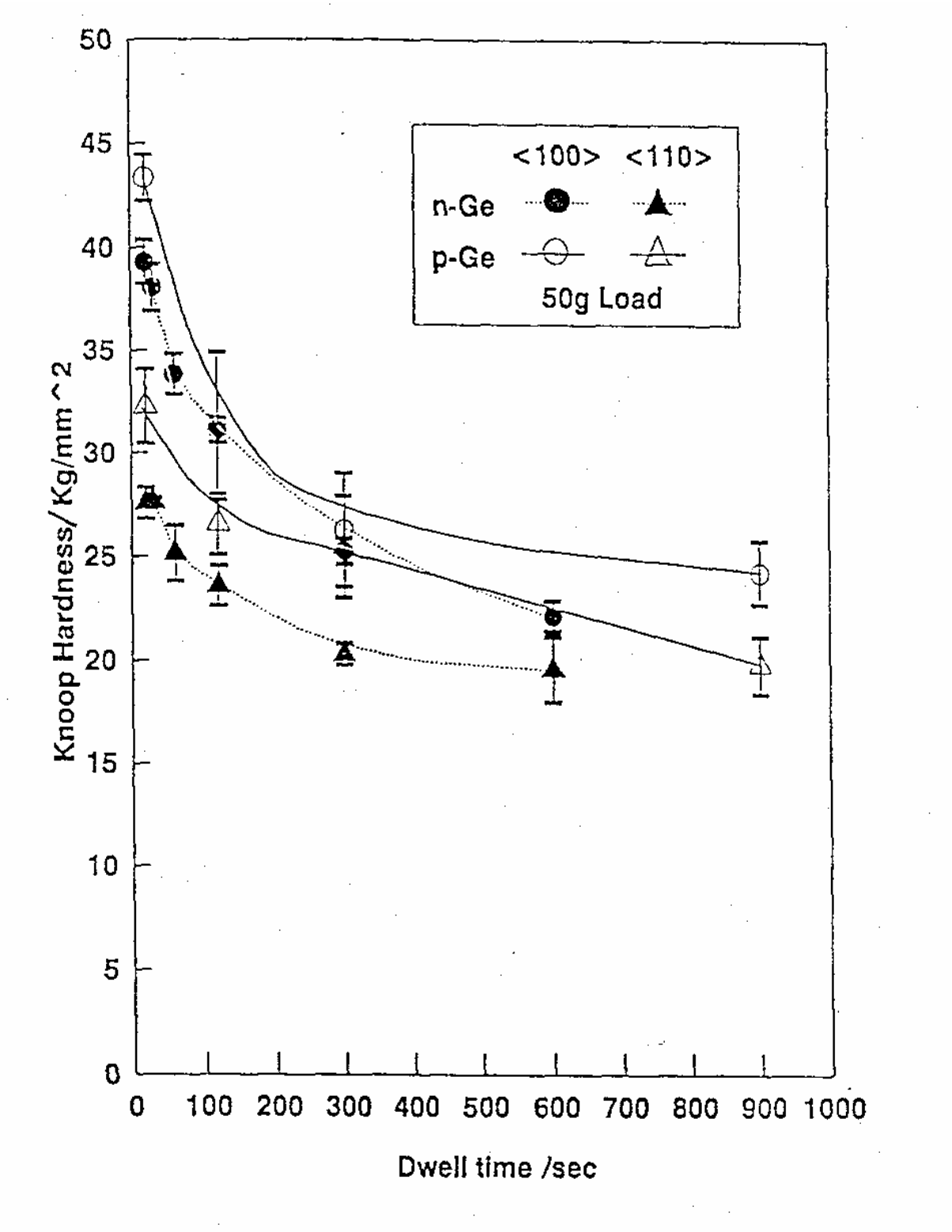

Figure 5.1: An example Figure - Comparison of Indentation Creep at 700C for (001) n- and p-Ge

Good advice is to use figures when the number cannot be written in one or two words so "1 254" rather than "one thousand two hundred and fify four". However where one or two words will do then that is the preferable manner so "sixty" rather than "60". Easily hyphenated numbers are quite acceptable e.g. "ninety-five".

Decimal or fractions and powers should always be presented as figures.

The preferred standard for numbers that require many digits for their expression (on either side of the decimal point) is to group the digits in threes without any separation comma (or period). Non fractional numbers need not show a decimal point, but numbers less than one should have a single nought to the left of the decimal point. Some examples:

4 506.171 9 125 614.03 15 329 0.062 315 7

Perhaps the commonest, and also most serious, problem with expressing numbers is implying unreasonable accuracy. It is wrong to imply false accuracy by showing digits outside the accuracy range or by invalid addition of zeros to the end of a decimal fraction. By convention the following would both be accurate to seven significant figures:

2 930 000 0.046 312

If they are actually accurate to only three significant figures then they should be expressed as 2.93×10^{6} and 46.3×10^{-3} respectively

When powers of 10 are to be associated with the expression of a number, the preferred form is to write the decimal part such that the exponent on ten is +/-1, +/-2, or a multiple of +/-3. Care should be taken to avoid inappropriate powers, for example 10^{-6} kg would be better as simply mg.

5.5.3 Abbreviations

All technical documents should be written in full prose. Generally abbreviations should be used sparingly as they do not make text easier to read. If in doubt leave them out and certainly they should be used only when:

i) the reader can be expected to be familiar with them;

ii) they make the text clearer by compacting the format;

iii) they do not make the text more difficult to follow.

Shorthand and other common symbols intended to compress text should not be used. For example it should always be "therefore" never "∴".

Uncommon abbreviations need to be explained on their first use and included in the glossary if there is one (see Section 2.2.6). However very common abbreviations, for example units like, kg. or m. do not need explanation.

When discussing with portions of the report it is acceptable to use an abbreviated form when a letter or number is included, e.g. "as shown in Sec. 2.1" or "see App. A". The accepted abbreviations are:

Chapter	Ch.	Section	Sec.	Equation	Eqn.
Appendix	App.	Table	Tab	Figure	Fig.
Reference	Ref.				

Note that the plural form of these abbreviations is the same as the singular. For example "see Fig. 4 and 5" and NOT "see Figs. 4 and 5".

Where there is no reference to a number or letter then the word should be used in full. For example "as shown in the previous chapter" and NOT "as shown in the previous Ch."

5.5.4 Acronyms

Acronyms (e.g. NASA for National Aeronautics and Space Administration) are a special form of abbreviation. Their use is increasingly common as a response to the increasing complexity and specialisation in the way we handle life. However the guidelines for when to use them are the same as for other abbreviations - that is, use them only when it improves the readability of the document.

There is a tendency to use acronyms to puff up a report’s technical image or even to make the meaning obscure or to show how knowledgeable the author is. Clearly these are all bad practices - acronyms should only be used to improve the document's clarity and facilitate communication.

A few acronyms have gained the status of words in their own right e.g. Radar (Radio frequency Detection And Ranging) and Laser (Light Amplification by Stimulated Emission of Radiation). If they are in the dictionary then you can use them as normal words without explanation. Otherwise an acronym should be explained on its first introduction. For example on the first mention its should be "BRI (Bristol Royal Infirmary)" and thereafter "BRI".

In addition to this introduction of an acronym in the text they should also be included in any glossary or list of terms the document may have.

APPENDIX A – EXAMINATION ANSWERS

A1. GENERAL APPROACH

Writing answers in examinations can be a stressful business. You are under time constraints, have no access to notes, check lists, and the other material you would normally have when writing essays and documents, and a lot can depend on the results.

In these conditions examiners do not expect the same high standard of presentation as for a piece of coursework. However it is still in your best interests to put some effort into making your answers clear by putting effort into the layout, and the English, of your answer. Firstly there are limits to the licence on presentation and if it is very bad the examiner is entitled to take that into account. Secondly, while examiners do make every effort to ensure they give all the marks the content of your answer deserves, the better the layout, the easier the examiners' job is and the less likely that marks you deserve will be missed.

Writing good English should be second nature to you by now, so in the exam just consciously slow up a little and let your normal writing style predominate, as opposed to producing a panic ridden, scribbled, incomprehensible answer that will get you fewer marks overall.

When the exam question requires an essay, try to give the answer some structure that illustrates your understanding of the material. Avoid a facts dump (especially if in the same order as the lecture material) as the examiner will have nothing to convince him you actually know anything more than a well trained parrot. The closer you can get to a formal essay (which follows the same guidelines you would use for a piece of coursework) the better.

A2. SPECIFIC POINTS

A2.1. Instructions

On the front of the exam answer booklet are instructions to write between two margin lines and to leave at least two lines at the end of each question before starting the next. It is in your own interests to follow these instructions. The only exception to this is that it is OK to put question numbers in the left margin.

These instructions enable the examiners to implement the faculty marking procedures. These marking and checking procedures are in your interest. They are designed to make sure nothing is missed, and that marks are added up correctly and therefore ensure you get full credit for the answers you have given. Examiners and checkers are required to make notes on the answer and need the space to do this. If you do not leave that space you risk messing the procedure up – and thus losing marks.

Both right and left margins are needed to record the marks and the checking. This is particularly true of the right column (the one most often breached) where the actual marks are placed. If it is full of your handwriting the marks many be missed when adding up.

The space at the end is for the total marks for the question to be recorded.

A2.2. Layout Advice

The Engineering Faculty asks that in addition to leaving two clear lines between questions, you start each new question on a new page. This makes things much clearer in an untidy exam script and helps avoid questions being missed when more than one examiner is marking the paper.

There is no need to worry about later questions being missed because there are blank pages between them. Part of the marking procedure is that the lead examiner has to mark every page of the answer booklet to indicate he or she has looked at it – even if there is nothing on it. A checker then looks at each page to ensure this has been done. So everything in your answer booklet will be seen by the examiner no matter where it is.

Indeed in general you should not be concerned about wasting paper (as long as you make sure you use both sides of the paper). A well spaced out answer is easier for the examiner to mark, which might just give you the edge.

NOTES AND REFERENCES

1. Contrary to popular belief split infinitives have never been a grammatical error only a style problem. Even then whether their use is good or bad in a particular context is debatable. See entry in; Bryson, Bill. "*Troublesome Words*", Penguin, London, 1984.

2. Cecil, David; "*A Portrait of Jane Austen*", Constable, London, 1978.

3. Lamerton, Robert; in the introduction to; Hesiod, "*Works and Days and Theogony*" Hackett, Indianpolis, 1993.

4. Joyce, James; "*Finnegan's Wake",* Faber and Faber, London, 1939.

5. "British Standard Recommendations for the Presentation of Theses and Dissertations"; British Standards Institute, BS4821: 1190.

6. Russell, Bertrand; *"The Principles of Mathematics",* George Allen and Unwin, London, 1903.

7. Von Daniken Erik; (Translated Heron, Michael), "*Chariots of the Gods*", Souvenir London, 1969.

8. For example; Story, Ronald; "*The Space Gods Revealed*", London, New English Library,1977, and, Story, Ronald; "*Guardians of the Universe?*" New English Library, London, 1980.

9. "Recommendations for Citing and Referencing Published Material"; British Standards Institute, BS5605 : 1990

10. The "Double Passive" is explained in the "*Oxford Guide to the English Language*" Oxford University, Oxford, 1983.

11. Robert Bain quoted in Partridge, Eric; "*Usage and Abusage*", Hamish Hamilton. London, 1942